

Imperial College London  
Department of Infectious Disease Epidemiology

**From evidence to practice:**  
*The use of mathematical models to inform HIV  
programme planning and policy decision making*

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## Declaration

I hereby declare that the work in this thesis submitted for examination for the Doctor of Philosophy degree is my own work. All sources used in this thesis have been cited appropriately. Additional contributions and dissemination, including publications arising from this work, are described prior to each chapter.

Signed:

A handwritten signature in black ink, reading "Kelsey K Case". The signature is written in a cursive style with a large, stylized 'K' and a long, sweeping underline.

Kelsey K Case

January 2016

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## **Abstract**

From early in the HIV epidemic, mathematical models have been used to understand patterns of infection and the potential for spread and can be a valuable tool to help inform strategic decisions. This thesis aims to investigate the use of mathematical models to inform HIV programme planning and policy decision making. This is done by examining key mathematical models used for this purpose, generating recommendations to advance the utility of these models, and investigating their use in the policy environment. Quantitative and qualitative methods from epidemiology, political science and social science are used to provide an integrated global health perspective. Mathematical models are first used to investigate the long-term epidemiological implications of different policy decisions for HIV prevention and treatment in the countries most affected by HIV. Next, they are used at the national level in a country application to produce short-term projections of incidence within the population. The results from the second model are used to frame a discussion which arose at the international level regarding its use and formulates recommendations for improved use. Finally, a descriptive multi-case study investigation is conducted in Malawi and Zambia exploring the use of mathematical models in guiding national policy with respect to HIV interventions. A qualitative approach drawing on principles from grounded theory is used and a theoretical framework is developed to guide and provide structure for the investigations. This framework views research utilisation as a spectrum and considers a range of different types of use across this continuum. This chapter describes the use of modelling within the policy environment, the key stakeholders involved, and identifies the barriers, facilitators and conditions for use of modelling to inform programme planning and decision making. Taken together, this thesis progresses from global to local, taking modelling beyond the research arena and into the policy environment.



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## Acronyms

|               |                                                          |
|---------------|----------------------------------------------------------|
| <b>AIDS</b>   | Acquired immunodeficiency syndrome                       |
| <b>AIM</b>    | AIDS Impact Module                                       |
| <b>AIS</b>    | AIDS Indicator Survey                                    |
| <b>ANC</b>    | Antenatal care                                           |
| <b>ART</b>    | Antiretroviral therapy                                   |
| <b>ARV</b>    | Antiretroviral                                           |
| <b>BBSS</b>   | Behavioural and Biological Surveillance Survey           |
| <b>BMGF</b>   | Bill and Melinda Gates Foundation                        |
| <b>CCM</b>    | Country coordinating mechanisms                          |
| <b>CDC</b>    | United States Centers for Disease Control and Prevention |
| <b>CHAI</b>   | Clinton Health Access Initiative                         |
| <b>CHS</b>    | Casual heterosexual sex                                  |
| <b>CSO</b>    | Central Statistical Office                               |
| <b>CSW</b>    | Commercial sex worker                                    |
| <b>DHNA</b>   | Department of Nutrition, HIV and AIDS                    |
| <b>DHS</b>    | Demographic and Health Survey                            |
| <b>EPP</b>    | Estimation and Projection Package                        |
| <b>FSW</b>    | Female sex worker                                        |
| <b>GAMET</b>  | Global AIDS Monitoring and Evaluation Team               |
| <b>GBD</b>    | Global Burden of Disease                                 |
| <b>HIC</b>    | High income countries                                    |
| <b>HIV</b>    | Human immunodeficiency virus                             |
| <b>HMIS</b>   | Health management information system                     |
| <b>IDU</b>    | Injecting drug user                                      |
| <b>IHME</b>   | Institute for Health Metrics and Evaluation              |
| <b>I-TECH</b> | International Training & Education Center for Health     |

|               |                                                                   |
|---------------|-------------------------------------------------------------------|
| <b>JMTR</b>   | Joint mid-term review                                             |
| <b>LIC</b>    | Lower income country                                              |
| <b>LMIC</b>   | Low- and middle-income countries                                  |
| <b>LMC</b>    | Lower-middle income country                                       |
| <b>MC</b>     | Male circumcision                                                 |
| <b>MCDMCH</b> | Ministry of Community Development, Mother and Child Health        |
| <b>MoH</b>    | Ministry of Health                                                |
| <b>MoT</b>    | Modes of Transmission                                             |
| <b>MSM</b>    | Men who have sex with men                                         |
| <b>NAC</b>    | National AIDS Commission (Malawi); National AIDS Council (Zambia) |
| <b>NASF</b>   | National AIDS Strategic Framework                                 |
| <b>NGO</b>    | Non-governmental organisation                                     |
| <b>NICE</b>   | The National Institute for Health and Care Excellence             |
| <b>NSA</b>    | Not sexually active                                               |
| <b>NSO</b>    | National Statistics Office                                        |
| <b>OPC</b>    | Office of the President and Cabinet                               |
| <b>PEPFAR</b> | The U.S. President's Emergency Plan for AIDS Relief               |
| <b>PETS</b>   | Public Expenditure Tracking Study                                 |
| <b>PLHIV</b>  | People living with HIV                                            |
| <b>PMTCT</b>  | Prevention of mother-to-child transmission                        |
| <b>PreP</b>   | Pre-exposure prophylaxis                                          |
| <b>RCT</b>    | Randomised controlled trial                                       |
| <b>STI</b>    | Sexually transmitted infection                                    |
| <b>TWG</b>    | Technical working group                                           |
| <b>UN</b>     | United Nations                                                    |
| <b>UNAIDS</b> | Joint United Nations Programme on HIV/AIDS                        |
| <b>UNGASS</b> | United Nations General Assembly Special Session                   |

|             |                                   |
|-------------|-----------------------------------|
| <b>UNZA</b> | University of Zambia              |
| <b>VCT</b>  | Voluntary counselling and testing |
| <b>WHO</b>  | World Health Organization         |

# **Chapter 1**

## **Introduction**

## 1.1 Background

In June of 1981, the US Centers for Disease Control and Prevention (CDC) reported a cluster of young, previously healthy, gay men in Los Angeles diagnosed with the rare opportunistic infection *Pneumocystis carinii* pneumonia without any clinically apparent underlying immunodeficiency (1). At that time, these reports were among the first clinical evidence of a disease that soon would become known as acquired immunodeficiency syndrome, or more commonly – AIDS. The reports continued across different cities and countries and amongst different populations indicating varying routes of transmission. Cases were observed among injecting drug users (2), haemophiliacs, and recipients of blood transfusions, suggesting transmission through exposure to blood and blood products (3, 4). Cases were also observed amongst the female sexual partners of infected males suggesting heterosexual transmission (5), and amongst the children of infected adults suggesting perinatal transmission (6, 7). As case reports rapidly rose in the United States (8) and Europe (9), the potential magnitude and seriousness of the epidemic became apparent. In 1982, the US CDC developed a definition of an AIDS case for reporting purposes and the public health surveillance of AIDS had begun (10).

The retrovirus that causes AIDS was discovered in Paris in 1983 (11) and shortly thereafter in the US (12), then later coined human immunodeficiency virus, or HIV. At the same time, central Africa was identified as an epidemiological setting with significant heterosexual transmission occurring in the general population indicating the global nature of AIDS (13-15). By the late 1980s, the majority of reported AIDS cases were from North and South America. However, the significant burden in sub-Saharan Africa was apparent from the AIDS case-report data available, anticipated to be only a small fraction of the total burden due to delays in reporting and the limited access to healthcare facilities able to diagnose AIDS within this region (16).

The AIDS case-report data combined with available HIV seroprevalence data were used to describe the three distinct epidemic patterns that were emerging globally. In Pattern I areas, HIV likely spread extensively in the late 1970s with most cases occurring among men – predominantly men who have sex with men (MSM) and injecting drug users (IDU) – with an overall population prevalence <1% but very high prevalence among these key risk groups. In Pattern II areas, most cases were observed among heterosexuals, likely due to extensive spread in the 1970s with infections occurring equally amongst males and females, and an overall population prevalence >1%. In Pattern III areas, the epidemic was mixed amongst heterosexuals and key populations with HIV likely introduced later in the early to mid-1980s, presumably as a result of sexual contact with individuals from Pattern I/II countries (17).

These early years of AIDS can be characterised as an emergency response situation, coupled with great uncertainty in both the scale and scope of the epidemic and thus the potential demographic consequences, healthcare and health system needs. In sub-Saharan Africa, the geographic scope and intensity of HIV infection was particularly difficult to assess. It was quickly realised that with the delay from HIV infection to the development of AIDS, combined with substantial concerns regarding the accuracy and completeness of AIDS case-reporting, reliance on these data did not provide an appropriate representation of the underlying epidemic (18). Estimates of disease burden were needed in order to inform public health planning and policy decision making.

## **1.2 HIV/AIDS in the global context**

Since being identified in the early 1980s, it is estimated that over 70 million people have been infected with HIV and over 36 million people have died of AIDS related deaths, with the majority of this burden disproportionately affecting sub-Saharan Africa (19, 20). AIDS remains a leading cause of death worldwide (21). In 2014, it was estimated that approximately 2 million people were newly infected and 1.2 million died of AIDS-related deaths (22). There has been an unprecedented effort at the global level in response to HIV and AIDS with a convergence of political will, donor funding and science (23). The AIDS response has been unique in part due to the severity of infection, the longevity of infection, and the global reach of the disease (24). Countries in southern Africa have been particularly affected, with more people living with HIV (PLHIV) in South Africa than any other country (25). In Swaziland, more than 50% of women age 30–34 years old are living with HIV (26). HIV and AIDS have predominantly affected individuals during their most productive, and reproductive, years of life (27) with substantial demographic (28), social (29, 30) and economic (31, 32) effects as a result. The countries most affected, have also been among the poorest, with limited domestic resources directed for health (33).

Sensitive and controversial issues have surrounded HIV/AIDS including sexual behaviour, drug use, commercial sex and homosexuality. These issues make the AIDS response further unique compared to other infectious diseases, for example influenza and malaria. There have also been exceptionally high levels of stigma and discrimination surrounding AIDS – stigma associated with the disease in itself and individuals affected, but also heightened by the additional stigma that may be associated with race, gender, sexual behaviour and drug use (34). As a result, there are different social, cultural and political barriers that can impede a response to AIDS and the potential for ideology to obscure public health needs (35). Legal barriers can also affect this response. The buying and selling of sex is illegal in many countries which can impede the development and provision of interventions and services specifically addressing this population

(36). In 2014, same-sex behaviour was still criminalised in 78 countries, with two countries – Nigeria and Uganda – recently adopting new anti-gay legislation (37). These dimensions can all play an important and significant role in policy decision making for HIV (38).

### **1.2.1 The emergence of global stakeholders**

The establishment of new institutions and the emergence of new global actors have further globalised HIV/AIDS. The World Health Organization (WHO) took the United Nations (UN) lead on responsibility for AIDS, initiating a Special Programme on AIDS in 1987 which soon became the Global Programme on AIDS. At the World Health Assembly in 1993, WHO outlined the need for coordination of UN activities in their response to the epidemic and thus the Joint United Nations Programme on HIV/AIDS (UNAIDS) was launched in 1996 with the overall aim to lead, coordinate and strengthen the UN response on AIDS (39).

In 1996, the breakthroughs in antiretroviral treatment (ART) were presented at the International AIDS Conference in Vancouver, Canada, which transformed the prognosis of AIDS from a fatal disease to a chronic illness (40, 41). But the high cost of drugs, originally US \$20,000 per patient per year, and the need for lifelong therapy, made treatment prohibitively expensive in many settings (42). The high burden of disease and the lack of health resources in the countries most affected, combined with this exorbitant cost, made treatment provision unfeasible for the majority of domestic health budgets in resource-limited settings. In 2000, the United Nations Security Council debate recognised AIDS as a threat to global security which led the way in confirming AIDS as a global issue requiring global action (43), and signified that health was not just a domestic issue but a foreign policy issue (44).

The inequity of treatment became an international human rights cause. Organisations mobilised in response to the substantial need for treatment and care globally. In South Africa, activists campaigned and demanded that the government provide universal access to ART (45), while the governments of Brazil and India took on the World Trade Organization for licencing that would allow the production of generic drugs (46, 47). In the US, activists led by ACT UP, the Advocacy Coalition to Unleash Power, campaigned against the patent legislation of the pharmaceutical companies, in particular the US's threat to impose sanctions on South Africa after the government (under Nelson Mandela), passed a law stating the country could bypass global intellectual property rules to allow the production of generic antiretrovirals (48).

The Harvard Consensus statement, signed by over 100 faculty members from Harvard University, outlined a comprehensive approach to address the inequalities in antiretroviral treatment provision. This statement defined the necessary parameters to make ART

immediately available in resource-limited settings while at the same time determining best practices for treatment provision and the costs for delivery. It further outlined mechanisms by which ART provision in resource-limited settings could be financed by resource-rich settings (49). Shortly thereafter, Médecins Sans Frontières, a private international association dedicated to providing medical aid to areas where it is most needed, launched treatment programmes which demonstrated the effective implementation and use of antiretroviral drugs in resource-limited settings (50, 51).

Major international efforts followed including the establishment of The Global Fund to Fight AIDS, Tuberculosis and Malaria in 2002 which aimed to create a “war chest” of funds to fight these three key diseases (52), shortly followed by the US President’s Emergency Plan for AIDS Relief (PEPFAR). PEPFAR dedicated an initial US \$15 billion over five years to help save lives around the world from HIV/AIDS, the largest-ever commitment from a nation dedicated to a single disease. At the same time, other donor countries and national and international non-governmental organisations (NGOs) also began to scale-up assistance for HIV/AIDS. The field has since moved at a remarkable pace, cutting across many different disciplines including biology, epidemiology, economics, social and political science, with a myriad of different actors and stakeholders working and operating at different levels (53).

There has been an exceptional response to AIDS in terms of funding. The disbursement of international HIV assistance from donor governments rapidly increased from US \$1.2 billion in 2002, to \$7.7 billion in 2008 (54). But funding for HIV/AIDS has since plateaued, coinciding with the global economic downturn (55). At the same time, the cost of the AIDS response continues to expand as countries scale-up lifelong treatment provision and work to provide comprehensive HIV prevention programmes. This situation of stabilised donor funding in an environment of escalating resource needs has resulted in a strong demand, particularly from international stakeholders, for strategic and efficient programme planning and national responses informed by the best available evidence.

### **1.2.2 Evidence-informed decision making in the HIV/AIDS policy context**

The concept of evidence-based practice, the use of current best evidence to make decisions, developed from foundations in medicine and clinical research. The term evidence-based medicine emerged in the early 1980s but gained considerable momentum among the medical community in late 1980s and early 1990s, solidified with publication in the *Journal of the American Medical Association*, where it was described as “a new paradigm for medical practice” (56). Evidence-based *medicine* was clinically focussed on the use of best evidence to maximise

benefit for individual patients, and drew largely from randomised clinical trial research (57). Evidence-based *public health* shortly followed in the late 1990s in Australia and the United States, expanding beyond clinical trial data and an individual-level focus to incorporate a wider array of evidence to achieve health benefits at the community and population level (58). Evidence-based health policy has been formally defined as “the process of integrating science-based interventions with community preferences to improve the health of populations” (59). For public health, the concept of evidence-*informed* decision making is perhaps more appropriate recognising that the development of health policy necessitates a comprehensive decision-making process which requires taking additional factors into account, for example the resources available and feasibility of implementation.

A focus on simply research and evidence can neglect programme development and implementation aspects of the planning process. A *programme science* approach described more recently in the literature, aims to bring together researchers and those engaged in programme planning and implementation to address the design of prevention programmes in their entirety. Programme science refers to the systematic application of theoretical and empirical scientific knowledge to improve the design, implementation and evaluation of public health programmes (60). Strategic planning, policy development and programme implementation are integrated incorporating different sources of evidence including policy analysis, resource allocation and epidemiological data (61).

The public health response to HIV/AIDS has had a strong demand at the international level for data and strategic information in order to plan an appropriate response. HIV/AIDS was initially a health crisis of uncharted territory – the potential scale, the global scope, the fear, stigma and discrimination – one that demanded a best practice response in health, and arguably a response of new practice (62).

The evidence available to inform policy decision making for HIV/AIDS interventions has continually evolved (63). Today, we now know that antiretroviral treatment is not only able to greatly reduce mortality in those infected with HIV, but there is now a substantial evidence base for the efficacy and effectiveness of ART in reducing the probability of transmission of HIV. In those infected with HIV, antiretrovirals have the potential to decrease the probability of transmission to uninfected partners (64-67) and can prevent transmission from mother-to-child (68-75). Similarly, antiretrovirals can be used to reduce the likelihood of HIV infection after potential exposure. Post-exposure prophylaxis guidelines and recommendations exist to prevent HIV infection from both occupational and non-occupational exposure (76, 77). Recent evidence of a reduction in incidence as a result of pre-exposure prophylaxis (PrEP) (78, 79) – the

use of antiretrovirals in HIV-negative individuals to prevent HIV infection – demonstrates the potential for this intervention to be included as part of a comprehensive, evidence-informed prevention strategy.

Male circumcision is another HIV prevention intervention where there is ample evidence of a reduction in risk of HIV infection (80), acceptability (81), cost-effectiveness (82) and feasibility of implementation. There is also a substantial body of evidence in support of effective interventions to reduce risk among injecting drug users. This includes evidence for the potential effectiveness (83-85) and cost-effectiveness (86-88) of methadone replacement programmes, and evidence of the effectiveness of needle exchange programmes in both reducing HIV risk behaviour and HIV seroconversion among injecting drug users (89, 90).

The assumption of a linear relationship between evidence and policy can be questioned even in countries which support and advocate for evidence-informed decision making (91). Political factors often determine the issues included in national policy agendas and, particularly for topics of sensitive nature, the options considered and the policies adopted (92). Programmes which convey traditional cultural values or serve a particular political agenda are often more appealing to fund (93). Male circumcision, programmes for injecting drug users, and other interventions, such as condom promotion, may be viewed by decision makers as externally inspired or going against cultural or societal values (94). Consequently, political factors can obstruct HIV prevention, prevailing over the available evidence base and blocking important evidence-informed strategies and access to HIV prevention programmes (44). PEPFAR, the largest single contribution to HIV/AIDS, required until 2008 that one-third of the entire prevention budget was spent on abstinence-until-marriage programmes (95) despite the evidence base which indicates these programmes have no effect on HIV risk behaviour (96). Further, condom distribution in PEPFAR-supported programmes was only supported for high-risk groups, and programmes for youth could not encourage condom use as a primary prevention method (97).

In the United States, a ban on federal funding of needle exchange programmes still exists today despite the evidence for effectiveness, and despite recent outbreaks of HIV and hepatitis as a result of increased heroin use in several states (98, 99). In other countries, outreach and harm reduction programmes for commercial sex workers (CSW) and MSM have greatly lagged behind or have been non-existent (100, 101). Further, the lack of consistency in prevention interventions implemented across countries with similar epidemiological and socioeconomic situations signifies that action and funding are not necessarily directed towards the specific drivers of the epidemic in each context (102). The inconsistencies in intervention strategies

employed across similar epidemiological contexts can produce mixed messages and generate further ambiguity for decision makers.

The HIV epidemic, and its future, is influenced by both what is done, and what is chosen not to be done, by both policy action and inaction. Mathematical models can be used as analytic tools to aid in the development of evidence-informed programmes and policy for HIV.

### **1.3 The potential role of mathematical modelling in global health**

A model can be defined as a simplified representation of a complex system (103). A mathematical model describes the behaviour of a system using mathematical concepts and language, and mathematical modelling is the process of developing this description. Mathematical models of the solar system were developed as early as 150 AD to predict the movement of the sun, moon, and planets (104). Mathematical models are used across many disciplines including the natural sciences (in physics, biology and earth science), engineering (computer science), and in the social sciences (economics, sociology, political science). In meteorology, mathematical models of the atmosphere and oceans are used for weather forecasting (105, 106), and in economics, economic decision modelling is used to estimate outcomes and cost-effectiveness of different strategies or decision options (107).

Mathematical models may be used to *describe* the behaviour of a system or results that occur, to *explain* why this occurred, and to *predict* future behaviour or results (108). In order to describe, explain or predict the behaviour of infectious diseases, mathematical models which describe the dynamic nature and spread from infectious to susceptible individuals are needed. This is a non-linear process that changes over time (109). Infectious disease models are unique from entirely statistical models. The latter, summarise associations between variables without assuming a causal pathway, whereas infectious disease models provide a mechanistic representation for how disease burden is established (110). They provide a quantitative approach to describe the dynamics of disease transmission within a population, whereby the spread of infection is defined by an (often simplified) mathematical representation of a complex biological system (111).

The ability to investigate complex infectious disease dynamics with mathematical models has the potential for their use as valuable tools inform public health policy. For example, use to inform infectious disease outbreaks and spread and to support disease control and elimination (112). The recent Ebola outbreak in West Africa was the largest and most complex since discovery of the virus. Mathematical models were used to estimate and understand the dynamics of the outbreak, to estimate the burden of infection, the potential for further spread

and to explore the potential effect of different intervention strategies, in order to inform the development of public health strategies for control (113-117).

Following the discovery of HIV as the aetiological agent for AIDS, simple mathematical models were developed in the mid-1980s to describe the transmission dynamics of HIV infection (118, 119). These models were informed by the limited biological and epidemiological data available at that time, and drew upon mathematical modelling of other sexually transmitted (120-122) and infectious diseases (123). The purpose of these early models was to help improve the general understanding of HIV transmission dynamics and to identify the key factors influencing the spread of infection by investigating how changes to the model assumptions and parameters would affect the results (124). Since this time, nearly every aspect of the natural history, treatment and prevention of HIV has been the subject of mathematical models (125-129).

In this thesis, I focus primarily on three mathematical models which are used to inform agenda setting and policy formulation for HIV – the Estimates and Projection Package (EPP) and the AIDS Impact Model (AIM) in Spectrum (henceforth referred to as ‘EPP/Spectrum’); the Goals model; and the Models of Transmission model. These models were chosen for their current widespread use at the national and global level. Each model serves a distinct purpose:

1. To generate national and global estimates of HIV prevalence and related indicators (EPP/Spectrum)
2. To better understand national HIV incidence and the populations at risk of HIV acquisition (Modes of Transmission)
3. To generate long-term projections of future disease burden and explore the impact of different intervention strategies (Goals).

The following three subsections briefly reflect on these perspectives and the evolution of the models that are the focus of this thesis. Table 1-1 summarises the key function of each model and the key international supporters for each.

### **1.3.1 Estimates of the global HIV epidemic – EPP/Spectrum**

In 1997, UNAIDS and WHO began producing country-specific estimates of HIV prevalence, published every two years (130-132). Since 2003, this process has been country-led but supported by UNAIDS and partner organisations who provide technical assistance to national AIDS programmes for the use of mathematical models to estimate prevalence and other HIV-related indicators at the national, and more recently, sub-national level (133). The purpose of this process is to provide tools that enable countries to monitor their HIV epidemics. Nearly every country in the world generates estimates as part of this process (134).

The methods used have developed over time in conjunction with the data available, incorporating new data and new knowledge and understanding of the epidemic as it has become available. The first generation of HIV surveillance was reliant upon AIDS case-report data and the available sentinel studies on HIV prevalence (135, 136). In the countries most affected by AIDS, case-report data was limited and often unreliable thus the pre-cursor to the EPP model (Epimodel) simply utilised a point estimate of prevalence and combined this information with assumptions about the natural history of infection and the start year of the epidemic, to recreate a historical trajectory of infection (137).

In 2000, UNAIDS and WHO introduced *2<sup>nd</sup> Generation HIV Surveillance*, a strategy that aimed to better capture the diversity of different HIV epidemics, recognising that the global burden of HIV actually represented a combination of different HIV epidemics, beginning at different times, growing at different rates and affecting different populations in different countries. The different types of epidemics would necessitate different types of surveillance, policy and programmatic responses. Three types of epidemics, or epidemic states, were classified which expanded upon Chin & Mann's description of Pattern I, II and III areas described in Section 1.1 (17). Countries were classified as *low-level epidemics* if prevalence was below 1% in the general population and under 5% in all key populations; *concentrated epidemics* if prevalence was above 5% in any key population; and *generalised epidemics* if prevalence was >1% in the general population (138). Accordingly, recommendations for surveillance in concentrated epidemics focused on enhanced surveillance among key populations at greater risk of infection (sex workers, clients, injecting drug users), while in generalised epidemics the recommendation was for routine sentinel surveillance among pregnant women attending antenatal care (ANC) (138).

The mathematical models used today in the UNAIDS estimation process, include the Estimation and Projection Package (EPP) and the AIDS Impact Module (AIM) which are part of the Spectrum suite of models (139), but commonly referred to as 'EPP/Spectrum'. The EPP model is developed by the East-West Center, an independent public organisation established by the US Congress to serve as a resource for information and analysis to support policy decision making (140). The AIM model is developed by Avenir Health, a global health organisation which aims to enhance social and economic development by providing analytic tools to support policy, planning and resource allocation decision making (141). UNAIDS supports the development of EPP and AIM with a technical Reference Group on Estimates, Modelling and Projections – comprised of epidemiologists, demographers, statisticians and public health experts – which exists to provide recommendations on the methods to use to estimate HIV and related indicators (142).

Today, the EPP model uses this routinely collected HIV surveillance data and national survey data to generate estimates of adult prevalence at the population level, then estimates incidence from prevalence. The estimated incidence trend among all adults is passed to AIM where incidence is disaggregated by age and sex and progression is tracked from infection to death, including eligibility for treatment, ART uptake and mortality on ART and in the absence of ART. In generalised epidemics, EPP fits smooth prevalence curves to ANC data to capture trends over time, and for concentrated and low-level epidemics, uses data from key population surveys to fit smooth prevalence curves for each sub-population, aggregated to represent national prevalence (143). Data from nationally-representative household surveys (e.g. Demographic and Health Surveys or AIDS Indicator Surveys) are used to inform the overall level of prevalence, and now also inform the trend over time when multiple surveys are available (144). The methods used in this process continue to further evolve as new knowledge is acquired, new data sources become available, and opportunities to validate the parameters arise.

### **1.3.2 From prevalence to incidence – The Modes of Transmission model**

The different epidemic states defined by the levels of prevalence represented a description and classification of HIV epidemics that was intended to provide more strategic and tailored responses. This type of classification recognised that the different epidemic types would have different trajectories due to different underlying disease dynamics, and thus would have different surveillance, prevention and programme needs. However, a core criticism was that these somewhat arbitrary classifications allowed for basic “prescriptions” for prevention programming influenced by broad epidemic type without detailed analyses to more fully understand the epidemiological profile and changes occurring over time (145). The classifications were also not necessarily representative, for example in Thailand and many districts in India, the epidemics would be classified as generalised given that prevalence in the general population was above 1%, but would more appropriately be considered concentrated based on the key transmission dynamics – commercial sex, unprotected anal sex and injecting drug use – and the strategies needed for prevention amongst these key populations (146).

The dynamic nature of epidemics necessitates a detailed, up-to-date understanding of the magnitude and trajectory. HIV prevalence is indicative of the historic spread of infection, as opposed to the current trajectory, and measures of prevalence in a population become less informative over time. This is because reductions in HIV prevalence will occur if the rate of AIDS deaths is greater than the rate of new infections, thus prevalence declines do not necessarily indicate successful programmes (147). In the era of ART scale-up, increasing levels of prevalence may equally be a result of an increase in new infections, or conversely, due to reductions in AIDS

mortality as people living with HIV have greatly improved survival outcomes on ART (148). Incidence of HIV is a more informative indicator than prevalence to determine the current state of an epidemic and if it is being controlled, but direct measurement of incidence presents a substantial challenge. HIV case-reports represent infections acquired in the past and many people remain asymptomatic for years before diagnosis unaware they are infected. Direct measurement of incidence requires longitudinal population cohort data or an accurate diagnostic for recent infection. Longitudinal population cohorts allow for direct assessment of HIV seroconversion in uninfected individuals (149-158), but these cohorts require long follow-up periods, are costly to run, and may not be representative of the wider population due to increased exposure to prevention and care practices within the study setting. The use of laboratory assays of incidence in combination with data from a single cross-sectional survey has been fraught with challenges (159-161) and will require huge sample sizes for measurement (162, 163). Mathematical models provide an alternative solution.

In 2002, the Modes of Transmission (MoT) model was born out of a meeting of the UNAIDS Reference Group on Estimates, Modelling and Projections (142). Developed by researchers with support from UNAIDS and the World Bank, a key aim of this model was to move from HIV prevention planning tailored by the broad epidemic classifications based upon levels of prevalence, to more strategic and efficient planning based on those at risk of acquiring infection and the behaviours that contribute to that risk (145). This approach represented a shift in focus from prevalence to incidence, in-line with this same shift in focus occurring at the international level. The use of the MoT model was intended to raise awareness within countries of the changing patterns of HIV risk at the national level. It intended to illustrate heterogeneity occurring within different epidemics and to predict those currently at highest risk of HIV infection, allowing countries to use this information to guide appropriate and effective prevention activities (164). Use of this framework was also intended to help countries address the recognition of key populations at greater risk of infection, particularly those populations that may have been previously unrecognised or that were highly stigmatised, for example MSM, injecting drug users, sex workers and their clients.

To estimate HIV incidence, the MoT model uses the distribution and pattern of risk behaviours across the population and combines this information with the current distribution of prevalent infections to calculate the expected distribution of new adult infections by mode of exposure in the subsequent year (165). The development of this model was also responsive to the growing amount of biological and behavioural surveillance data available (albeit still very limited in most settings) to inform analysis and estimation. It was intended to be a user-friendly model,

interpretable by non-specialists, freely available, and applicable in a range of epidemic settings. It was also part of the UNAIDS *Know your Epidemic, Know your Response* framework which aimed to identify key epidemiological drivers in order to more strategically direct programmatic responses to the populations most at risk of infection (166). These qualities, combined with financial, technical and advocative support at the international level (167, 168), resulted in the widespread use of this model at national levels (169-183) .

The routine estimates produced by countries using EPP/Spectrum, described in Section 1.3.1, provide decision makers with a very broad overview of the epidemic including the historical trajectory and short-term projection. However, in the regions most affected, notably sub-Saharan Africa, this approach produced estimates of incidence for the entire population by age and sex but without further disaggregation by different risk groups. The utility of the MoT model is that it provides estimates of the pattern of incidence within the population, among different risk groups, and thus provides an additional level of detailed information which can be used by to tailor prevention activities towards those at greatest risk of infection, allowing for more efficient resource allocation. These two models are complementary and intended for use by similar audiences, notably programme planners and national decision makers.

The potential effect of the implementation of different intervention strategies at the population level can also be investigated using mathematical models, discussed in the next section.

### **1.3.3 The population-level effect of interventions - The Goals model**

A key advantage of mathematical models is their utility translating results from individual randomised clinical trials and observational studies into potential population effects. While randomised controlled trials can provide information on the efficacy of an intervention, mathematical models can investigate the longer-term impact at the population level and explore the sensitivity of this effect (110). This is particularly useful for examining effects on HIV incidence in order to provide insight into the potential impact of interventions that are otherwise difficult to evaluate with empirical data due to logistics, ethics, costs and the length of time required to observe an effect (184). There have been many modelling applications that use evidence from observational and clinical trials to explore the potential effects on HIV incidence at the population level. These include modelling to observe the effects of demonstrated behaviour change among key populations, for example partner reduction, condom use, safer injecting practices (185-187), increasing coverage of male circumcision (188-193), antiretroviral treatment (126, 194-200), and pre-exposure prophylaxis (PrEP) (201-206).

The design of comprehensive national HIV/AIDS strategy necessitates a critical assessment of the potential effect of different intervention strategies (207). There is also a need to consider probable, or even just possible, future scenarios (208). Central to this is scenario modelling and long-term projections.

### *Scenario modelling*

Scenario modelling and analysis, the process of analysing potential future outcomes by modelling different situations, can be used to better understand the implications of combining different programme and policy decisions allowing for the exploration of different mixes of the available interventions (110, 209-211).

The use of scenarios as a tool for public health planning coincided with the development of computers and has roots in military planning. The demand in the United States for war game simulation models resulted in the emergence of scenario analyses conducted by Herman Kahn at the Rand Corporation in the 1950s. These included the development of early missile defence warning scenarios and scenario planning for the potential of nuclear war (212). In the 1960s, scenario planning was extended into strategic planning in businesses and other organisations to analyse the impact and long-term implications of different decisions and investments. For example, Royal Dutch Shell pioneered the use of scenario modelling to consider the potential effects of changes in oil prices on the corporate environment (213, 214).

In science, scenario modelling is used extensively in climate change research to consider human contributions to climate change, the effects of different future climates and the potential impact of interventions, such as technologies or policy decisions, on emissions (215). In public health, an important policy role of models is the evaluation of potential intervention strategies (216). Models are used to inform national infection and disease prevention and control, and health care delivery strategies. For example, the use of scenario modelling to inform screening strategies for chlamydia in England, The Netherlands and Australia (217-220), and the use of scenario modelling to inform breast cancer screening strategies in the United States (221, 222). Scenario modelling has also been used to inform national immunisation strategies including measles mumps and rubella (MMR) (223, 224) and human papilloma virus (HPV) (225-234), and global strategies for polio eradication (235, 236).

For HIV, context-specific variables can be used in combination with scenario modelling to predict the impact of interventions and illustrate the effectiveness of specific prevention approaches at the population level (237). These analyses can also identify and highlight gaps and areas for improvement in the current strategies employed. For example, highlighting the effect of early

intervention for HIV (238) with the general conclusion that changes introduced earlier in the epidemic have a disproportionately greater effect than similar changes made later (239).

Because of the long timescale associated with HIV, scenarios are often generated in conjunction with long-term projections which describe plausible future trajectories and can yield valuable insights into future mortality, burden of disease, the impact of ART and long-term need for ART under defined situations. Scenarios may also be used to examine a range of different prevention and treatment strategies and identify the impact of increased investment in programmes and interventions (240-242). The aim of the use of scenarios is not necessarily to predict the future, but instead to identify and consider a range of possible future outcomes.

#### *Long-term projections*

For HIV, long-term projections are necessary in order to observe the full impact of treatment and prevention interventions, and can be used to help shift thinking from the short-term emergency response to long-term planning and prevention. Long-term projections can also be used to consider the potential future magnitude and to determine how rapidly spread is predicted to occur in various populations and geographic areas (243). Projections provide a platform for discussion and debate, may help to stimulate dialogue and can help build political commitment and mobilise political support (208).

The development of long-term projections began early in the epidemic with the specific aim to inform agenda setting and public policy making. Historically, there has been a lack of consensus among modellers and statisticians with regards to the potential long-term future of HIV (244-247). This was due in part to lack of knowledge and understanding of virus spread and disease progression, and further exacerbated by the lack of data available to inform the projections (248). The method development has historically, but still relevant today, surpassed the data available (207).

The Goals model is a dynamic transmission model also developed by Avenir Health (developer of the AIM model in Spectrum described in Section 1.3.1) with the specific aim to support national strategic planning for HIV (249). It is one of the most widely used models for generating long-term projections of HIV and conducting scenario analyses to assess the potential impact of interventions and identify the resource needs and investments required for different intervention strategies (185, 237, 240, 241, 250-252). This model is used to inform high-level processes including the development of the PEPFAR Blueprint (253), the UNAIDS Investment Framework (242), and to inform the recent Global Fund Needs Assessment for the Fourth Replenishment (254).

A unique feature of this model is an impact matrix which quantifies the effect of behavioural prevention interventions on risk behaviours and the effect of biomedical interventions on transmission. This allows for investigation into the effect of scale-up of a wide range of interventions including male circumcision, ART, pre-exposure prophylaxis (PrEP), voluntary counselling and testing (VCT), and outreach programmes for youth, sex workers, MSM, and IDU. It is the quantification of the effect of behavioural interventions on risk behaviour that is perhaps the most unique feature of this model, providing a method which synthesises the data available from published studies to allow for the investigation of the potential effect at the population level (255).

A further unique feature (at that time) was that the epidemiological outputs could be directly linked to a simple unit cost model to estimate the cost of implementing different intervention scenarios in order to support programme and policy decision making. The key model features including quantifying the impact of interventions, generating long-term projections and simple linkage to a costing model to estimate the resources required, responded to the demand at the national and international level for this information. The ability to use this model in any country setting, and aggregate results to the regional and global level has resulted in the widespread application of this model to generate results at the national and international level.

**Table 1-1 Key functions and support of the EPP/Spectrum, Goals and MoT models**

| Model               | Key Functions                                                                                                                                                                                                                                | Key Support                                                                                                                                 |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>EPP/Spectrum</b> | <b>Estimates:</b> Trends in HIV prevalence, incidence, AIDS deaths (adults & children)<br><b>ART indicators:</b> Estimates of need for ART, ART coverage<br><b>PMTCT indicators:</b> Estimates of need for PMTCT, PMTCT coverage             | <b>UNAIDS</b><br><b>Avenir Health</b><br><b>East-West Centre</b><br><b>UNAIDS Reference Group on Estimates, Modelling &amp; Projections</b> |
| <b>Goals</b>        | <b>Long-term projections:</b> Future projections of HIV amongst adults<br><b>Impact of interventions:</b> Impact of ART, male circumcision, behaviour change<br><b>Resource needs:</b> Linkage with costing model to estimate resource needs | <b>Avenir Health</b>                                                                                                                        |
| <b>MoT</b>          | <b>Incidence:</b> Predicted distribution of new adult HIV infections in the next year                                                                                                                                                        | <b>UNAIDS</b><br><b>World Bank</b>                                                                                                          |

PMTCT: Prevention of mother-to-child transmission

#### **1.3.4 Criticisms of the use of mathematical models**

A key historical criticism has been the validity of model outputs. The overall aim of infectious disease modelling is to extract as much information as possible from the data available in order to provide an accurate representation of a biological system. Decisions on model complexity, model assumptions and parameter values are all required and will be influenced by the data available and by an understanding of key epidemiological determinants (256). For HIV, these key determinants include HIV transmission, representation of disease progression, patterns of behaviour and sexual mixing. There was very limited understanding of these key determinants and equally limited data available to inform models early in the epidemic. This both hindered the development of early mathematical models and greatly impeded the use of the results from these models (257). As a result of this limited understanding, a lack of consensus perpetuated early models and projections (244, 245). Heterogeneity in risk of acquiring and transmitting infection, and in sexual behaviour and mixing patterns, were largely unknown at that time and thus a wide range of potential future outcomes were plausible depending on the assumed patterns of sexual behaviour (258-260). This resulted in projections of the future course of the epidemic which received significant attention and have created considerable controversy (208, 248, 261-263). In hindsight, these early long-term projections failed to anticipate the hyper-endemics of southern Africa, greatly underestimated the global effect of HIV, and overestimated the spread of concentrated epidemics in Asia (23, 264).

Revisions to estimates of HIV prevalence over time have also raised questions regarding the accuracy and validity of HIV estimates (265). The UNAIDS estimates and those from other global modelling processes, including malaria (266) and tuberculosis (267), continually evolve in a process of ongoing method development (268). Changes to model parameters or incorporation of new data sources can affect both current estimates and future short-term projections, but they can also affect the historical trajectory of infection. For example, the early UNAIDS/WHO estimates of HIV in generalised epidemics (130-132, 269) were based on the very limited data available at that time, namely routine surveillance in women seeking antenatal care (270-272). It was only when data from nationally representative surveys became available that the biases in ANC data relative to the general population were understood (273-275). HIV prevalence in pregnant women seeking ANC was higher than prevalence in the general population and thus applying HIV prevalence in ANC to the general population overestimated the scale of the epidemic. The availability of nationally representative data led to an improved understanding of the important differences across urban and rural populations and between sexes which resulted in changes to model parameters and the subsequent revision and downward adjustment of the

2007 Global Estimates (275). The downward adjustment to the estimates of HIV in India was one of the most dramatic examples of this effect (276). The Indian National Family Health Survey conducted between 2005-2006 included the first measurement of HIV prevalence in the general population (277). In this nationally representative survey, HIV prevalence was found to be half the level compared to previous estimates informed by prevalence amongst pregnant women. The adjustment to HIV estimates in India contributed substantially to this downward adjustment at the global level.

In China, early HIV surveillance was established in the areas most affected. The expansion of the national surveillance system and the availability of more nationally-representative data resulted in subsequent downward revisions to the national estimates of HIV prevalence in China (278). Here, it was the contribution of key risk groups to national epidemic spread that was unclear. The use of prevalence among key populations from convenience samples or surveys that are not nationally-representative, for example surveys in capital cities, can lead to overestimation when applied at the national level if they are only capturing those at highest risk.

Different organisations generating different estimates for the same context can also lead to a lack of confidence in modelled results, for example the global estimates of HIV incidence, prevalence and AIDS deaths produced by IHME as part of the Global Burden of Disease, compared to the same indicators produced by countries and published in the UNAIDS Global Report (279, 280). Conflicting reports can create confusion – to the public, to policymakers, and to researchers (257). However, the processes of questioning and comparing methods and understanding differences in the methods used and results obtained, have provided opportunities to learn from different approaches and advance science forward, which is arguably also an advantage (281).

These criticisms and caveats are particularly important to take into account when considering the use of these tools to inform policy decision making, programme planning and resource allocation. If the results from mathematical models are viewed as inaccurate or unrealistic, it can lead to distrust and dismissal of the results which can undermine the potential benefit of these tools and further undermine public confidence. The controversy surrounding changes in the estimates of disease burden, and widely varying long-term projections, have resulted in the media, civil society and the general public expressing scepticism in statistical and scientific claims (282). In addition, few public health decision makers are given adequate information or possess the technical skills necessary to assess the quality of modelled estimates (283) and may find modelling results difficult to comprehend or deem the proposed solutions as unrealistic (238).

Decision makers may also reject the use of modelled or imputed data due to the debates over validity or appropriateness of the methods used (284).

Today, HIV is comparatively, one of the more “data-rich” infectious diseases which has allowed for increased complexity in the methods used and the analyses possible. At the same time, there has been a rapid increase in the production of mathematical models and modelling analyses from researchers and academics. There is also a demand at the international level for this information, for target setting and in order to monitor indicators, for example progress towards the Millennium Development Goals. There is international support for the use of modelling processes which are intended to inform agenda setting and policy formulation, for example the support given from both UNAIDS and the World Bank to countries to use the Modes of Transmission model to inform HIV prevention strategy. While there are many different models used to estimate HIV, a select few are frequently used in countries at the national level and developed for the specific purpose of informing programme planning and decision making.

EPP/Spectrum has been used by countries to generate HIV estimates since 2003, establishing a routine process of model use at the national level, intended for direct alignment with national programme planners and decision makers to support country ownership of the results produced. Use of the Modes of Transmission and Goals models are not routine processes at the national level, but their use is encouraged and supported by international organisations. While there is an abundance of literature published by researchers and international organisations on the policy relevance of mathematical models, there remains a more limited understanding of how these models are actually perceived and used in the policy environment, specifically how planners and policy makers use these tools to inform programmes, policy and resource allocation.

## **1.4 Outline of the thesis**

The aim of this thesis is to investigate the use of mathematical models to inform HIV decision programme planning and policy decision making at the national level, with a particular focus in low and middle-income countries. This will be done by first investigating key mathematical models developed to inform HIV programme planning and decision making, generating recommendations to advance the utility of these models for this purpose, and then investigating the use of these models in different country settings.

### **1.4.1 Objectives**

There are three key objectives to support the project aim:

1. To use the Goals model, developed to inform HIV programme planning and resource allocation decisions, to investigate the potential long-term future of HIV and the impact of intervention scenarios at the global and national level.
2. To use the Modes of Transmission model, developed to inform HIV prevention decision making, to investigate the current epidemic situation and the predicted distribution of new HIV infections in a country-supported technical process. In addition, to synthesise the policy discussions at the international level which arose from the use of MoT analyses to inform decision making.
3. To investigate how EPP/Spectrum, Goals and the MoT model are used at the national level to inform HIV programme planning and decision making in two sub-Saharan Africa contexts.

The methods used for these objectives include desk and field studies, encompassing technical application in the Republic of Armenia, a pilot study conducted at a southern Africa regional workshop in Johannesburg, South Africa, and case study investigations in Zambia and Malawi (Table 1-2). With each objective, recommendations are generated for improved policy relevance of these tools.

#### **1.4.2 Rationale**

Today, it is widely acknowledged that AIDS is a complex problem requiring a comprehensive response (285). In an era of stabilising or potentially declining resources for HIV (286), the need for efficient programme planning and policy decision making guided by the available evidence base is paramount for a sustainable future (287). Mathematical modelling has made the important contribution of providing an improved understanding of the dynamics of HIV epidemics (216) and have been critical in order to provide estimates of incidence, prevalence, mortality and need for treatment (288, 289). Mathematical models have been used to estimate and predict the distribution of new infections within a population (290-296) and to illustrate key populations affected and those at greater risk of infection (297). They have also be used to investigate the resultant effect at the population level of individual-level interventions, for example, male circumcision (188, 191-193) and ART (126, 195-198). Dynamic transmission models which incorporate behavioural and population changes over time have been used to illustrate the potential effect of different behavioural interventions risk behaviours such as partner reduction, condom use, safer injecting practices (185, 186). Long-term projections have been generated to provide insight into the future magnitude of the epidemic and used in conjunction with scenario modelling to explore the potential longer-term effects of different

intervention strategies (298). These long-term projections are essential in order to fully illustrate the impact of treatment and prevention interventions.

All of these uses can make mathematical modelling a key resource to support national programme planning and policy development for HIV prevention and care – aiding in planning and assessment for current and future burden of infection and services needed, the resources required to provide and fund these services and prevention programmes, and the human resource and health system needs for implementation (299). However, the use of modelling to inform national HIV policy development and programme planning is less clear. While the results from modelling may be able to inform policy and programme decisions, use of this information is likely determined by many factors including whether the modelling addresses issues already of concern, whether the results are consistent across different models, whether the results lead to actions that are deemed feasible and whether there are intermediary links translating the research findings to key stakeholders in the decision-making process (238). Timing may also be critical. There are several policy stages where information from modelling can be useful, in particular, problem identification – which requires estimates of disease burden – and need recognition which requires both estimates and projection, for example the need for ARVs (238).

In the past three decades there has been a proliferation of HIV modelling applications and processes, some of which are now supported (or required), by donors and intergovernmental organisations at the national, international and global level. As a result, it is important to critically evaluate the models used, to analyse the methods employed, challenge the assumptions, discuss and debate the results, and identify how their use and interpretation can be modified and improved.

The Goals and MoT models were specifically designed as analytic tools to inform programme planning and policy decision making. In contrast to more complex and technically-specific models developed for research purposes and applied in specific settings, both models were intended to be more user-friendly, freely available tools that could be widely applied in different epidemiological contexts. Despite their widespread use, we still have an inadequate understanding of how these models are actually used at the country level and what transpires from these modelling processes. A greater understanding of how this information is actually used and perceived can enhance its practicality. A consideration of the policy context and the key stakeholder perspectives of mathematical modelling within this context may also identify and facilitate opportunities to improve the utility of models for informing national HIV programme planning and decision making.

### **1.4.3 Structure of the thesis**

Following this introduction, I begin by reviewing the theoretical foundation surrounding research utilisation in Chapter 2, drawing from, social and political science and health policy perspectives. This review presents research utilisation as a continuum and then considers explanatory models associated with different types of utilisation along this continuum. The scope is then broadened with a theoretical reflection of the wider political context within which research utilisation sits. The purpose of this chapter is to develop a theoretical perspective to inform and guide the research strategy and methodology later applied in the case study investigations presented in Chapter 5. The work to develop the theoretical framework was ongoing and iterative throughout the research process, with the initial hypotheses informed from the work conducted in Chapters 3 and 4.

In Chapter 3, I begin with a desk study using a mathematical model, the Goals model, designed to inform HIV policy and programme decisions for intervention scale-up. I explore the potential long-term futures of the epidemic and the impact of different interventions, first at the global level and then focused in more detail in two, epidemiologically diverse, countries. I then investigate the model parameters and structure in more detail and generate recommendations for modifications to the methods used. The analyses conducted in this chapter provide an example of the use of modelling and scenarios to explore the potential longer-term impact of policy choices including failure to implement change.

Chapter 4 moves the focus from a desk study to an in-country technical application using the Modes of Transmission model which was developed to assist decision makers to appropriately target HIV prevention activities. This model is used to assess the current state of the epidemic, the specific subpopulations affected, and to then project the short-term distribution of new infections in order to identify where new infections are predicted to occur. The aim of this process at the country level is to shift the focus from prevalence to incidence and to inform more strategic prevention planning. The model paradigm, structure and data requirements are reviewed and guidance and recommendations are generated for future analyses in order to strengthen and improve future use of this model for policy decision making. In both Chapter 3 and 4, the models used and analysed are mathematical models commonly applied in country-supported processes with the specific intention to inform more strategic and efficient HIV programme planning and policy decision making. These models have substantial international support both financially and technically.

Finally, in order to better understand how these models are actually used at the country level within the policy context, a multi-case study was designed, piloted and then conducted in two

sub-Saharan Africa countries – Zambia and Malawi – which is presented in Chapter 5. This chapter draws directly upon the theoretical framework described in Chapter 2 and uses qualitative methods to investigate in-country how these mathematical models and the findings from the models are used to support national-level decision making. Key stakeholder mapping is conducted in each context and key informant interviews are conducted with over 90 individuals to provide a descriptive analysis on the use of mathematical models for national HIV programme planning and decision making.

Chapter 6 brings the work conducted in all chapters together to summarise the findings and to interpret these findings within the current context of HIV programme planning and decision making and discusses the way forward and areas for further research.

#### **1.4.4 Reflexive stance**

A reflexive stance informs the reader how the researcher conducts their research and relates to the research participants (300). This is a self-critical and self-conscious analytical scrutiny of one's self as a researcher and allows the reader to consider and assess the potential influence of the researcher on the research process (301).

The author completed this thesis in varying roles and it is important to consider the perspectives associated with these roles and the positionality, or the potential influence of the researcher's position on the methods used, the data collected and the interpretation of the results (302). A classic distinction to use in this description is "insider" versus "outsider" which can be defined in other ways such as local versus foreign, participant versus researcher. There may be different interpretations of findings or viewpoints based on this status, for example an insider may have better access to key stakeholders, ask more meaningful questions and be more perceptive of non-verbal cues, but may also be inherently biased. An outsider may offer a less-biased perspective and be seen as independent thus may be able to probe sensitive questions, and can perhaps extract more information as a result of requiring more detailed explanations (303).

Throughout the thesis, the author was both a PhD student and a staff member at Imperial College London in the Department of Infectious Disease Epidemiology (DIDE) and also part of the Centre for Health Policy at Imperial College London. The author's role was as Research Manager of the Secretariat of the UNAIDS Reference Group on Estimates, Modelling and Projections. The UNAIDS Reference Group exists to provide impartial scientific advice to UNAIDS and other partner organisations on the methods used to produce estimates and projections of HIV prevalence, incidence and related indicators. This role provided a predominantly technical perspective and allowed access at different levels. Situated within a Department internationally

recognised for the development of infectious disease models and methods provided an insider technical perspective in terms of understanding the method development in infectious disease modelling and key issues surrounding HIV modelling. The additional linkage with the Centre for Health Policy at Imperial offered an additional perspective with access to specialists in health policy and economics and allowed the author to be a part of the discussions and learning occurring within this group. Working directly with the method development for the UNAIDS-supported mathematical models provided a further insider perspective from a technical lens and allowed for active engagement and insight into new knowledge, data sources and issues arising in regards to the ongoing development of HIV modelling.

As the Research Manager of the UNAIDS Reference Group, the author was also able to interact with other UN organisations including WHO, the Global Fund and the World Bank. This provided an institutional and UN perspective on mathematical modelling and estimates and projections of disease burden and how these are couched within the global agenda. The nature of this role also presented opportunities to work directly with countries to facilitate the use of mathematical models. The work conducted in Armenia in Chapter 4 is demonstrative of such an opportunity as is the pilot study in Chapter 5 conducted at a workshop with countries from southern Africa. In both situations the author represented the UNAIDS Reference Group as a technical expert from Imperial College London. There were other similar opportunities during this time period that are not included in this thesis, working with the Moldova, Somalia, Sudan, and the Caribbean region, which similarly shaped the author's interest surrounding the technical development of mathematical models, the use of these models at the country level, and their use to inform national programme planning and policy decision making. These experiences will also shape the research findings.

During this thesis, the Institute for Global Health was founded at Imperial College London which brought together epidemiology, health policy and public health into a single institution. The motivation for this thesis aimed to take advantage of these links and draw across these disciplines to provide an integrated global health perspective. Both quantitative (Chapters 3 and 4) and qualitative (Chapter 5) methods were used to support this process.

The impetus for the long-term projections presented in Chapter 3 was an independent forum established by UNAIDS – aids2031 – which sought to engage scientists, epidemiologists, economists, political scientists, programme managers and leaders to take a long-term view of the epidemic to consider what could be achieved by 2031, 50 years after the recognition of AIDS (304). As part of this project, the author generated long-term projections for 22 countries substantially affected by HIV. These projections were subsequently used to assess the long-term

global burden with different intervention response scenarios, and used (by other research groups) to quantify the resources required for each response. Through generating these projections for the aids2031 project, the author identified the need for further analysis of the Goals model and the need to further investigate the impact of interventions at not just the global level, but on a country-by-country basis. The author recognised that different epidemiological contexts will require different responses and the appropriate portfolio of interventions will need to be tailored specifically for each country. This analytic process resulted in the work presented in Chapter 3.

Shortly after the thesis began, the HIV Modelling Consortium was established at Imperial College London in the Department of Infectious Disease Epidemiology. The Consortium aims to help improve scientific support for decision making by co-coordinating a wide range of research activities in mathematical modelling of the HIV epidemic (305). One of the initial modelling topics addressed by this group was the Modes of Transmission model (presented in Chapter4). An international consultation was held in Montreux, Switzerland in April 2011 to discuss key concerns with the use of this model for policy decision making. The author participated in this meeting and subsequently developed the discussion presented in Chapter 4 in response to, and to clarify, the issues raised by international stakeholders at this consultation.

Throughout this process of engagement on the research and method development side, but also engagement with countries using the models, it became clear to the author that there was a disconnect between those who develop and produce mathematical models and those who actually use the models. The case study investigations presented in Chapter 5 were born out of this understanding and the realisation that while the pace and scale of the development of mathematical models was increasing seemingly exponentially, very little was known regarding how these tools were actually used in the countries most affected.

The case study investigations conducted in Chapter 5 necessitated access to key stakeholders including international organisations, ministry officials, researches and technical experts. A consultancy project undertaken by the author with the Bill and Melinda Gates Foundation (BMGF) allowed for, and greatly facilitated, this access. The research settings of Zambia and Malawi were opportunistic, these were countries selected by BMGF in consideration for potential grants to the governments of each country to develop plans to improve the use of data for strategic decision making for HIV. The potential planning grants from BMGF provided the opportunity for the case study investigations to occur and were conducted in parallel to initial consultations conducted between BMGF and key stakeholders in Zambia and Malawi.

As a researcher, a technical expert, often affiliated with UNAIDS, and a consultant with BMGF, the researcher was continually aware of these different positions and the potential for influence on the data obtained. However, these varying roles also allowed for different perspectives to inform both the data collection and the interpretation of results – considering throughout the perspective of mathematical modellers, that of the UN and funding bodies like BMGF, and the perspective of those on the ground who use these models or are presented with the model results. Importantly, the different affiliations facilitated an enormous amount of access – to key stakeholders, to international meetings and workshops, to ministry officials, to technical experts – which provided a rich dataset and research experience.

**Table 1-2 Description of methods used, models examined, geographic focus and time period for the results presented in this thesis**

| <b>Chapter</b> | <b>Methods</b>                                       | <b>Mathematical Model</b>       | <b>Geographic focus</b>                                                  | <b>Time period conducted</b>         |
|----------------|------------------------------------------------------|---------------------------------|--------------------------------------------------------------------------|--------------------------------------|
| <b>3</b>       | <b>Quantitative:</b> Mathematical modelling          | <b>Goals</b>                    | <b>Global:</b> 22 key countries<br><b>National:</b> South Africa & China | 2009-2010                            |
| <b>4</b>       | <b>Quantitative:</b> Mathematical modelling          | <b>MoT</b>                      | <b>National:</b> Armenia                                                 | 2011                                 |
| <b>5</b>       | <b>Qualitative:</b> Pilot, case study investigations | <b>EPP/Spectrum, Goals, MoT</b> | <b>National:</b> Zambia & Malawi                                         | 2011 pilot<br>2013-2014 case studies |

## **Chapter 2**

### **Developing a theoretical perspective to investigate research utilisation**

## Summary

In this Chapter I present the development of a theoretical framework on research utilisation in the decision making process which will later be used to guide the qualitative case study investigations presented in Chapter 5. Research utilisation can be described as the process of interaction between research inputs and decision outputs. The role of research utilisation draws upon theoretical perspectives from both social and political science. The research utilisation spectrum is presented as the broad theoretical perspective which describes three types of utilisation – instrumental, conceptual and symbolic. Each type is associated with different explanatory models which explain how research information is used to inform decision making during the agenda setting and policy formulation stages of the policy cycle. Taken together, the utilisation spectrum and the different explanatory models will provide the general structure and perspective from which the case study investigations will be conducted.

## Contributions and dissemination

Early stages of this work benefited from feedback and advice from Sarah Hawkes at University College London. I have also received constructive comments from my supervisors.

The author presented a portion of this work at a Wellcome Trust meeting on *Using Theoretical Frameworks for HIV and STI Control*, 8-10 January 2014, London, UK.

## 2.1 Introduction

The overall focus of this thesis is on the use of mathematical models to inform HIV programme planning and decision making. In Chapter 5 a multi-case study investigation is conducted in two countries in sub-Saharan Africa – Zambia and Malawi. Qualitative methods are used to investigate how the mathematical models investigated in the preceding chapters are actually used in-country to inform national HIV programme planning and decision making. The qualitative research conducted in the case studies in Chapter 5 necessitates an underlying theoretical framework to inform and direct the research approach including the hypotheses investigated, the analyses conducted and the framing of the research findings (306). This chapter describes the development of this framework.

It is worth noting that use of theoretical frameworks in qualitative research generally differs compared to quantitative research. In qualitative research, theoretical frameworks are predominantly used to guide the research strategy while their use in quantitative research is largely to define and identify relationships among variables (301). Within the theoretical framework, explanation and prediction generally lie in the realm of models and theories. There may be many theories or models within a single framework. Some scholars (307) are very precise with the distinction between theories and models whereby a *theory* is a set of interrelated propositions containing constructs that describe, explain or predict behaviour and a *model* is a representation of a specific situation, narrower in scope than underlying theory and often more precise in its assumptions (308). This distinction may not always be explicit and the terms are often used interchangeably which will be reflected in this review.

The work to develop and refine the theoretical framework was ongoing and iterative throughout the research process, beginning before the case studies commenced and continuing after they ended. From the outset, the specific intention was to refrain from being prescriptive with the underlying theory in order to remain open to new findings and interpretations that emerged during the data collection. A substantial body of literature pertaining to research utilisation (and decision making, although not the explicit focus) was reviewed and conceptualised throughout this process. Appendix 2-1 details in full the different models and theories reviewed and the reasons for not including each in the theoretical framework developed. The models and theories ultimately included to guide this research were deemed particularly applicable and relevant to the contexts of Malawi and Zambia. They predominantly focus on how research information is used as opposed to describing how the decision making process unfolds.

In the next section (2.2), I begin with a theoretical consideration of different types of utilisation and consider explanatory models of research utilisation drawn predominantly from social

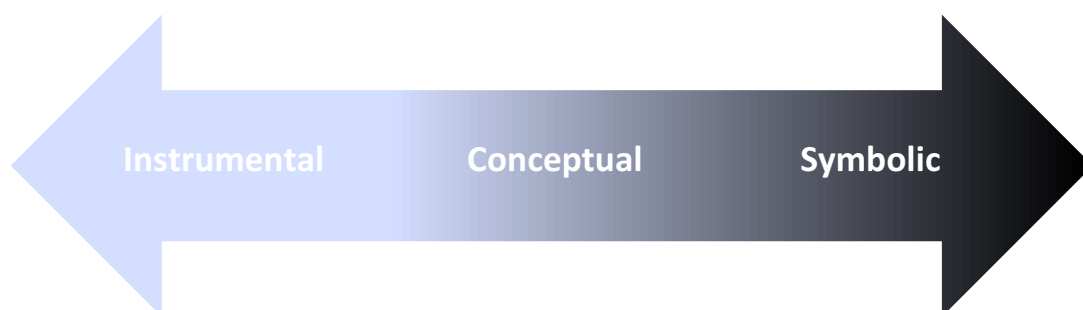
science literature, but readily applicable to health policy. I then broaden to consider the political context within which research utilisation sits in Section 2.3, introducing classical political theory and the role of power in the public policy environment from a political science viewpoint. Within this context, the policy process is conceptualised from the perspective of policy stages which serve to further demarcate the scope of investigation in the case studies. Taken together, this will provide the overarching boundaries of enquiry used to organise, inform and guide the case study investigations presented in Chapter 5. The limitations are discussed in Section 2.4 and the application of the theoretical framework is discussed in Section 2.5.

## 2.2 Research utilisation

It is insufficient to assume that simply producing research evidence is sufficient for uptake of this information. The term *research utilisation* can be described as the process of interaction between research inputs and decision outputs (309). Research utilisation may refer to use in the planning or delivery of programmes or services, towards the formation of policy directives, practice guidelines, or towards resource allocation (310). Other closely related terms may include research transfer, knowledge transfer, knowledge-to-action, evidence-based action and evidence-informed action.

Explanatory models of research utilisation can be conceptualised across a spectrum of “utilisation” Figure 2-1. This spectrum represents an expanded view of utilisation, ranging from *instrumental* use of research information on one end, *symbolic* use on the other end and *conceptual* use in the middle. This broader perspective of utilisation was described in the 1970s (311) based on early empirical studies on use of social science (312, 313) and public health (314) research to inform government decision making.

**Figure 2-1 Research Utilisation Spectrum**



Instrumental use of research evidence represents use in a very direct and specific way, whereby a specific decision or action is directly attributable to research information (315). In other words,

the inputs (research evidence) directly relate to the outputs (decision made). Conceptual use represents more general and indirect use of research evidence such as influencing thinking or understanding, or resulting in a change in awareness or “enlightenment”, but generally without a direct and identifiable link (316). Symbolic use, as described by Knorr (317), can represent research information as a substitute for a decision, for example distributing or publishing a report to signify addressing a problem while actual decisions are either postponed or neglected. Here, it is generally not the content of a research study that is important, but simply that a study was done or commissioned which shows responsiveness (318). Symbolic use can also represent use of research information to legitimate a decision or give confidence, for example the use of data and arguments to publicly support a decision that has been taken (on different grounds) or use which represents an opinion already held (319, 320). Note that while symbolic use may represent use for more tactical purposes or for justification, this type of use is not unimportant and is not necessarily improper use of research information (321). As stated by Pelz in the late 1970’s (311),

*“In the domain of policy making, one suspects that this third mode – symbolic or legitimated use – may in fact be more prevalent than conceptual use with instrumental use appearing rarely.”*

In the following sections, this utilisation spectrum is used as a framework for the consideration of different explanatory models of research utilisation. The utilisation spectrum also provides a conceptual framework for the case study investigations in Chapter 5 and is used to inform the data analysis and interpretation of the results.

### **2.2.1 Instrumental use of research evidence: Problem-solving and knowledge-driven models**

The ***problem-solving model***, also referred to as the *policy-driven model* is perhaps the most common concept of research utilisation. Here, policy issues shape research priorities, for example – a problem exists, a decision needs to be made and research evidence provides the key missing link for the policy decision (322). This explanatory model represents a rational, linear process that often begins with a policy problem presented to researchers in order to identify potential solutions, or decision makers seeking out the information needed (through journals, conferences or networks) to fill a gap in knowledge, Figure 2-2. A specific example would include research commissioned by the government to solve a policy problem whereby research evidence clarifies the situation, reduces uncertainty and directly informs the policy

decision (322). The direct application of results from a specific study is another example. In both of these examples, research information is used instrumentally.

**Figure 2-2: Problem-solving model**



The key assumptions of the problem-solving model are that researchers and policy makers agree on the end goals and evidence is actively sought, systematically gathered, applied and used in the policy process (323). While this process may occur in specific situations, it is very optimistic and would likely require firmly supported, unambiguous research findings, opportune timing with findings available at the time the decision needs to be made, and comprehensible results that are in agreement with current political interests and ideals (318). It may also happen if research is institutionalised or embedded in the decision making process, for example with technical advisory groups, providing an established process for utilisation of research information, directly linked to decision making (324). Instrumental research use in this way may occur only occasionally; however, this is often the expected model from a researcher's viewpoint with surprise, disappointment or discouragement when this logical, linear sequence does not occur (309).

Similarly, the **knowledge-driven model** is also a linear model of policy decision making that reflects instrumental use of research evidence. Also known as the *classic* or *purist model* and derived from natural sciences, the assumption here is that research leads policy. Basic research identifies a potentially policy-relevant opportunity, applied research tests the findings for practical application, and if successful, appropriate technologies are developed for implementation (325), Figure 2-3.

**Figure 2-3: Knowledge-driven model**



The key assumptions here are that empirical research logically and rationally informs decision making and that research generates the knowledge that drives policy action (326). Research evidence is again instrumental, but here it is the expert 'on-top', as opposed to the expert 'on-tap' in the problem-solving model with the assumption that research can, and should, influence policy decision making (327). This model would likely be relevant in the case of technology research, for example drug development or vaccines, and may rely on effective strategies for the transfer of research evidence into practice.

Both the problem-solving and knowledge-driven models fit with a rational view of policy decision making. Originating from management science literature and described by Simon in the late 1940s (328), rationalism assumes a logical, linear process whereby decision makers identify a problem, gather and review all of the available data and select the solution that best matches their goals (329). Criticism of this representation is that it is prescriptive on how policy decisions should be made, as opposed to descriptive of how decisions are actually made (330). Rational decision making is also criticised as being idealistic, requiring substantial intellectual capabilities, sources of information, time and finances to compare all of the potential options to make a single decision. In practice, decision makers generally have to operate as quickly and efficiently as possible and it would not be realistic to act in this way for every decision made (331). Nonetheless, it is often the assumption, particularly by researchers, that policy decisions are made in this rational way. And the *idea* of research utilisation (and evidence-based policy) perhaps fits most naturally with rational models of decision making, and instrumental use of research information, despite being perhaps more of an idealistic reality (332).

### **2.2.2 Conceptual use of research evidence: Enlightenment and interactive models**

A fundamental criticism of the theoretical basis for research utilisation is that it is weak because it rests heavily on a rational view of policy making, as depicted by the problem-solving and knowledge-driven models described in Section 2.2.1. In an attempt to provide a more descriptive (as opposed to prescriptive) account of the policy decision-making process, incremental models posit that decisions are made not through a rational process but by small adjustments to the status quo in light of political realities (331). These occur as a series of small steps, or increments, over the longer term. Originally described by Lindblom as *successive limited comparisons*, options that are not far from the status quo are compared, assessing the response and resultant attitudes and opinions from these changes (331). Broadly, this can be stated as past policy guides future policy with incremental changes.

Following an incrementalist view of policy making, Weiss first proposed the **enlightenment model** in the late 1970s (333) as an alternative framework for research utilisation in response to the limitations of the knowledge-driven and problem-solving models. The enlightenment model has been slightly modified over time with similar interpretations and slight variations including the *percolation*, *limestone*, and *infiltration* models. For research utilisation, these models extend the range of ways research is viewed to be used in decision making. They go beyond instrumental use to more conceptual use with the gradual ‘seeping’ or percolation of insights, ideas, theories, concepts and perspectives (329). Weiss describes this as ‘knowledge

creep' and 'decision accretion', whereby generalisations seep or creep into policy deliberations more subtly than "utilisation" would imply, and decisions take shape more gradually and in small steps over time as opposed to a distinct event or occurrence (309). It is argued that this concept of infiltration and enlightenment is a more probable or expected way that much of research enters the policy space (313, 333).

Examples of the types of research information that may be used in this way would include journal articles, newspapers, mass media coverage and dialogues filtering through populations. Over time, the reiteration or infiltration of findings from research may gradually cause a shift in perceptions (enlightenment). It may be difficult to cite a specific study or specifically identify the form of research evidence that influenced the position, but the general view is that research information formed the perspectives and positions (309).

The enlightenment model reflects more conceptual use of research evidence with research being one of many sources of knowledge, with the role of research evidence being less problem-solving and more debate or argument generating, highlighting issues, creating concern and setting the agenda (326). This conceptualisation aligns with an evidence-informed view of policy making, as opposed to evidence-based policy making (327). Policy change would then be expected as research evidence accumulates, but it may take many years to observe an overhaul of policies or procedures (325, 334).

Criticisms of this model are that it lacks robustness and is an oversimplification of the complicated and often indirect pathways from research evidence to decision making. As more studies are conducted and more research becomes accessible and available, it can further complicate knowledge and understanding, particularly if there are complex, varied, or contradictory findings. Sensational or highly publicised findings often generate more attention which may lead to invalid generalisations, while many valid research findings and important results may simply not percolate through (318). Importantly, this model fails to capture and reflect what is often a close dialogue between researchers and decision makers, particularly in the realm of health policy decision making (326).

To address these criticisms and to account for the important role of interpersonal relationships, the **interactive model**, also known as the *social interaction model*, followed in the 1980s. Again, this model also falls under an incrementalist view of policy making but expands upon the enlightenment model to focus on the interactions and interpersonal networks between researchers and decision makers (318) with the viewpoint that exposure to each other's worlds and needs can increase the probability of the use of research evidence to inform decision making

(329). Here again, this model represents more conceptual use of research evidence whereby decision makers seek information from a variety of sources and research information is only one component of a complicated decision making process.

This non-linear model represents a disorderly back-and-forth process of social interaction and interconnections that is in contrast with the rational, linear transitions from research to policy described in the problem-solving and knowledge-driven models in Section 2.2.1. Weiss argues that the interactive model is a formal description of a familiar process for how people obtain knowledge and opinion in a policy area (318). In illustrating this, the aim is to reflect the complexity of the policy-making process (323).

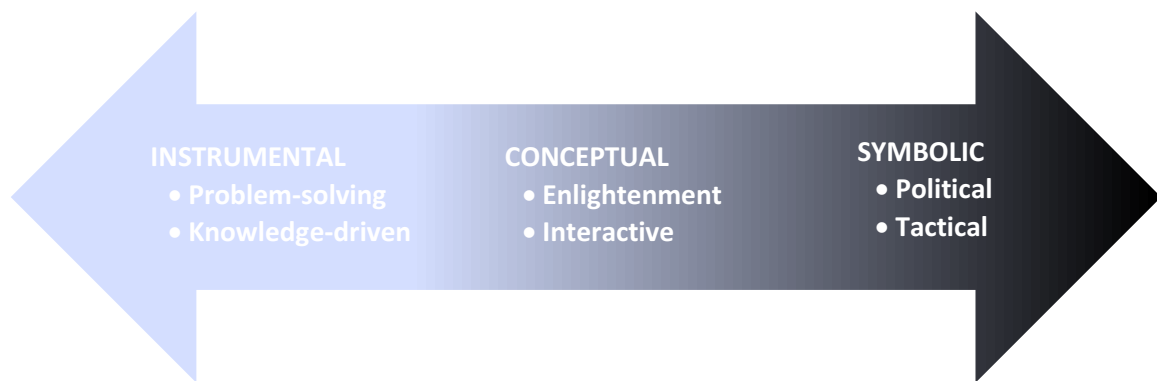
### 2.2.3 Symbolic use of research evidence: Political and tactical models

At the other end of the research utilisation spectrum is the symbolic use of research evidence to inform decision making. The **political model** describes use of research evidence to support a decision already made or a position already taken; it may be used to reduce uncertainties, to justify a position or to provide edge in a debate or difference of opinions. This could also be considered legitimative use whereby a policy decision is made and research evidence may be requested afterwards to support and justify the decision. Here, research information may be viewed more as a collection of arguments than evidence for consideration (318).

In the **tactical model**, research evidence may be used to support or justify government inaction, delay or rejection of policy issues and to deflect criticism. The focus is not on the actual content but instead that research is being conducted (322). Examples of tactical use may include government declaration of awaiting research results before making a decision (to justify inaction), or tactically demonstrating responsiveness with statements that research is being conducted to address an issue in order to rationalise inaction or delays in decision making. The political and tactical models are not mutually exclusive and are often interlinked.

Figure 2-4 illustrates where the different explanatory models fall on the research utilisation spectrum. This spectrum – representing instrumental, conceptual and symbolic use – and the different explanatory models will be used as a conceptual framework to guide the qualitative investigations in Chapter 5.

**Figure 2-4 Overview of types of research use and explanatory models of research utilisation**



The different explanatory models discussed in this chapter have largely originated from the social sciences, but they have been found to have much broader applicability (329), and lend themselves well towards application to health policy and development (334-337). This is important because research utilisation in health policy may differ from more general policy making. The emergence of the evidence-based medicine movement (discussed in 1.2.2) has resulted in an expansion in calls for the use of evidence to inform at all levels of the health system (338, 339). It is recognised at the global level that the cycle of research to action is responsible for achievements in global health, that gains in knowledge and understanding are important for future health improvements (340). This may be particularly relevant for resource-limited settings where there is a strong need for effective responses to the complex health needs and issues faced now and in the future (341). The explanatory models included in this framework are less specific than some more contemporary models of research utilisation, also developed in high-income countries, but perhaps more relevant to specific country governments or health systems, for example the United States, Canada and Western Europe (310, 342).

There was a broad range in the definitions of what constitutes research evidence used in the development of these models and theories; however none were in direct relevance to the use of mathematical models as research evidence. To the author's knowledge, a similar conceptual framework has not been applied to investigate the use of mathematical models to inform HIV planning and decision making. The utilisation spectrum, representing instrumental, conceptual and symbolic use has been applied to investigate research utilisation in clinical practice (343, 344). A conceptual-instrumental spectrum has been used to organise and frame a case study investigation on research use to inform sexual and reproductive health in sub-Saharan Africa (345). In regards to the explanatory models, de Goede et al (346) used the interactive model as a framework to investigate barriers to the use of epidemiology research to inform local health policy in The Netherlands.

By adopting this broader perspective of research utilisation framed across the entire spectrum, it casts a lens that is likely broad enough for this more novel definition of research information (i.e. mathematical modelling) and also applicable in novel settings, including low and middle-income countries. Next, we briefly consider the political context within which the case study investigations will be conducted.

## **2.3 Considering the policy environment of decision making**

The case studies on research utilisation occur within the political contexts of Zambia and Malawi. The main focus of these case studies is investigating research utilisation, as opposed to an analysis of the decision making process. However, it is still important to consider the policy environment within which research utilisation occurs. The theoretical perspectives considered in this section draw predominantly from political and health science literature and can be applied to frame each political context. This includes the representation of power and influence in the policy process. The policy process itself can be disaggregated into different stages to provide a more focused lens for investigation.

### **2.3.1 The political context and power of decision making: Pluralism, elitism, elite pluralism**

The classical political theories of *elitism* and *pluralism* reflect on how power and influence are distributed in the political process. Classical pluralism posits that power is widely distributed in society with decision making occurring mostly within the structure of government; however, many non-government groups are also able to exert influence. This is the dominant theory of the distribution of power in liberal democracies, for example in the United States and the United Kingdom, with key features including open electoral competition, absence of dominant elite groups, and the freedom to organise into political parties and express views (347).

In contrast, classical elite theory or *elitism* suggests that power is concentrated in a privileged minority group with public policy reflecting the values and interests of this group which may, or may not, be in accordance with the values of the majority (348). This theory may be particularly relevant to those settings where hierarchical and authoritarian structures of power still exist.

To date, the majority of the analyses and studies on research utilisation have done so in predominantly western, pluralistic contexts (349). The different explanatory models and theories of research utilisation discussed in Section 2.2 may be most relevant in specific political contexts. For example, the *enlightenment* and *interactive models* of research utilisation described in Section 2.2.2 are perhaps more relevant in a pluralist context where decision making may be more widespread among different actors, interests and institutions. The *political*

and *tactical* models described in Section 2.2.3, may be more likely rooted within an elitist context where the power of decision making is more centrally localised.

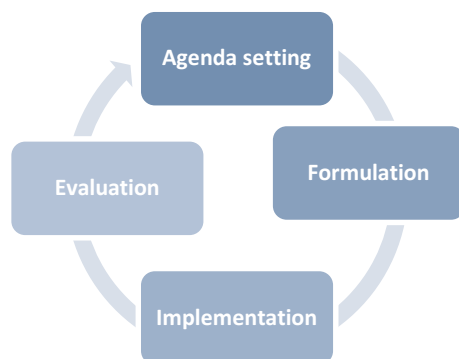
It has been argued that with globalisation and the emergence of various international and global actors there is the potential for a type of elite pluralism whereby decisions are dominated by policy elites from a narrow range of organisations (330). This consideration of elite pluralism may be particularly relevant for HIV-related decision making in sub-Saharan Africa given the heavy reliance on donor funding.

The concepts of pluralism, elitism and elite pluralism will be used to conceptualise the broad context of the public policy environment, within which the policy process is considered.

### 2.3.2 The policy process: Stages heuristic and the policy cycle

Within the broad context of the policy environments described above, the policy process can be divided into four distinct stages, originally defined as the *stages heuristic* (350, 351). These stages include: problem identification and need recognition (i.e. agenda setting), policy formulation, policy implementation and policy evaluation. The stages can be viewed as part of an ongoing cycle, sometimes referred to as the policy cycle, Figure 2-5.

Figure 2-5: The Policy Cycle



While the stages heuristic is one of the best known public policy frameworks (with numerous adaptations), the main criticism is that the distinct stages over-simplify the entire process which generally does not occur in this linear or cyclical fashion. However, conceptually, it is still useful to disaggregate the policy process into the segments of the stages heuristic or the policy cycle, and then consider the extensive body of theoretical work relevant to these specific stages in order to organise and focus the scope of investigation (352). Research utilisation can occur at any stage of the policy cycle. The aim of this thesis is to investigate the use of mathematical models to inform HIV programme planning and policy decision making and thus the focus will be on the agenda setting and policy formulation stages.

## **2.4 Potential limitations of the theoretical framework**

Limitations of the different explanatory models have been discussed in turn in Section 2.2. More broadly speaking, the theoretical frameworks developed in the 1970s and 1980s neglect to account for the increasingly prominent role of globalisation and the international and global actors and agencies heavily involved in what is now an increasingly linked global world – linked in terms of movement of people, products, goods, ideas, finances, infection and disease at a greater scale and intensity than ever before (330). Policy decision making for HIV is particularly affected by globalisation and global actors (see Chapter 1 on this topic, Section 1.2) which may not be appropriately reflected in many of these early models and theories.

In addition, the majority of the concepts reviewed have been developed from studies in high income countries (HIC), often in western, pluralistic settings. In low and middle-income countries (LMIC) the policy environments may differ for many reasons, but in particular due to greater reliance on external and donor funding (303). Decision making in resource-constrained countries often occurs in response to opportunities or funds provided by external donors or global initiatives (353). Policy decision making for HIV prevention and programme planning may also differ compared to other disease groups or types of decisions, as a result of what is often a complicated network of donor support and funding for HIV.

Context is important and there may be variation across settings, even within the same region, including differences in political systems, culture and stakeholders which can make generalisations difficult. However, the point of this research is to carefully consider these factors and learn as much as possible in each context, identifying elements among the comparisons that may be applicable to other settings, while recognising the limitations.

## **2.5 Application of the theoretical framework to examine research utilisation in a multi-case study investigation**

The overall focus of this thesis is on mathematical modelling and its use to inform HIV programme planning and decision making. The next two chapters, Chapters 3 and 4, investigate different mathematical models commonly used, and with high-level support for their use, for this purpose. In Chapter 5, in-country case studies are conducted in Malawi and Zambia to investigate research utilisation. The theoretical framework outlined herein is used to organise and guide this inquiry, and provides a general structure and perspective from which to conduct the analysis.

The investigation of research utilisation in Chapter 5 is a retrospective analysis which focuses explicitly on the agenda setting and policy formulation stages of the policy process. Research

utilisation is defined as the use of mathematical models and results from models to inform HIV programme planning and decision making. The research utilisation spectrum represents the broad theoretical perspective. Three types of utilisation are described across this spectrum – instrumental, conceptual and symbolic. Each type is associated with different explanatory models which explain how research information is used to inform decision making. Evidence for all of these explanatory models will be investigated, including evidence that supports alternative or contrasting hypotheses. This theoretical framework, while perhaps “theory-laden”, is not “theory-determined” (354). The framework and the explanatory models are not prescriptive and new hypotheses can be identified or develop throughout the research processes. The aim is to enter with a broad theoretical perspective but to follow the data and remain open to new findings and interpretations.

An initial naïve hypothesis was formulated at the beginning of this research investigation. The environment of limited resources in combination with a continued need for programme and treatment scale-up necessitates the development of strategic and efficient HIV programmes. This may result in pressure from donors, international and intergovernmental organisations, for the use of evidence-informed decision making. It was hypothesised that these factors in combination with a substantial increase in mathematical modelling applications and modelling processes supported by intergovernmental organisations (including UNAIDS and the World Bank) would result in the direct and instrumental use of mathematical models to inform HIV programme planning and decision making. As such, applying the problem-solving or knowledge-driven models, it would be expected that mathematical models and results from modelling analyses would rationally inform decision making. Either by being the “missing link” to inform policy decisions (problem-solving) or by generating the information that motivates policy action (knowledge-driven).

The review herein revealed that conceptual use of modelling information is likely a more realistic expectation in light of political realities, the many factors involved in decision making and the way in which knowledge and information is often acquired, characterised by a gradual seeping or percolation of insights and perspectives, ‘knowledge creep’ as described by Weiss. Thus it was alternatively hypothesised that with the influx of different mathematical models and modelling processes in recent years, these types of analyses would now have gained traction with decision makers. As a result, their use would be expected as an additional piece of evidence to inform decision making resulting in incremental changes to the status quo for resource allocation, programme planning and policy decisions for HIV, aligning with the enlightenment or percolation models. Additionally, the relationships between researchers and decision makers

and the various processes of interaction and interrelation, will result in exposure to each other's worlds which may also increase the probability of the use of modelling to inform decision making. Here again, more conceptual use as an additional piece of information or use to increase knowledge and understanding (interactive model).

In order to increase the credibility of the findings, evidence for alternative explanations or examples that contradict emerging findings also need to be investigated, remaining open to the entire range of possibilities that may emerge from the data (355). Symbolic use will be investigated as a contrasting hypothesis, investigating evidence for the political and tactical models. The public policy environments of the two case-study countries under focus are more recent democracies but due to the power structures among the actor networks, and a strong reliance on donor funding, the HIV decision making environment may reflect elitism or perhaps elite pluralism. It is plausible that relatively new democracies, perhaps characterised by elitism or elite pluralism with power more centrally concentrated and heavily reliant on donor funding, could result in examples of political or tactical use of mathematical models.

This theoretical framework will be revisited in Chapter 5. In the next Chapter, I move on to the direct application of a mathematical model with the aim to better inform national HIV programme planning and policy decision making.



## Chapter 3

**Modelling the future of HIV:** Examples of using a widely available tool to predict long-term trends in the AIDS pandemic

## Summary

From early in the HIV epidemic, mathematical models have been used to understand patterns of infection and the potential for spread. Models that include transmission dynamics can be used to generate long-term projections. The Goals model is a transmission model commonly used to inform programme planning and resource allocation for national HIV prevention strategies. In this chapter, the Goals model was first used to investigate the potential long-term epidemiological implications of different policy decisions for HIV prevention and treatment in the countries most affected by HIV. Models were fit to 22 countries in order to generate projections for incidence, prevalence, AIDS deaths and the number of people on treatment given two potential future scenarios. The scope was then narrowed to two countries – South Africa and China – and the impact of interventions was explored in greater detail in these contexts. Sensitivity analyses were conducted to provide a qualitative assessment of the potential variability in the results with different parameter assumptions. The results illustrate that ambitious investment in intervention scale-up has the potential to substantially alter the future course of the epidemic. However, the importance of individual interventions will depend on the epidemiological context and thus the design of optimal strategies requires careful consideration of the local epidemiological profile, the current gaps in the strategies employed and the areas of need. Mathematical modelling can be a valuable tool to help inform and provide insight into these important programme and policy decisions.

## Contributions and dissemination

This work has benefitted from a detailed understanding of the Goals model facilitated by John Stover at Avenir Health. The author additionally received numerous requests from aids2031 collaborators, colleagues, other mathematical modellers, co-authors, peer reviewers and from supervisors to model different scenarios and intervention scale-up, a process through which provided valuable insights and understanding.

Portions of this work were presented at the International AIDS Conference in Vienna Austria, 18-23 July 2010. *The Future of HIV: The impact of prevention and treatment on HIV infections and AIDS deaths through 2031.*

This work provided the underlying epidemiological projections which informed the following publication:

Hecht R, Bollinger L, Stover J, McGreevey W, Muhib F, Madavo CA, & de Ferranti D. *Critical choices in financing the response to the global HIV/AIDS pandemic*. Health Affairs. 2009; **28**(6), 1591-1605.

Related publication from this work: Hecht R, Stover J, Bollinger L, Muhib F, Case K, & de Ferranti D. *Financing of HIV/AIDS programme scale-up in low-income and middle-income countries, 2009-31*. Lancet. 2010; **376**(9748), 1254-1260.

### 3.1 Introduction

From early in the HIV epidemic, mathematical models have been used to better understand patterns of infection and the potential for the virus to spread. In 1986, Anderson et al (118) introduced a model that has provided the foundation for many subsequent models, including the Goals model. Many models have been developed to represent spread of HIV in specific populations and to address specific questions about the virus. Over time there has been an increase in the complexity of models and in the statistical rigour with which some have been fitted. However, such academic exercises have not necessarily translated into the modelling tools used by policy makers where simplicity and ease of use is an advantage. This is important because mathematical modelling can be a valuable tool to inform planning of public health interventions.

This chapter provides an example of the use of modelling and scenarios to explore the potential longer-term impact of policy choices including failure to implement change. The scenarios were implemented using the Goals model (249). Goals is an HIV transmission model frequently used at the national level to create epidemiological projections in order to explore the potential impact of interventions, and identify resource needs and investments, to support strategic planning and policy (185, 237, 240, 241, 250-252). This model is also used to inform high-level processes including the development of the PEPFAR Blueprint (253) presented by Secretary of State (at that time) Hillary Clinton, the development of the UNAIDS Investment Framework (242), and to inform the recent Global Fund Needs Assessment for the Fourth Replenishment (254). The key model features – quantifying the impact of interventions, generating longer-term projections, and simple linkage to a unit cost model to estimate resource needs – along with technical support provided by a modeller, have resulted in this widespread and often high-level use.

Because of this frequent application and the potential importance for country, regional and global processes, it is important to have a comprehensive understanding of the Goals model. Therefore, the specific objectives of this chapter are two-fold: First, to use the Goals model to investigate the potential long-term epidemiological implications of different policy decisions for HIV prevention in the countries most affected by HIV. And second, to narrow the focus to the country level in order to investigate in greater detail the impact of prevention interventions using this model.

To fully explore and critique a model of this complexity would be a major undertaking that goes beyond the aims of this thesis. Thus, the results here can be seen as an example rather than a definitive exploration of future trends. The analyses described in this chapter initially began in

2008 to contribute to the aids2031 exercise (298) and are extended and reported here to illustrate the nature of the model and the projections under the assumptions available at the time. The potential impact of the interventions is still relevant despite changes in some baseline values. It is important to note that the projections within do not reflect the impact of the expanded treatment guidelines that have occurred since this time.

## **3.2 Methods**

The Goals model version 3.33 (249), was used to calibrate country-level epidemiological projections. The model simulates the adult population, age 15-49, divided into males and females, without further disaggregation by age. To capture heterogeneity in risk behaviours, the sexually active population is divided across five groups corresponding to the level of sexual activity: low-risk heterosexuals (those with an average of one partner per year); medium-risk heterosexuals (multiple partners in the past year); high-risk heterosexuals (female sex workers and their clients); men who have sex with men (MSM); and injecting drug users (IDU). The probability of infection is influenced by many factors including the number of partners per year, the number of sex acts per partner, condom use, HIV prevalence, STI prevalence, type of contact (heterosexual or MSM), ART use, stage of HIV infection, circumcision status and for transmission among IDU, needle sharing behaviour. The model allows individuals to transition from a higher-risk group to a lower risk group.

The Goals model was used for both objectives and the following describes the methods used for each objective in turn.

### **3.2.1 Methods for investigation of long-term epidemiological implications of programme and policy decisions for HIV prevention and treatment in 22 high-burden countries**

To explore the long-term future of HIV in different contexts, individual models were fit in turn to each of the 22 countries where over 75% of all new infections were expected to occur while allowing for geographical representation, Figure 3-1. Projections were generated for incidence, prevalence, AIDS deaths and the number of people on treatment given two plausible future scenarios. Baseline projections were fit to prevalence data from 1990-2007 (356) for each country. The country-specific data and behavioural inputs – the proportion of the population sexually active and in each risk group, the number of partners per year, the number of sex acts per partner, STI prevalence, condom use, marriage rates and age at first sex – were obtained via triangulation of data sources including behavioural surveillance surveys, Demographic Health Surveys, national surveys, UN Population Division data, UNGASS data, UNAIDS data, published reviews and published studies from each country. Table 3-1 details the assumptions for the



Two scenarios were explored, projecting to 2031:

- *Status quo*: Continuation of efforts for both prevention and treatment with no increase from coverage levels achieved in 2007 through 2031.
- *Expanded response*: Rapid and extensive scale-up of treatment and prevention interventions achieved by 2015 and maintained through 2031. This scenario assumes strong political will and optimal resources available for HIV/AIDS interventions. For generalised epidemics this scenario targets interventions towards the general population in addition to populations at higher risk and includes male circumcision, while for concentrated epidemics this scenario aims to achieve high coverage of interventions for key populations at greater risk.

A description of each intervention and the levels of coverage achieved in the expanded response scenario by type of epidemic (hyper-endemic and generalised epidemics or concentrated and low-level epidemics) is detailed in Table 3-2.

**Table 3-1 Behavioural parameter value ranges for all countries, 2007**

| Risk group/sexual activity class        | Generalised/hyper-endemic |           |           |          |         |       | Concentrated/low level |           |          |          |         |          |
|-----------------------------------------|---------------------------|-----------|-----------|----------|---------|-------|------------------------|-----------|----------|----------|---------|----------|
|                                         | NSA†                      | Low       | Med       | High     | MSM     | IDU   | NSA†                   | Low       | Med      | High     | MSM     | IDU      |
| <b>MALES</b>                            |                           |           |           |          |         |       |                        |           |          |          |         |          |
| Proportion of 15-49 year population*(%) | 12.0-36.0                 | 9.5-57.4  | 13.5-40.5 | 4.5-15.0 | 0-3     | 0-1.6 | 6.7-35.0               | 45.5-67.9 | 3.0-20.3 | 4.0-12.0 | 0.5-5.2 | 0.13-6.8 |
| Age at first sex (years)                | 16.2-20.8                 |           |           |          |         |       | 16-23.7                |           |          |          |         |          |
| Number of sexual partners per year      |                           | 1-1.4     | 2-4       | 4-12     | 2-14    |       |                        | 1         | 2-3      | 3-10     | 5-15    |          |
| Sex acts per partner                    |                           | 50-80     | 10-40     | 4-15     | 3-31    |       |                        | 50-84     | 17-35    | 3-16     | 5-15    |          |
| Sex acts in which condoms are used (%)  |                           | 0.2-7.6   | 10-60     | 20-80    | 33.5-65 |       |                        | 0.9-13.5  | 23-55    | 41-95    | 30-86   |          |
| STI prevalence (%)                      |                           | 1-5       | 5-12      | 6.5-15   | 4.5-12  |       |                        | 0.5-3     | 2.3-6.5  | 4.3-20   | 3.3-15  |          |
| <b>FEMALES</b>                          |                           |           |           |          |         |       |                        |           |          |          |         |          |
| Proportion of 15-49 year population*(%) | 11.0-39.0                 | 55.1-79.9 | 1.0-15.0  | 1-6.1    |         | 0-0.1 | 15.3-38.5              | 51.2-79.3 | 2.0-11.0 | 0.2-4.8  |         | 0-1.4    |
| Age at first sex (years)                | 15.9-19                   |           |           |          |         |       | 17-21.1                |           |          |          |         |          |
| Number of sexual partners per year      |                           | 1         | 2-3       | 35-240   |         |       |                        | 1         | 2-3      | 50-320   |         |          |
| Sex acts per partner                    |                           | 50-80     | 25-40     | 1-4      |         |       |                        | 50-84     | 17-35    | 2-4      |         |          |
| Sex acts in which condoms are used (%)  |                           | 0.2-7.6   | 10-60     | 20-80    |         |       |                        | 0.9-13.5  | 23-55    | 41-95    |         |          |
| STI prevalence (%)                      |                           | 3-13      | 6.5-20    | 10-28    |         |       |                        | 0.5-3     | 3.5-13   | 6.7-26   |         |          |

†not sexually active

\*Proportion of the population that falls into each risk group applies at the beginning of the epidemic and changes over time

**Table 3-2 Coverage levels achieved in the expanded response scenario by epidemic type**

|                                                                                                                                         | Coverage in 2015        |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------------|
|                                                                                                                                         | Expanded Scenario (G/H) | Expanded Scenario (C/LL) |
| <b>Community mobilisation</b><br><i>Percentage of adults reached by community mobilisation</i>                                          | 70%                     | n/a                      |
| <b>Mass media</b><br><i>Percentage reached with HIV/AIDS communication programmes</i>                                                   | 80%                     | n/a                      |
| <b>Counselling &amp; testing</b><br><i>Of those engaging in risky behaviour, percentage testing and receiving results in past year</i>  | 80%                     | n/a                      |
| <b>Condom promotion</b><br><i>Social marketing and distribution of condoms</i>                                                          | 60%                     | 50%                      |
| <b>Youth education in-school</b><br><i>Percentage of school youth reached per year</i>                                                  | 100%                    | n/a                      |
| <b>Youth education outreach out-of-school</b><br><i>Percentage aged 12-17 years reached per year</i>                                    | 50%                     | n/a                      |
| <b>Workplace education programmes</b><br><i>Percentage of formal sector workforces with access to workplace HIV prevention services</i> | 50%                     | n/a                      |
| <b>Outreach &amp; harm reduction for sex workers</b><br><i>Percentage reached by HIV interventions per year</i>                         | 60%                     | 80%                      |
| <b>Outreach &amp; harm reduction for MSM</b><br><i>Percentage reached by HIV interventions per year</i>                                 | 60%                     | 80%                      |
| <b>Outreach &amp; harm reduction for IDU</b><br><i>Percentage reached by HIV interventions per year</i>                                 | 60%                     | 80%                      |
| <b>Needle exchange programmes for IDU</b><br><i>Percentage of IDU participating</i>                                                     | 40%                     | 80%                      |
| <b>Drug substitution programmes for IDU</b><br><i>Percentage of IDU participating</i>                                                   | 20%                     | 40%                      |
| <b>Male circumcision</b><br><i>Prevalence of male circumcision</i>                                                                      | 60%                     | n/a                      |
| <b>ART</b><br><i>Of all those eligible, the proportion receiving treatment</i>                                                          | 80%                     | 80%                      |

G/H: generalised/hyper-endemic; C/LL: Concentrated/low-level

Coverage defined as the proportion of the population in-need who use the service (357)

Table adapted from (357, 358)

### **3.2.2 Methods for analyses of the impact of HIV interventions using the Goals model in two key contexts – South Africa and China**

To explore in greater detail than possible across 22 countries, further analyses focused on two important countries. The contexts of South Africa, a hyper-endemic situation with a high population prevalence and China, a concentrated epidemic where HIV predominantly affects key populations at higher risk, were used as a basis to explore the effects of prevention interventions as applied in the Goals model in greater detail. Specifically, the aims were to analyse the impact of prevention interventions and treatment (with scale-up of interventions occurring in combination and in isolation), to conduct sensitivity analyses for these interventions, and to independently explore the effects of varying the assumptions for male circumcision and for antiretroviral treatment.

Context-specific scenarios were developed for each country (Appendix 3-2) which broadly follow those developed in Table 3-2, but here the expanded response scenario was specifically tailored to the epidemiological context of each country. Interventions were first scaled-up in combination, with coverage increasing linearly from the levels achieved in 2007 to reach the target coverage defined in the expanded response scenario (Appendix 3-2) by 2015 and maintained through 2031. Next, all prevention interventions (excluding antiretroviral treatment) were scaled-up in combination to examine the effect from prevention alone, followed by the effect of treatment alone. All other interventions were then scaled-up in isolation to identify the interventions resulting in the single greatest impact in each country and the assumed behaviour change resulting from increased coverage of the behavioural prevention interventions. For comparison, the *status quo* scenario represented a continuation of “business as usual” with no further scale-up of interventions from the coverage levels achieved in 2007, and thus no change in behaviour.

For both countries, sensitivity analyses were conducted on the individual prevention interventions resulting in the greatest impact, and for all interventions in combination, using the upper and lower quartile (representing 25% and 75% of the maximum impact) of the effectiveness coefficients in the impact matrix detailed in Appendix 3-3 (255). For male circumcision in South Africa, the scale-up in the expanded response scenario from 35% coverage in 2007 (359) to 60% coverage by 2015 (and then maintained) was varied between 45% and 90% to observe the effect of coverage of male circumcision on new infections and AIDS deaths.

Antiretroviral treatment eligibility was defined as the last three years before death in the absence of treatment based on a mean rate of progression of 11 years which approximately

corresponds to a CD4 count of 200 cells/ $\mu$ l (360). Treatment retention was optimistic assuming 95% retention each year (361). The default value for the relative infectiousness (relative to the asymptomatic stage) when on treatment was an 80% reduction in infectiousness and this assumption was varied – 50% and 99% reductions – in the expanded response scenario to explore the sensitivity of this parameter.

### **3.3 Results**

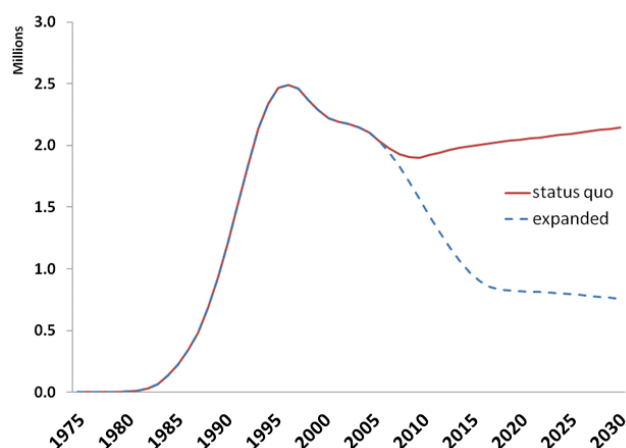
The results are presented in turn. First, at the macro-level with projections for the 22 countries combined to provide insight into the potential long-term future burden of the HIV epidemic, and the plausible effect on this trajectory with intervention scale-up. The focus is then narrowed and results are presented from further investigations for South Africa and China.

#### **3.3.1 Results from investigation of the long-term epidemiological implications of programme and policy decisions for HIV prevention and treatment in 22 high-burden countries**

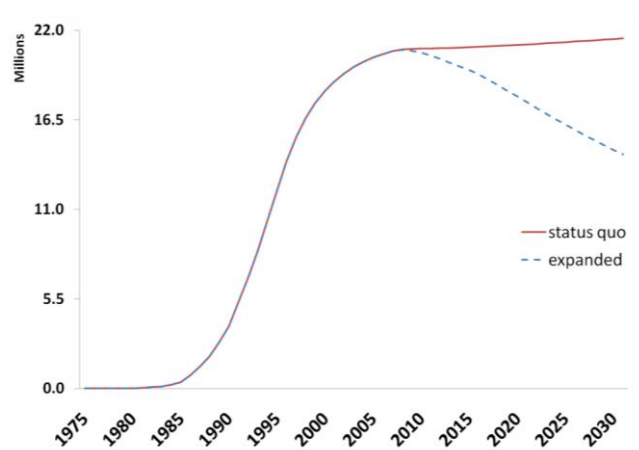
The long-term projections illustrate both the potential future scale of the pandemic in terms of new HIV infections per year and the prospective benefits of an expanded response with scale-up of interventions to 2015 and maintained through 2031. For all 22 countries combined, the rapid scale-up of prevention interventions and treatment (the expanded response scenario) has the potential to result in a rapid decline in both new infections and AIDS deaths and an overall reduction in prevalence, Figure 3-2. If the coverage of interventions from 2007 are merely maintained without increase (the status quo scenario), then new HIV infections will be a reflection of the existing prevalence of infection within countries, population size and its expected increase over time, and the trajectory of infection at that time, which results in a gradual increase in new infections primarily due to population growth (Figure 3-2A). Treatment coverage will need to continue to expand or those newly in need of treatment will rapidly progress to death in the absence of treatment, leading to a sharp increase in predicted mortality (Figure 3-2C).

**Figure 3-2 Combined results for incidence, prevalence and AIDS deaths in adults 15-49 years**

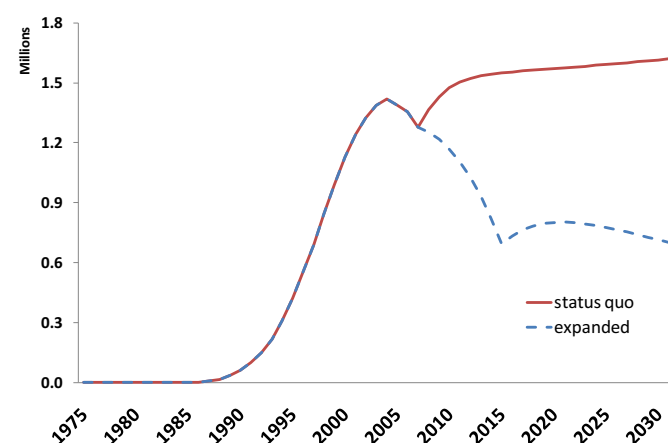
**A Annual new HIV infections**



**B Number currently infected**



**C Annual AIDS deaths**



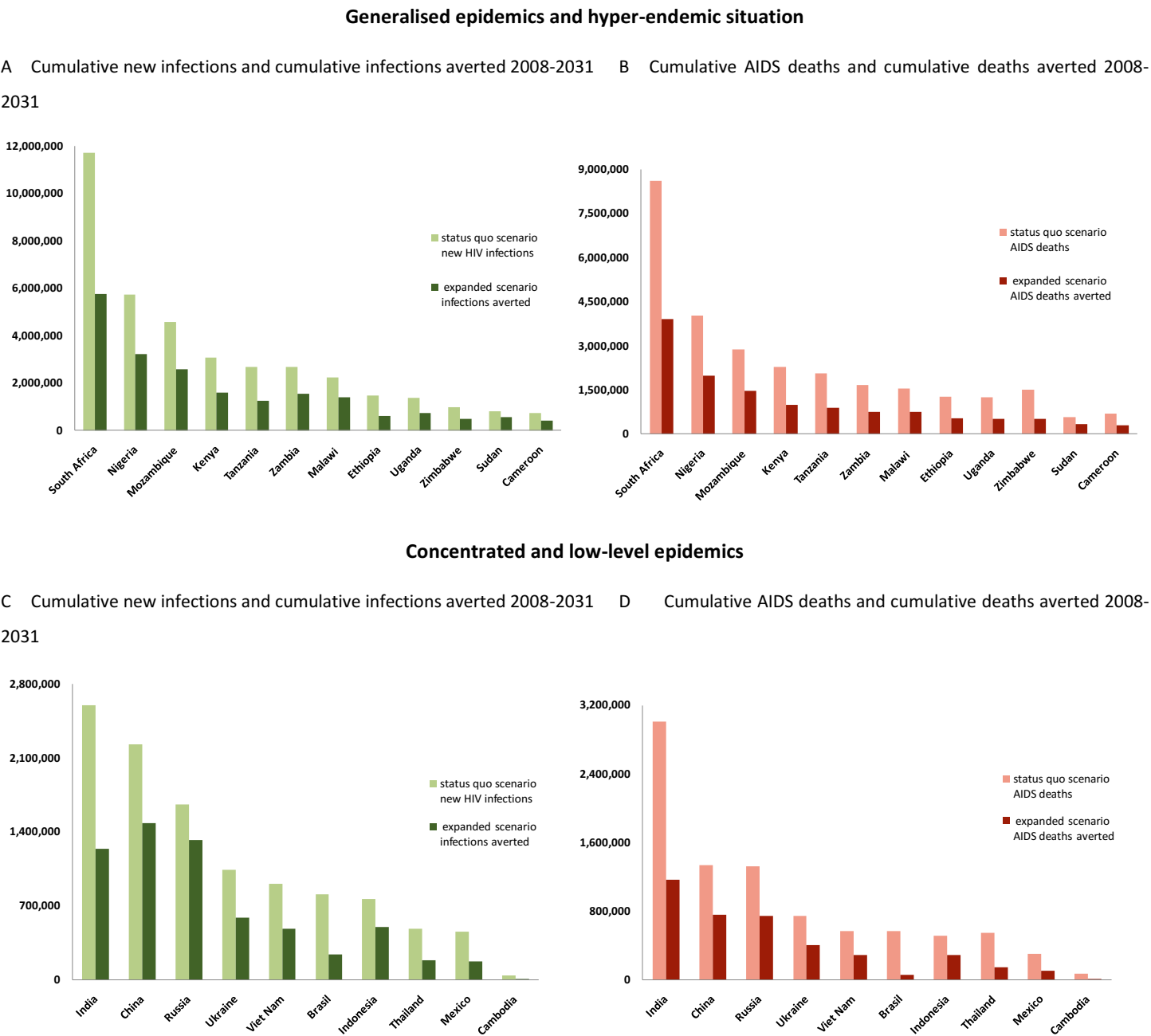
New infections are expected to increase with population growth if prevention and treatment levels are merely maintained, but can be greatly reduced to just over 700,000 per year with scale-up of existing interventions (A). There is the potential for a 33% reduction in the number of adults infected in 2031 (B). If the rate of scale-up of treatment is halted and coverage levels of treatment are merely maintained, an increase in AIDS deaths will occur as those already on treatment will be maintained while those newly in need of treatment will go on to die (C). This figure represents the combined results from 22 countries where >70% of new infections are expected to occur. New HIV infections have been smoothed using a 5-yr moving average.

From 2008-2031, there are nearly 50 million new infections and over 37 million AIDS deaths predicted in the status quo scenario and over 21 million people living with HIV. A rapid expansion of a strategic combination of available interventions has the potential to avert 26 million of these new infections and 17 million AIDS deaths, Figure 3-3. In generalised epidemics, South Africa, Nigeria and Mozambique are predicted to suffer the greatest number of new infections as a result of their large population sizes (Figure 3-3A). South Africa is projected to be particularly affected with by far the greatest burden of new infections and AIDS deaths under both scenarios. While prevalence remains comparatively low in Nigeria (3.1% in adults aged 15-49 in 2007) the scale in sheer numbers has important future implications for the resources required for both prevention and treatment.

In concentrated epidemics, it is again the countries with the largest populations, India and China, which will likely experience the greatest number of cases from 2008-2031. There is great scope for prevention, particularly in the more recent epidemics in Russia, China and Ukraine where the rapid scale-up of key interventions could potentially prevent the vast majority of new infections (Figure 3-3C). More established epidemics in Brazil and Thailand illustrate more marginal benefit as a result of having already achieved fairly high coverage of treatment and key prevention interventions.

Table 3-3 details the predicted number of infections and AIDS deaths in the year 2031 along with the associated prevalence of infection, the number infected and the number of people on treatment for each scenario. The expansion of interventions can dramatically change the future outlook of AIDS resulting in a substantial reduction in AIDS deaths and new HIV infections in 2031 which has important implications for the even longer-term future. The number on treatment will continue to expand (compared to the status quo) for all countries except Brazil, where the high treatment coverage already obtained, combined with expanded prevention, results in a decline in the projected number on treatment (Table 3-3).

**Figure 3-3 Cumulative new infections and cumulative infections averted and cumulative AIDS deaths and cumulative AIDS deaths averted in adults 15-49 years from 2008-2031 under two future scenarios**



Cumulative new infections in the status quo scenario and cumulative infections averted in the expanded scenario 2008-2031 (A & C) and cumulative AIDS deaths in the status quo scenario and AIDS deaths averted in the expanded scenario 2008-2031 (B & D) in generalised epidemics and a hyper-endemic situation (A & B) and in concentrated and low-level epidemics (C & D). The countries illustrated represent the countries expected to have the greatest future burden of new infections while allowing for geographical representation. The expanded scenario incorporates a rapid scale-up of treatment and prevention interventions and includes male circumcision for generalised epidemics and rapid scale-up of prevention interventions targeting populations most-at-risk in concentrated and low-level epidemics.

Table 3-3 Projection results in 2031 for adults 15-49 years under two future scenarios†

|                     | Status Quo Scenario – 2031 |                    |             |                    |                             | Expanded Scenario - 2031 |                    |             |                    |                             |
|---------------------|----------------------------|--------------------|-------------|--------------------|-----------------------------|--------------------------|--------------------|-------------|--------------------|-----------------------------|
|                     | Prevalence                 | New HIV Infections | AIDS deaths | Currently Infected | On treatment (ART coverage) | Prevalence               | New HIV Infections | AIDS deaths | Currently Infected | On Treatment (80% coverage) |
| <b>South Africa</b> | 18%                        | 516,000            | 382,000     | 5,429,000          | 437,790 (28%)               | 12%                      | 202,000            | 171,000     | 3,897,000          | 1,686,000                   |
| <b>Nigeria</b>      | 2%                         | 258,000            | 194,000     | 2,900,000          | 202,000 (26%)               | 1%                       | 75,000             | 76,000      | 1,774,000          | 746,000                     |
| <b>Mozambique</b>   | 13%                        | 236,000            | 154,000     | 2,242,000          | 147,000 (24%)               | 7%                       | 71,000             | 57,000      | 1,327,000          | 570,000                     |
| <b>Zambia</b>       | 13%                        | 141,000            | 87,000      | 1,402,000          | 218,000 (46%)               | 7%                       | 40,000             | 35,000      | 777,000            | 348,000                     |
| <b>Kenya*</b>       | 5%                         | 141,000            | 103,000     | 1,630,000          | 196,000 (40%)               | 3%                       | 50,000             | 47,000      | 1,077,000          | 459,000                     |
| <b>Tanzania</b>     | 4%                         | 118,000            | 92,000      | 1,347,000          | 122,000 (31%)               | 3%                       | 48,000             | 45,000      | 1,023,000          | 441,000                     |
| <b>Malawi</b>       | 8%                         | 114,000            | 78,000      | 1,163,000          | 124,000 (35%)               | 4%                       | 27,000             | 29,000      | 621,000            | 284,000                     |
| <b>Uganda*</b>      | 2%                         | 57,000             | 49,000      | 689,000            | 70,000 (33%)                | 1%                       | 20,000             | 24,000      | 507,000            | 232,000                     |
| <b>Ethiopia</b>     | 1%                         | 55,000             | 50,000      | 710,000            | 60,000 (29%)                | 0.8%                     | 26,000             | 27,000      | 621,000            | 264,000                     |
| <b>Zimbabwe*</b>    | 4%                         | 29,000             | 35,000      | 422,000            | 23,000 (19%)                | 4%                       | 11,000             | 23,000      | 426,000            | 215,000                     |
| <b>Sudan</b>        | 1%                         | 37,000             | 28,000      | 374,000            | 900 (1%)                    | 0.5%                     | 6,000              | 8,000       | 172,000            | 77,000                      |
| <b>Cameroon</b>     | 2%                         | 26,000             | 25,000      | 342,000            | 24,000 (25%)                | 1%                       | 8,000              | 12,000      | 250,000            | 115,000                     |
|                     |                            |                    |             |                    |                             |                          |                    |             |                    |                             |
| <b>India</b>        | 0.13%                      | 85,000             | 88,000      | 1,086,000          | 62,000 (20%)                | 0.12%                    | 35,000             | 50,000      | 970,000            | 478,000                     |
| <b>China</b>        | 0.2%                       | 107,000            | 68,000      | 1,006,000          | 48,000 (19%)                | 0.1%                     | 23,000             | 19,000      | 433,000            | 185,000                     |
| <b>Russia</b>       | 1.2%                       | 65,000             | 49,000      | 649,000            | 28,000 (16%)                | 0.5%                     | 14,000             | 12,000      | 251,000            | 116,000                     |
| <b>Viet Nam</b>     | 0.7%                       | 45,000             | 29,000      | 423,000            | 31,000 (26%)                | 0.5%                     | 16,000             | 11,000      | 265,000            | 111,000                     |
| <b>Ukraine</b>      | 2.4%                       | 37,000             | 31,000      | 391,000            | 8,000 (8%)                  | 1.6%                     | 16,000             | 11,000      | 262,000            | 108,000                     |
| <b>Indonesia</b>    | 0.2%                       | 35,000             | 24,000      | 341,000            | 13,000 (15%)                | 0.1%                     | 10,000             | 7,000       | 177,000            | 73,000                      |
| <b>Brazil</b>       | 0.4%                       | 30,000             | 23,000      | 539,000            | 222,000 (80%)               | 0.3%                     | 20,000             | 18,000      | 400,000            | 172,000                     |
| <b>Mexico</b>       | 0.3%                       | 20,000             | 14,000      | 235,000            | 51,000 (57%)                | 0.2%                     | 10,000             | 8,000       | 179,000            | 76,000                      |
| <b>Thailand*</b>    | 0.7%                       | 15,000             | 15,000      | 241,000            | 64,000 (61%)                | 0.6%                     | 8,000              | 10,000      | 205,000            | 99,000                      |
| <b>Cambodia</b>     | 0.2%                       | 1,200              | 1,700       | 27,000             | 9,000 (67%)                 | 0.2%                     | 900                | 1,500       | 29,000             | 14,000                      |

†Figures have been rounded

\*These declining epidemics continue along their declining trajectories to 2031 which may result in unrealistically low projections

### **3.3.2 Results from analyses of the impact of interventions – South Africa and China**

Projections at the country level allow for a more focussed investigation of the interventions driving the reductions in prevalence, incidence and AIDS deaths. This refined scope also allows for the examination of the assumed effects on behaviour change with the scale-up of behavioural interventions and the exploration of sensitivity analyses for key interventions. The results are presented for each context, first for the impact of interventions when only the prevention interventions are scaled-up (i.e. excluding treatment), compared to the scale-up of treatment only and all interventions (treatment and prevention) scaled-up simultaneously. Results are then presented when each intervention is scaled-up in isolation.

#### *South Africa*

In South Africa, when only the prevention interventions were scaled-up, an estimated 4.2 million infections were averted through 2031; however, the impact on reduction in AIDS deaths takes nearly a decade to observe. Conversely, increasing treatment coverage alone results in 2.7 million infections averted over the same time period and has an immediate and substantial impact on AIDS deaths. A combination of both treatment and prevention interventions has the greatest effect, with over 5.5 million infections averted and nearly 4 million deaths averted by 2031 and a 61% decrease in new infections occurring in 2031 compared to the status quo (Figure 3-4, A and B).

When interventions are applied in isolation, ART has the greatest impact on projected new HIV infections as a result of reduced infectiousness when on treatment, followed by male circumcision where the impact is a result of the reduced probability of infection when circumcised (Figure 3-4C). The impact observed from VCT (Figure 3-4C) in this model is driven by behaviour change as knowledge of one's HIV status is assumed to result in an increase in condom use. In the low, medium and high activity groups this results in an increase in the proportion of sex acts where condoms are used from 4.7% to 13.2%, 25% to 34.7% and 50% to 62%, respectively, by 2015. The remaining interventions are clustered together and illustrate less impact when applied in isolation with the interventions for MSM and sex workers having the most impact on new infections (Figure 3-4C). The impact observed from increasing the coverage of outreach and harm reduction programmes for sex workers and their clients from 20% coverage of those in need in 2007 to 60% coverage in 2015 is due to a slight increase in condom use in the high risk group (increasing from condom use in 50% of sex acts in 2007 to 58.5% of sex acts in 2015) and a decrease in the mean rate of partner acquisition per year. For sex workers, there is a decrease from 240 partners per year in 2007 to 229 partners per year by

2015 and for male clients the reduction is from an average of 8 partners per year in 2007 declining to 7.6 partners per year in 2015. For MSM, increasing coverage of outreach and harm reduction programmes from 10% reached in 2007 to 60% reached by 2015, results in increased condom use (use in 40% of sex acts in 2007 to 50.9% by 2015), and a very slight decline in the rate of partner acquisition (from 2 partners per year in 2007 to 1.89 partners per year by 2015). Additionally, increasing coverage of outreach and harm reduction programmes for MSM also results in behaviour change across the high risk group (sex workers and clients), with an increase in condom use from use in 50% of sex acts in 2007 to use in 59.1% of sex acts by 2015 and a slight reduction in the mean rate of partner acquisition in the high risk group, with males decreasing from 8 partners per year to 7.6 partners per year and females (sex workers) decreasing from 240 partners per year to 227.9 partners per year by 2015. It is these interlinked behaviour changes that are largely responsible for the impact of MSM interventions, rather than the direct effect on the relevant population. This is an important finding with substantial implications, and warrants reconsideration and correction within the impact matrix structure for future applications and use.

### *China*

In China, where the scale-up of interventions occurred predominantly for interventions reaching key populations at greater risk, increasing treatment coverage alone can reduce annual new infections by approximately 50% by 2031. All prevention interventions combined can further reduce new infections as a result of behaviour change. A combination of both treatment and prevention allows for the greatest reduction in new infections, preventing nearly 75% of annual new infections by 2031, resulting in over 700,000 cumulative AIDS deaths averted through 2031 (Figure 3-4, A and B).

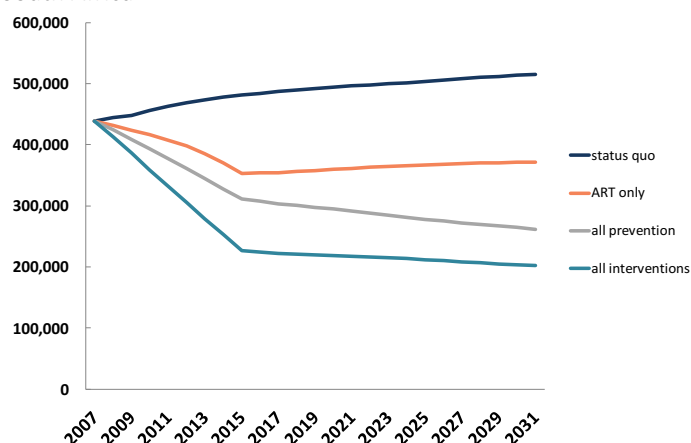
When interventions are applied in isolation, the widespread use of ART is also the most influential factor followed, in order of impact, by outreach programmes for MSM and needle exchange programmes for IDU (Figure 3-4C). The effects on behaviour change of increasing coverage of programmes for MSM, from 8% in 2007 to 60% by 2015, are a slight reduction in the mean rate of partner acquisition from 5.5 partners per year in 2007 to 5.2 partners per year by 2015, and an increase in the proportion of sex acts where condoms are used from 40% in 2007 to 51.3% by 2015. The impact observed from increasing the coverage of needle exchange programmes from 2% to 40% coverage, is due to a 4.8% decrease in the percent of IDU who share needles (from 25% in 2007 to 20.2% in 2015) and a 9.3% increase in the percent of sex acts in which condoms are used by those in the high risk group (from use in 41% to use in 50.3% of sex acts); while increasing coverage of drug substitution programmes, from 4% to 20%

coverage results in a 2.6% decrease in the percent of IDU sharing needles. Here again, in the Goals model, outreach and harm reduction programmes for MSM and for IDU also have an impact on behaviour change in commercial sex workers and their clients – despite these not being the directly relevant populations for intervention effect – which results in a slight increase in condom use and slight reduction in the mean rate of partner acquisition.

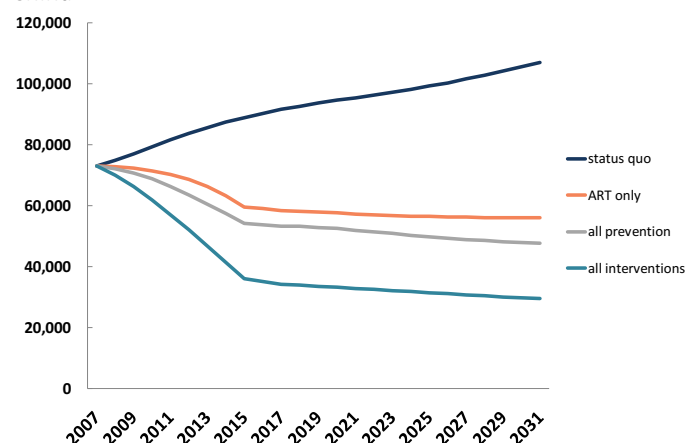
**Figure 3-4 Impact of interventions**

**A Annual new infections – combined prevention interventions**

**South Africa**

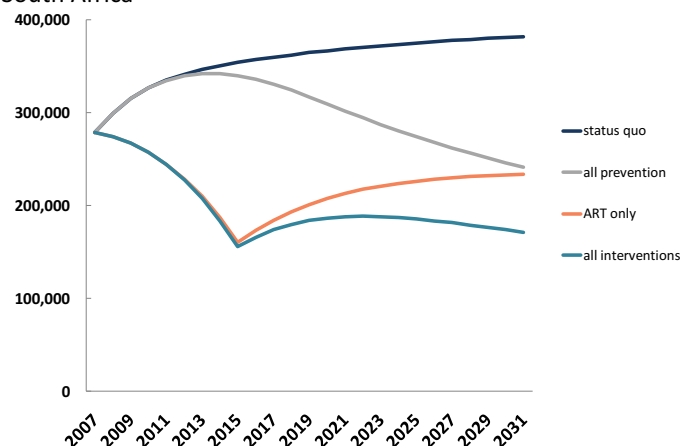


**China**

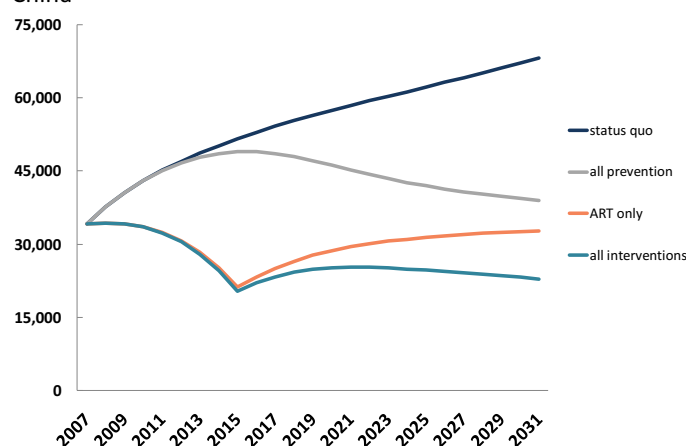


**B Annual AIDS deaths – combined prevention interventions**

**South Africa**

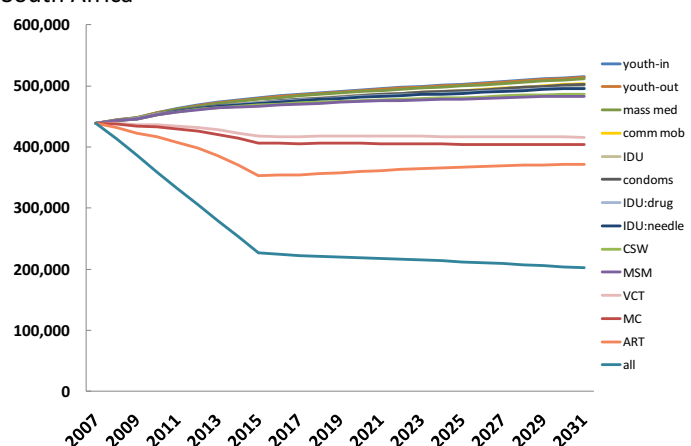


**China**

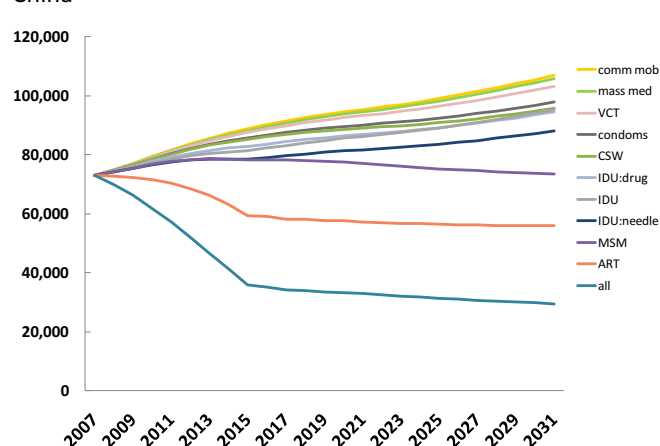


**C Annual new infections – increasing interventions in isolation**

**South Africa**



**China**



Results when interventions are varied in combination and in isolation for China and South Africa. **(A)** Treatment alone can substantially reduce new infections, and all prevention interventions combined can further reduce new infections if it results in behaviour change at the population level. Here, the difference in results for all prevention interventions in South Africa compared to China is largely due to the impact of male circumcision. A combination of all interventions is needed for maximum reductions in new HIV infections. **(B)** For both countries, treatment is the most important factor in isolation and will have a fairly immediate and sizeable impact on reducing AIDS deaths while the benefits from prevention, in terms of AIDS deaths averted, will be observed in the long term. **(C)** In South Africa, the greatest effects on projected new HIV infections come from the scale-up of treatment, MC and VCT, while in China it is treatment and outreach and harm reduction programmes for populations most-at-risk, in particular MSM and IDU. Some interventions will have only minimal impact from the nominal increases that occur as a result of already high reported coverage, for example mass media campaigns and youth education programmes in schools in South Africa.

### 3.3.3 Results from conducting sensitivity analyses

Sensitivity analyses were conducted to gain a sense of the impact of changed assumptions for intervention effectiveness. Assumptions were varied for the key behavioural interventions identified in the country results from South Africa and China in 3.3.2, for all behavioural interventions combined, and then for male circumcision and antiretroviral treatment. It should be noted this is not a methodologically rigorous exploration of uncertainty of the influence of all parameter assumptions, but a qualitative illustration of the potential for variation in the results with different model assumptions.

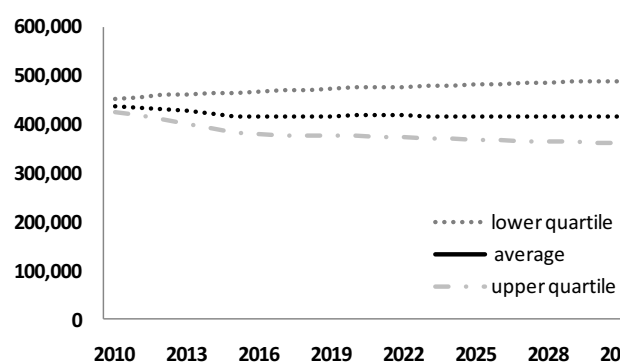
Analyses were first conducted to explore the assumptions for intervention effectiveness as defined in the impact matrix. The upper and lower quartiles of this matrix (Appendix 3-3) were used to illustrate the sensitivity and the potential for variability in impact and predicted outcomes. Figure 3-5 illustrates the results of varying effectiveness for the prevention interventions with the greatest impact in each context and for all the behavioural prevention interventions combined (i.e. without including expansions in treatment or male circumcision). For both voluntary counselling and testing in South Africa and outreach and harm reduction programmes for MSM in China (Figure 3-5, A and B) the results are quite sensitive to the assumptions made, particularly for the latter, with divergence in the direction of the future trends for new HIV infections depending on the assumptions used. When all interventions are combined, the direction of the trend remains the same and continues to decline, albeit only slightly for South Africa, even with conservative assumptions of effectiveness (Figure 3-5C).

Projected new infections and AIDS deaths are particularly sensitive to assumptions made for the future coverage (i.e. prevalence) of male circumcision (Figure 3-6A). When this intervention is scaled-up in isolation, low coverage of male circumcision (45%) has a minimal impact; achieving very high coverage (90%) results in substantial declines, a difference of nearly 200,000 new infections per year in South Africa.

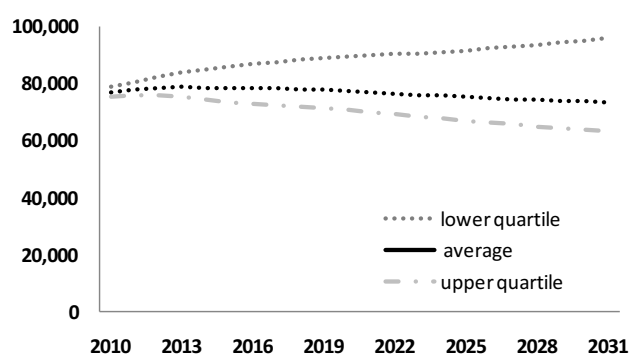
Antiretroviral treatment had the greatest impact in both settings, but this impact will vary depending on the assumptions made, including when treatment is initiated and the assumed reduction in infectiousness while on treatment. It has been assumed there is an 80% reduction relative to infectiousness in the asymptomatic stage. Varying this assumption to reflect conservative (50% reduction) and optimistic (99% reduction) parameter values will result in different levels of impact with new infections continuing to decline through 2031 or declining to 2015 and then slowly increasing when treatment coverage stops expanding and is maintained from 2015-2031 (Figure 3-6B).

**Figure 3-5 Sensitivity analyses for behavioural interventions**

A South Africa – New infections varying impact of VCT

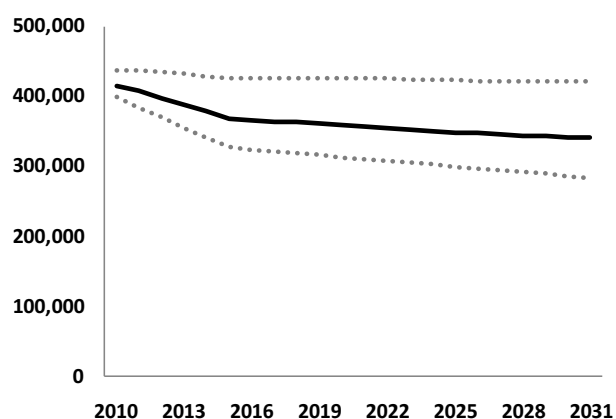


B China – New infections varying impact of MSM outreach & harm reduction programmes

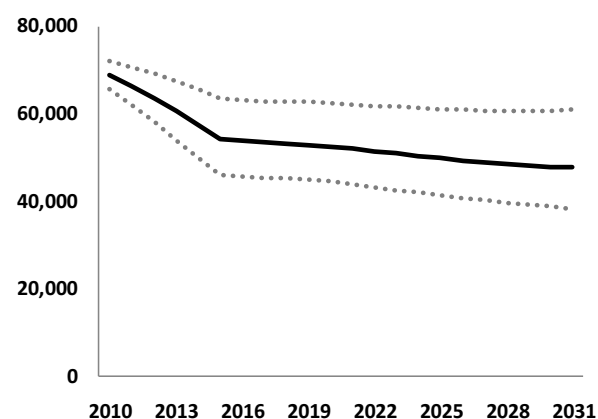


C Sensitivity analyses for all behavioural interventions scaled-up in combination – New HIV infections

South Africa



China

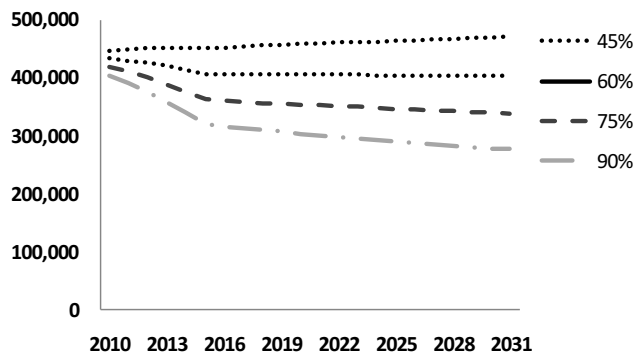


Sensitivity analyses for the behavioural prevention interventions resulting in the greatest impact on new HIV infections for South Africa (A) and China (B) when interventions are applied in isolation and when all interventions are combined (C). The upper and lower quartiles for the impact of interventions on behaviour change were used to derive upper and lower bounds. The figures represent new infections and AIDS deaths in the entire population. Treatment and male circumcision are not included in these results.

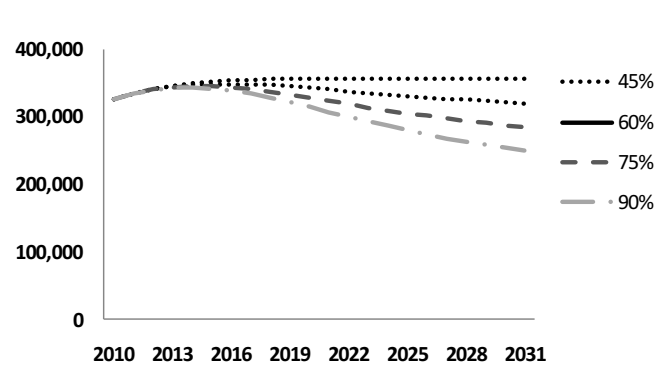
**Figure 3-6 Varying assumptions for coverage of male circumcision and the relative infectiousness on treatment**

**A South Africa - Varying coverage of male circumcision**

New Infections

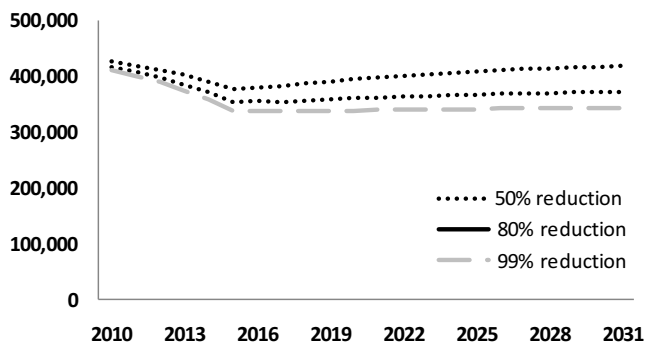


AIDS deaths

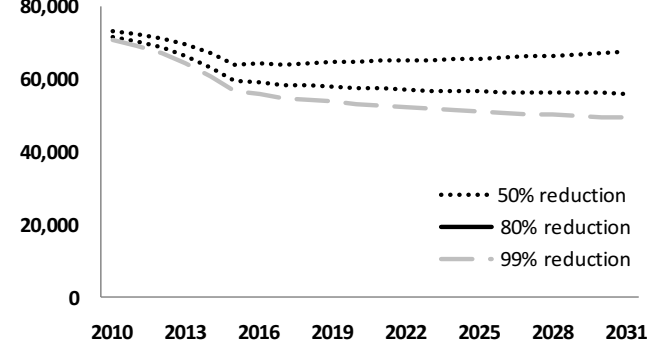


**B New HIV infections in South Africa and China when varying assumptions for the relative infectiousness on treatment**

South Africa



China



**A)** Projected new HIV infections and AIDS deaths in South Africa as a result of increased coverage of male circumcision only, without increases in interventions, or treatment. The solid line (60% coverage) represents the modelled target coverage in adults (15-49 years) used in this exercise while the dashed lines represent varying assumptions.

**B)** New HIV infections in South Africa and China as a result of increasing coverage of treatment in isolation. The assumptions for the reduction in infectiousness, relative to the asymptomatic stage, were varied from the 80% reduction used in this exercise to explore the effects of more conservative (50% reduction) and optimistic (99% reductions) assumptions.

### 3.4 Discussion

Generating projections allows the observation and quantification of the potential future scope of AIDS and the identification of how action and inaction can result in strikingly different futures. This analysis showed two potential long-term futures – one with the status quo maintained and another with expanded intervention scale-up. These findings are still relevant today in both illustrating the ongoing potential of the epidemic and in exploring the mechanics of a still widely used model.

Projections generally assume a similarity of future trends to past trends (261) and while it is true that the status quo projections follow the path of trends observed in recent years, it has been observed that the path of least resistance is to let old policy guide new policy (284). It is evident that if this same path is continued, population growth combined with an ageing HIV-positive population able to live longer, healthier lives will result in a substantial burden of infection and an undoubtedly expensive future. However, there is great scope for improvement with rapid and ambitious scale-up of prevention interventions and expanded treatment coverage.

The importance of individual interventions will depend on the epidemiological context and different interventions will increase in importance if they alter the factors and behaviours most associated with the local spread of infection. When comparing individual interventions in isolation in the country settings of South Africa and China, treatment has the greatest impact on new HIV infections as a result of the reduced infectiousness that occurs with suppressive therapy. Treatment also has the additional benefit of having an immediate impact on AIDS deaths, while the benefits from prevention, in terms of AIDS deaths averted, will be observed in the longer term. And while treatment and male circumcision result in substantial declines in new infections, they can only achieve so much in isolation, thus prevention will remain a critical component of a successful long-term strategy. Because the impact of behavioural interventions in the Goals model is dependent upon the change in coverage that occurs and the efficacy of interventions on behaviour change, interventions with the greatest potential for scale-up, higher measured efficacy and most associated with the local spread of infection will result in the greatest impact. Currently, under-utilised prevention programmes with demonstrated evidence for efficacy can have a sizeable impact as illustrated in China for the scale-up of needle exchange and outreach and harm reduction programmes for IDU and MSM, and in South Africa for the further scale-up of counselling and testing in particular, but additionally for outreach and harm reduction programmes for key populations at greater risk.

In these projections, the assumption is that effective prevention programmes are delivered which result in behaviour change in specific populations; however, the effects of prevention remain difficult to quantify. These effects can be measured in specific studies, extrapolated and pooled, and applied at the population level as is done in the Goals model, but it is not conclusively known whether the behaviour change observed in research studies translates to behaviour change in the population. In addition, the resultant behaviour change from the same type of intervention may vary across different countries and in different contexts, an inherent limitation when applying common parameters across a wide range of different country contexts.

What we do know is that behaviour does change (362), that it can change at the population level and that this change can result in considerable reductions in new HIV infections (363). And while changes in behaviour, in combination with prevention technologies (male circumcision) and increased access to effective treatment, can result in substantial declines and considerably alter the future course of the epidemic, they will not eliminate new infections in the next two decades.

There is great uncertainty when making future projections; uncertainty surrounding key parameters and assumptions made regarding sexual behaviour, and also the variance in that behaviour over time. The Goals model has many limitations which will affect the subsequent outputs. The impact matrix, which quantifies the behaviour change occurring as a result of exposure to prevention interventions, is derived from published studies which are more likely to report significant findings and thus may overestimate the impact of interventions. While many of these cells are defined from a wide range of published studies (in particular, changes in behaviour in high risk individuals as a result of targeted outreach programmes, increased condom use in medium risk individuals as a result of VCT, and HIV education programmes in schools), other cells are informed by a very limited amount of evidence, and many of the cells are empty as a result of not having evidence for efficacy on behaviour change. Therefore, it is also possible that this matrix may underestimate the potential impact of prevention interventions. It is recommended that this matrix is made more rigorous, that minimum data requirement criteria for inclusion are established and that a grading method (364), defined by the strength and quality of evidence, is used. Additionally, the finding that increasing coverage of harm reduction programmes for MSM and IDU also affects behaviour change in sex workers and their clients, as presently defined in the impact matrix, warrants reconsideration. It is recommended that this assumption is refined and that MSM and IDU are separated out from the high risk group defined in the matrix for future applications.

The modelling of treatment has several limitations. The model assumes the reduction in infectiousness when on treatment occurs immediately upon initiation and that a constant proportion survives on ART each year. There is a single progression pattern from infection to need for treatment, thus in the form used, the Goals model was unable to account for changing definitions of treatment eligibility and cannot incorporate a change to earlier treatment initiation (CD4 counts <350 cells/ $\mu$ l), which would result in further reductions in both incidence and AIDS deaths. However, it will require substantial investments in order to simply reach all those in need with CD4 counts under 200 cells/ $\mu$ l and thus this treatment assumption, while conservative given the revised WHO treatment guidelines (365), may also be optimistic, particularly given the current observations of median CD4 count at treatment initiation in both developing (366-368) and many developed settings (369). Treatment coverage in this model is defined as the proportion of all eligible persons who are receiving treatment with the numerator corresponding to the total number on treatment and the denominator the total number eligible. This definition of coverage differs from defining treatment coverage as the proportion of all newly eligible persons who are newly receiving treatment in each year. As people are able to live longer due to life-saving treatment, maintaining constant treatment coverage (by general definition) results in limited uptake of those newly eligible for treatment (as those on treatment are maintained), which results in the increase in deaths observed when treatment coverage remains constant as those who need treatment, but do not obtain it, quickly progress to death. This observation and illustration has policy implications, for how treatment coverage is defined and what is deemed treatment success – whether it is putting new people on treatment or maintaining those already on treatment – and suggests a move away from absolute treatment goals and towards a focus on increasing coverage of those newly eligible, expanding access to those in need, and maintaining those already on treatment.

Despite these limitations, estimates of the future number of new infections are critical in order to adequately plan for health care needs and assess priorities for expenditure. AIDS will continue to affect millions of lives for the next several decades and it is essential that a combination of all available tools, strategically selected in accordance with the epidemiological context, the current gaps and areas of need, and the available best evidence, are rapidly scaled-up and maintained in order to achieve optimal future outcomes. Mathematical modelling can help inform multifaceted and often controversial health policy issues surrounding HIV/AIDS and the exploration of the potential impact of interventions plays an important role in policy and these models and analyses can, and should, be used to mobilise political support.

The analyses presented here covered a broad number of countries, with an additional focus on two key countries. This work directly contributed to aids2031, an international consultation on the future of HIV and analyses of the resources required to support intervention scale-up (250, 251). Next, we consider another mathematical model, also commonly used at the country level to inform HIV programme planning, but focusing instead on the current state of the epidemic.

## **Chapter 4**

**The Modes of Transmission model:** A tool to inform investments in HIV prevention

## Summary

The Modes of transmission model (MoT) has been widely used to assist decision makers to appropriately target HIV prevention activities. This model estimates the number of new HIV infections acquired by those in identified risk groups based on population size, the aggregate risk behaviours within groups, the current HIV prevalence among partners, and the transmission probability associated with different risk behaviours. The strength of the model is its simplicity, which allows synthesis of a variety of data sources leading to improved characterisation of HIV epidemics in some settings. However, concerns have been raised regarding the structural assumptions in the model, limitations in available data to inform input parameters, and in the interpretation and communication of results. In this chapter, results from application of the Modes of Transmission model in the Eastern European setting of Armenia are illustrated. The results frame the discussion, which focuses on improved use of this model arising as a necessity after global discourse on the interpretation and use of these model results to inform programme planning and policy decision making. Specifically, the discussion in this chapter focuses on the MoT model paradigm, structure, and data requirements. It concludes by providing guidance for future analyses and interpretation of results and sets out recommendations in order to strengthen future applications to allow for improved use of this model to inform investments in HIV prevention.

## Contributions and dissemination

I received financial support from UNAIDS to conduct the Modes of Transmission analysis in Armenia. The results presented represent my own work and do not reflect official consensus estimates in Armenia. In order to conduct this analysis, I benefitted from unpublished data available in country, insight from local monitoring and evaluation experts from the Armenia Modes of Transmission study team, and from Annick Borquez formerly at Imperial College London, an expert on the Modes of Transmission model. The discussion section of this chapter has been published in a peer-reviewed journal and benefitted from contributions from co-authors and the anonymous reviewers. I have also received constructive comments from my supervisors.

Case KK, et al. *Understanding the models of transmission model of new HIV infection and its use in prevention planning*. Bulletin of the World Health Organization. 2012; **90**(11): 831-8.

## 4.1 Introduction

In the previous chapter, long-term projections of the HIV epidemic were generated first from a global perspective, and then narrowed in scope to the country level for two epidemiologically important contexts. These projections were produced from a research perspective without direct country involvement in the process. This chapter builds upon the work in Chapter 3 but now transitions from an external to more of an internal perspective with analyses conducted as a technical consultant working directly with countries, and further incorporating information gleaned from national and international stakeholder meetings and consultations. This chapter also shifts from long-term projections to the short term, recognising that programme planning and resource allocation often occurs in the short term, in-line with political and budget cycles. In order to design strategies for HIV prevention that are efficient, and evidence-informed, countries require an up-to-date assessment of their HIV epidemic, the key affected populations and those at greatest risk of infection. Mathematical models can provide a useful framework to better understand epidemic patterns and highlight priority areas for prevention within the population. The Modes of Transmission (MoT) model (290), recommended by UNAIDS, is one such tool that is frequently used to enhance understanding of HIV epidemics and to inform national-level strategy planning (169-171, 291-296).

Developed in 2002, the MoT model was originally designed to shift the focus from broad categorisations of epidemic type (low-level, concentrated, generalised) towards the identification of who is at risk of infection in a population, with the intent to inform more strategic prevention planning (145). In contrast to models which are region-specific (for example, the Asian Epidemic Model (370)), or country-specific (for example, the ASSA model (371) used primarily for South Africa), the MoT model was designed to be an easily accessible and straightforward method that could be applied in any epidemic setting. It differs from other approaches, such as the Estimation and Projection Package (EPP)(372) curve fitting approach within the Spectrum modelling software (373), which estimates HIV prevalence and incidence from surveillance data and does not aim to capture mechanisms of infection.

The MoT model has been recommended for use at the national level as part of a UNAIDS-Global AIDS Monitoring and Evaluation Team (GAMET) supported data synthesis process in southern and eastern Africa in 2008 (168). This process was a component of the UNAIDS 'know your epidemic, know your response' strategy (166), and the World Bank Epidemic, Response and Policy Syntheses (167). These approaches emphasise the importance of understanding, at a more local level (i.e. country level as opposed to global or regional), what subpopulations are most at risk of HIV infection and the risk behaviours that may facilitate transmission, and using

this information to tailor national responses appropriately. By the end of 2013, at least 45 countries with a diverse range of HIV epidemics had conducted MoT analyses (Table 4-1). The breadth of these analyses, both geographically and epidemiologically, emphasise the potential importance of this model and its applications.

In this chapter, the MoT model is presented and then applied in a country-supported technical process. Results are presented from this context-specific analysis and from other analyses across sub-Saharan Africa. The discussion focuses on the key policy-relevant issues that arose from these country processes and other applications that were discussed and debated at international meetings and amongst key international stakeholders. This includes clarification of the model paradigm, discussion of the model structure and the data required. Finally, recommendations are made to guide interpretation of the results for future applications in order to better inform and improve the use of this tool for programme planning and policy decision making.

## **4.2 Methods**

The MoT model uses information on the current distribution of prevalent infections in a population and assumptions about the patterns of risk behaviour within different risk groups to calculate the expected distribution of new adult HIV infections, by mode of exposure, in the subsequent year. The model inputs, informed through a comprehensive review of available epidemiological and behavioural data, are:

- The proportion of the adult male and female population in each of a number of risk groups (precisely defined by each country), including: sex workers and their clients, injecting drug users (IDU); men who have sex with men (MSM), those with multiple heterosexual sex partners in the last year, the spousal partners of those with higher risk behaviour, and those in stable heterosexual relationships (generally representing married or cohabiting couples, often referred to as 'low risk'),
- The prevalence of HIV and generic sexually transmitted infection (STI) within each risk group,
- The average number of sexual or injecting partners per year, and the average number of exposures per partner, accounting for the average level of protective behaviours (condom use, use of clean needles), for individuals in each risk group, and
- The probability of transmission per exposure act for each risk group (including the impact of STIs and the prevalence of male circumcision)

The model calculates the number of new adult infections estimated to occur in one year in each risk group from the number of HIV susceptible individuals, the number of contacts with HIV positive individuals, and the transmission probability associated with the nature of the contact. Taken together, this provides an estimate of the distribution of new adult infections according to the population risk structure defined by each country. Appendix 4-1 details the precise calculations used for this approach.

#### **4.2.1 Use of the Modes of Transmission model in country applications: Armenia**

From April 2010 through May 2011, the author worked with countries in the Eastern European region as an international consultant to provide technical support for use of the MoT model. During the period March-May 2011, the author worked with Armenia to conduct the MoT analysis. This process began with an initial in-country workshop in March 2011 to introduce the MoT model, the data required, the methodology, and to review and triangulate the available country data alongside national surveillance experts. A draft MoT analysis was conducted as part of this process informed predominantly by Armenian Demographic and Health Survey (DHS) and Behavioural and Biological HIV Surveillance (BBS) data. Local surveillance experts advised on the population groups to include in the MoT and on the quality of the data available. Appendix 4-2 details the sources of data used for each model input and the year of each data source. The workshop agenda is included in Appendix 4-3 and a short report is included in Appendix 4-4.

In May 2011, the MoT analysis was finalised during a second country workshop which reviewed and discussed the quality of each data input, identified the key model inputs, reviewed the missing data inputs and sources to use as a proxy in the absence of available data. The model results were compared to resource allocation for HIV prevention in Armenia and the key findings were discussed and recommendations and key messages were defined. The results were prepared for presentation to key stakeholders for feedback, discussion and consensus.

**Table 4-1 Modes of Transmission analyses by region, country and year**

|                                          | Conducted*  |
|------------------------------------------|-------------|
| <b>Sub-Saharan Africa</b>                |             |
| Angola                                   | <i>2013</i> |
| Benin                                    | 2009        |
| Burkina Faso                             | 2009        |
| Côte d'Ivoire                            | 2009        |
| Democratic Republic of Congo             | 2013        |
| Ethiopia                                 | 2012        |
| Ghana                                    | 2009        |
| Kenya                                    | 2005 & 2008 |
| Lesotho                                  | 2008        |
| Malawi                                   | 2013        |
| Mozambique                               | 2008        |
| Nigeria                                  | 2009        |
| Rwanda                                   | 2009        |
| Senegal                                  | 2009        |
| South Africa                             | 2010        |
| Swaziland                                | 2008        |
| Tanzania                                 | 2012        |
| Uganda                                   | 2008        |
| Zambia                                   | 2008        |
| Zimbabwe                                 | 2011        |
| <b>Middle East &amp; North Africa</b>    |             |
| Iran                                     | 2011        |
| Djibouti                                 | <i>2012</i> |
| Morocco                                  | 2010        |
| Tunisia                                  | <i>2012</i> |
| <b>Latin America &amp; Caribbean</b>     |             |
| Brazil                                   | <i>2012</i> |
| Colombia                                 | 2013        |
| Costa Rica                               | 2013/14     |
| Dominican Republic                       | 2009/10     |
| El Salvador                              | 2012        |
| Guatemala                                | 2012/13     |
| Guyana                                   | <i>2012</i> |
| Jamaica                                  | 2012        |
| Mexico                                   | 2012        |
| Nicaragua                                | 2013        |
| Panama                                   | 2013/14     |
| Peru                                     | 2009        |
| <b>Eastern Europe &amp; Central Asia</b> |             |
| Armenia                                  | 2011        |
| Belarus                                  | <i>2012</i> |
| Georgia                                  | <i>2012</i> |
| Moldova                                  | 2011        |
| <b>Asia &amp; Pacific</b>                |             |
| Thailand                                 | 2005        |
| Indonesia                                | 2011        |
| Myanmar                                  | 2011        |
| Nepal                                    | 2011        |
| Philippines                              | 2011        |

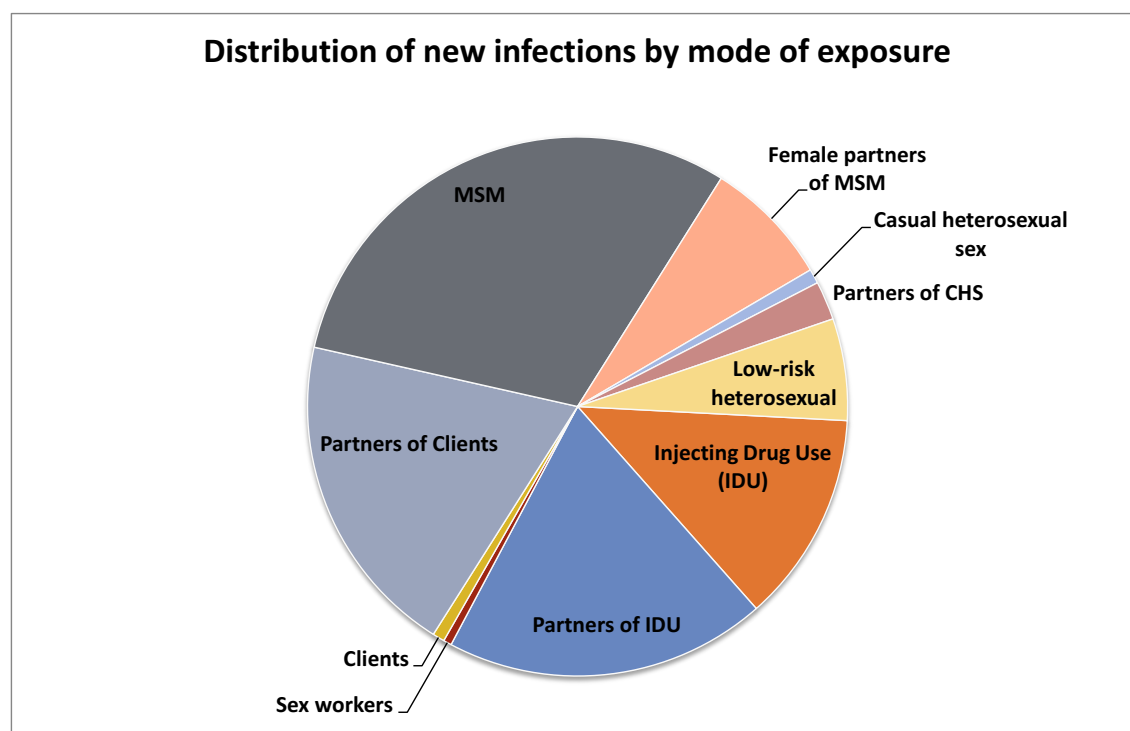
*\*Years in italics indicate a planned study where completion is not verified*

## 4.3 Results

### 4.3.1 MoT results from Armenia<sup>1</sup>

In Armenia, results from the MoT model conducted in 2011 indicated ongoing transmission among injecting drug users, a substantial proportion of new infections in MSM and elevated transmission among heterosexuals, particularly affecting the regular sexual partners of those with higher risk behaviours. Overall, the greatest proportion of new infections was estimated to occur in MSM (30%), followed by the regular sexual partners of clients (20%) and the regular sexual partners of injecting drug users (20%). New HIV infections in clients and sex workers were estimated to account for only a very small proportion of new infections (0.7% and 0.5% respectively), less than all other risk groups. Nearly half (49%) of all new infections were estimated to occur in the regular sexual partners of those with higher risk behaviours (MSM, IDU, clients and those with multiple casual heterosexual partners). Figure 4-1 depicts these results in a pie chart. The full MoT analysis and worksheet is detailed in Appendix 4-5.

**Figure 4-1 Distribution of new infections by mode of exposure: Armenia**



<sup>1</sup> Note that the model results contained herein reflect the author's work, have been produced by the author, and do not represent official consensus estimates from the Republic of Armenia.

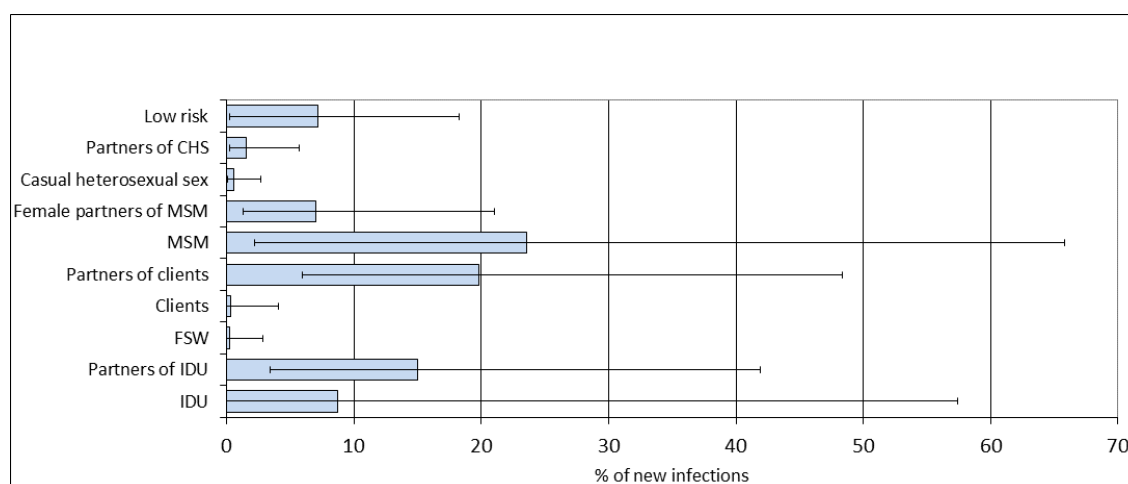
Putting these results in the context of the populations, incidence rates (per 100,000 person-years) were highest in the regular sexual partners of injecting drug users, followed by MSM and importantly, the regular female partners of MSM, and then injecting drug users, Table 4-2.

**Table 4-2 Estimated HIV incidence per 100,000 in Armenia**

| <b>Risk Group</b>               | <b>Incidence per 100,000</b> |
|---------------------------------|------------------------------|
| <b>Injecting Drug Use (IDU)</b> | 179                          |
| Partners of IDU                 | 604                          |
| <b>Sex workers</b>              | 22                           |
| Clients                         | 2                            |
| Partners of Clients             | 79                           |
| <b>MSM</b>                      | 405                          |
| Female partners of MSM          | 274                          |
| Casual heterosexual sex (CHS)   | 1                            |
| Partners of CHS                 | 5                            |
| <b>Low-risk heterosexual</b>    | 1                            |

There was substantial uncertainty in the results, particularly for the groups estimated to contribute the greatest proportions of new infections. This was due to the limited data available (or entire lack of data) to inform the behavioural inputs in the model. Figure 4-2 illustrates the median values and plausibility bounds for the 2.5-97.5 percentiles when varying the parameters for 1000 runs.

**Figure 4-2 Estimated distribution of new HIV infections in Armenia with plausibility bounds**

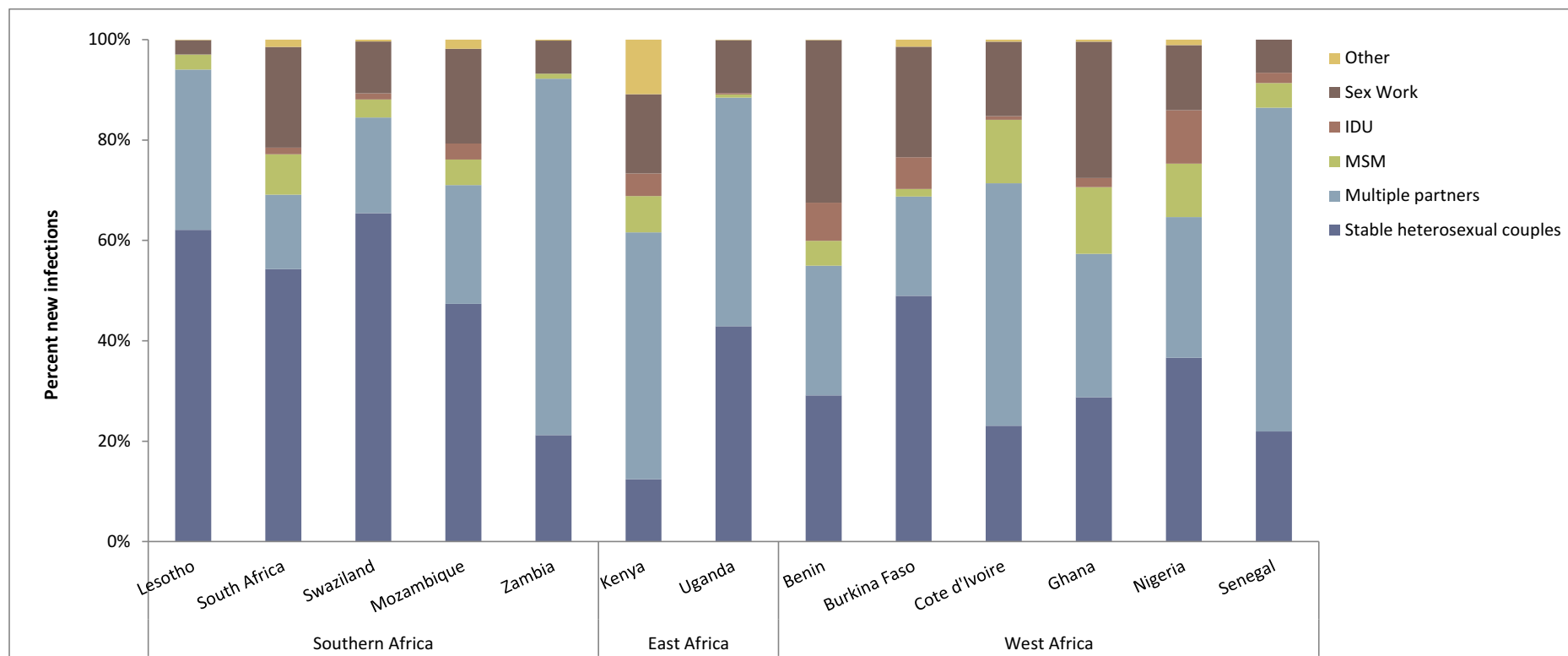


#### 4.3.2 MoT results from sub-Saharan Africa

The results from Armenia were, not unexpectedly, in contrast to the results from analyses conducted in sub-Saharan Africa, Figure 4-3. The results from countries in this region illustrated that the majority of new infections were estimated to occur in the general heterosexual

population, either in serodiscordant couples or as a result of having multiple sexual partners. Countries in southern Africa in particular, had very high proportions of infections estimated to occur in the low-risk or stable heterosexual population. It is worth noting that across nearly all countries there were not insignificant proportions of new infections estimated to occur amongst by MSM and infecting drug users. The potential contribution of these key populations to new HIV infections had previously gone largely unrecognised in these regions.

**Figure 4-3 Results from MoT analyses conducted in countries in sub-Saharan Africa**



Note: This figure has been adapted from (165), published by the author. The author has not conducted the analyses leading to the results from these countries.

## **4.4 Discussion**

### **4.4.1 Benefits of the MoT analysis**

Completion of the MoT analysis is part of a multi-stage process which generally includes a comprehensive review and synthesis of epidemiological and behavioural data, application of the MoT model to estimate the distribution of new infections, a review of prior or proposed prevention planning and resource allocation, comparison of resource allocation to the modelled distribution of sources of infection, and a national stakeholder consensus meeting to discuss the results and formulate key recommendations. This process provides a framework for countries to interpret and evaluate their data, to assess the data availability and quality, and to identify gaps in data collection. It can consolidate knowledge of the current situation, but can also expose gaps in information about specific risk behaviours. The model results may be used to raise awareness for potential groups who may not have received appropriate attention, to highlight areas for improvement in the prevention response, and to identify areas for further research.

In Armenia, this process highlighted the potentially substantial proportion of new infections in MSM, much higher than the 1.5% reported through surveillance data (374) and a highly stigmatised group receiving fairly nominal programme support. In addition, the potential importance of the regular sexual partners of IDU was illustrated. This group had the highest incidence per population but had not previously been considered a key population and accordingly did not have targeted services, despite the many programmes and services for IDU and the relative ease of incorporating this additional focus. The MoT process in Armenia provided an opportunity to identify and discuss improvements in survey design to better understand risk behaviours and obtain actionable information, for example, disentangling oral versus anal sex and condom use among MSM and needle sharing behaviours among IDU, as opposed to merely quantifying sex acts and injecting drug use, respectively.

In sub-Saharan Africa, the prospective contribution of new infections by men who have sex with men and injecting drug users from the MoT analyses was much larger than acknowledged before the advent of the MoT framework.

### **4.4.2 Limitations of the MoT analysis**

While the high-level concept of the MoT analysis has gained broad support, the simplicity of the model, its use of data, and how the results are interpreted, have raised important questions. Limitations of the MoT model and its assumptions can be divided into three categories: those

relating to the model structure, those relating to data used in the model, and those relating to the interpretation of the results.

### *Model Structure*

The MoT model is a static model representing a single year of risk with a simple structure that does not incorporate many complexities of HIV epidemiology. It represents mutually exclusive subpopulations and assumes the risk of infection is homogenous within each risk population. This means, for example, that all MSM are assumed to have the same risk of infection. It would not capture details such as clients of sex workers only visiting a particular type of sex worker or IDUs only sharing injecting equipment within a specific cluster. This could influence results if there are important differences among those classified within the same group. The model offers the flexibility to disaggregate a subpopulation if there is enough evidence to support heterogeneity in risk and if data are available to characterise the different subgroups within the subpopulation, but generally suitable data are unavailable to inform this further disaggregation.

In the model, members of the population must be assigned to only one risk group, each with risk of infection occurring from a single source. Individuals with multiple sources of risk are classified by the behaviour which results in the highest probability of transmission in a defined hierarchy. For example, a sex worker who also injects drugs is classified as an injecting drug user. This assumption implies that eliminating that source of risk will avert infection. Analyses which modified the model structure to allow for an individual's multiple sources of risk, for example, a sex worker who is also an injecting drug user, illustrate that this assumption could lead to overestimating the potential impact of interventions (375). Conversely, the impact of interventions targeted at less risky behaviours may be underestimated if the sizes of those risk groups are underestimated due to the hierarchy of risk behaviours. For example, in the MoT model, a successful intervention amongst sex workers would not affect sex workers who are also IDU (and would be classified as the latter).

The probabilities of transmission, and the parameter used to modify these probabilities in the presence of STI, are derived from published data and systematic reviews and meta-analyses of observational studies (376-378). While these represent the best available evidence, they may not capture potential variability of transmission in different geographical settings (378, 379). Additionally, there is no variation in the transmission probability by stage of HIV infection, and the model does not allow temporal patterns of sexual contacts, such as concurrent sexual partnerships, to influence transmission. MoT analyses conducted prior to 2013 (which includes the analyses presented herein) have not accounted for the effect of antiretroviral therapy on transmission.

The size of the 'low risk' subpopulation in the model, generally defined as those with one monogamous heterosexual partner in the last year, is often calculated as a residual after the sizes of other groups are entered to ensure the summed size of the groups matches the total population size. This creates a dependency between risk group sizes, so that if the size of high-risk groups is under-estimated, then the importance of the low-risk group will be over-estimated. Thus, poor data quality for a single risk group can result in biased estimates and misinterpretation of the relative importance of the low-risk group.

While the MoT model calculates the cumulative number of incident cases of HIV infection in one year, it does not capture secondary HIV transmissions arising from onward transmission within this year and thus may underestimate overall incidence. Further, the MoT model represents a closed population, defined by country borders and by age. Estimates obtained are for new HIV infections that arise within a country and do not account for exogenous HIV exposures which may contribute to a considerable fraction of HIV incidence in some countries such as in the Middle East and North Africa (380, 381). In Armenia, there was substantial discussion surrounding infections acquired abroad as a result of seasonal migration patterns, which are believed to account for approximately half of HIV infections diagnosed each year (382). These newly acquired infections would not be captured in the MoT analysis and may account, in part, for the low estimate of new HIV infections compared to other modelled estimates of incidence in Armenia.

### *Data*

The MoT analysis requires detailed, current information for the size of several 'risk groups', the prevalence levels of HIV and other STIs, and precise descriptions of sexual behaviour for each subpopulation. This is often more data than are available, particularly when describing hidden or stigmatised populations, but also when describing the general population in the countries where national survey data are not available. Standard survey instruments do not collect specific information about some of the detailed inputs required by the MoT (and most models), including the average number of sex acts per partnership, injecting behaviour, and the prevalence of HIV and STI in each distinct risk group. As a result, it is unlikely to obtain all the information required to characterise a specific group from a single study. Instead, estimates are often based on triangulation of several available data sources, collected at different time points within a pre-specified period (typically five years), using different study designs. In Armenia, there were no data on needle sharing behaviours amongst IDU or detailed behavioural data for MSM. These two populations, and the corresponding behavioural inputs, heavily influenced the national analysis and results but were informed entirely based on data from other countries.

The quality of the model results is dependent on the quality of the input data. The MoT model is highly sensitive to the specified sizes of the subpopulations (383) and behaviour within groups. While guidelines exist for estimating population sizes (384), the methods are often complex and of uncertain precision, particularly for hidden or hard-to-reach populations such as MSM in Africa (385). Consistently defining HIV risk for certain populations is not straightforward, for example women who occasionally sell sex in informal settings but do not self-identify as a 'sex worker'. These factors contribute to the use of different estimation methods producing substantially varying population size estimates which could affect the model results (146).

Ascribing patterns of risk behaviour to high-risk groups may also be subject to biases in self-reported behavioural measures. National household surveys such as the Demographic and Health Survey (DHS) are often used to inform model inputs for sensitive information including inputs for people engaging in casual heterosexual sex and the clients of sex workers. Increasing evidence suggests these surveys may substantially underreport higher risk behaviours (386-388). Other sources of HIV prevalence and behavioural data for hard-to-reach, hidden or stigmatised populations may not be representative; they generally come from surveillance or behavioural studies in capital cities or urban centres (often via convenience samples), which may be difficult to extrapolate to national-level estimates. In both Armenia and countries in sub-Saharan Africa where MSM are highly stigmatised and associated behaviours are often illegal, the little behavioural data available was usually from small studies and surveys in capital cities which may not be representative at the national level.

In spite of these limitations, it is important to recognise that the MoT model requires less data than many dynamic models (which are subject to the same data limitations) and still aims to capture the mechanisms of infection.

#### *Interpretation and communication*

The major misunderstanding of model results comes from a misinterpretation of the question addressed by the model analysis. The MoT model calculates the predicted distribution of new infections in one year. It does not estimate the total number of secondary infections that will result from a new infection in a risk group. It is important to distinguish between identifying among whom new infections are predicted to occur in the short term, which the model does, and the types of risk behaviours that sustain the epidemic (epidemic drivers) (146). Though a large fraction of HIV infections may occur in a single year among individuals in serodiscordant stable and monogamous partnerships in the population, for example in the analyses in sub-Saharan Africa, the index HIV positive partners in these couples may have previously acquired the infection through higher risk behaviour, commercial sex for example. Both partners may be

currently classified as part of the low-risk population, but the essential driver of such current transmission is previous sexual contact within commercial sex networks. This is an important distinction, particularly when using the results to inform programme planning, which may accordingly under-allocate resources for prevention in commercial sex settings. Further, the allocation of prevention resources to match the predicted distribution of new infections identified in the MoT analysis implicitly focuses prevention efforts on reducing the risk of acquisition amongst susceptible individuals, but in some cases it may be more effective or efficient to target prevention efforts towards the individuals that contribute most to onward transmission (146).

A challenge with the communication of the MoT model results has been that presentation of model results using concise pie and bar charts. These, as depicted in Figure 4-1 and Figure 4-3, do not represent the often substantial uncertainties about the data used as model inputs. Users of the MoT model can conduct a simple uncertainty analysis based on specifying ranges of plausible values for key inputs (depicted in Figure 4-2). The model then independently and uniformly samples a large number of parameter combinations from the specified plausibility bounds and calculates the model outputs for each combination of parameters, while maintaining HIV prevalence in the total population by adjusting the size of, and HIV prevalence in, the low-risk group. While this method gives some notion of how uncertainty in the inputs could affect the model predictions, it does not account for systematic bias or correlated errors between model inputs. The results can also substantially differ depending on the plausible ranges specified by the user and these plausibility ranges will not capture the intrinsic uncertainty caused by the simplified model structure.

Representation of uncertainty is a strength and an important consideration in the decision-making process. Even simple demonstration about how uncertainties in certain inputs translate into uncertainties in the model outputs is constructive. If recommendations do not change when uncertainty is represented, this can give decision makers more confidence in the use of the results. However, if the implications of the model are more ambiguous, then resource allocation decisions based on the model analysis should reflect this, and priority should be given to improving knowledge about the parameters that contribute the most uncertainty. In Armenia, there was almost no local data available to inform the potentially most important risk groups and correspondingly, extremely wide plausibility bounds (Figure 4-2). This limited the strength of confidence in the results and resulted in recommendations for improved data collection and collection of more actionable information from surveys to address these knowledge and information gaps.

Panel 4-1 summarises the questions that should guide an appraisal of MoT model results developed as a result of experience with the MoT process, working with countries and from feedback received at the international level. This should serve as a guide to forming a cautious and nuanced analysis and interpretation of results that will ultimately strengthen the contribution the model can make in decision making.

**Panel 4-1 Questions to guide an appraisal of MoT model results**

**Questions to ask when interpreting model results:**

- *What are the availability, completeness and quality of the data used as inputs and for model validation?*
- *How robust are the data for population sizes, particularly for populations that may be stigmatised?*
- *Could the size of key populations at greater risk be under- or over-estimated?*
- *Could sexual risk behaviours and protective behaviours (number of sexual partners, number of sex acts, use of clean needles, condom use), be under- or over-estimated?*
- *Could the contribution of new infections in the high risk groups, or the low risk group, be over- or under-estimated as a result of how the model represents these groups?*
- *Is there potential for a substantial contribution of new infections from outside the borders of the region under study, or the age group under study, which are not captured?*
- *Are the model results consistent with other epidemiological information?*
- *Are the uncertainties in model inputs and the limitations of the model structure fully reflected in the communication of the results?*
- *How should an estimate for the distribution of new infections in the short term be used?*

#### **4.4.3 The Way Forward**

Mathematical modelling can be used to inform health policy and focus decision making on key issues, including the design of HIV prevention programmes and the allocation of resources, but translating model outputs into important policy decisions should be done carefully and within the local context. Results need to be interpreted in the context of the underlying model structure and with consideration of the sensitivity to model parameters and potential deficiencies in data quality or availability.

Panel 4-2 summarises recommendations for optimal use of modelling in this process. Viewing the modelling exercise as a process rather than an endpoint, and using it as a tool to identify key data needs and to understand what aspects of the data or the model structure affect results, will enable more constructive use of the model. This will allow those advising policy makers on the basis of modelling to identify decisions that can be robustly recommended and those for which the model may not be able to adjudicate. One way to increase confidence in model findings is to test if the model can be corroborated with other independent data or epidemiological information.

## Panel 4-2 Recommendations for improved use of the MoT model & model improvements

### Recommendations for improved use of the Modes of Transmission model:

*Synthesise and triangulate available data.* Consider conducting a review of all available data on HIV, STIs, size estimates for risk groups, and sexual and injecting risk behaviours before commencing the MoT study to identify the best available data to use as model input parameters. Attempt to build a coherent picture of the epidemiology of HIV infection through synthesis and triangulation of the different data available.

*Emphasise the use of the MoT as a process.* If there are no other modelling results or data available for comparison, or if the model is insufficiently informed, use the MoT as a process rather than a hard outcome. Complete the analysis as a way of evaluating the data available with less focus on result generation and more concentration on understanding the gaps in knowledge of the epidemic and behaviour, the different groups involved, the validity and reliability of the data available, and the gaps in data collection.

*Improve the consideration given to data quality.* Representativeness of the data available is important. Good-quality data are essential for population-size estimates and HIV prevalence estimates within each population. The quality of all data used in the model is important: biases in estimates for one population can lead to biased estimates about the contribution of other groups.

*Bottom-up process.* Identify the data available to parameterise the model and the questions to be answered before tailoring the model at the local, country or regional level. Where epidemiological information indicates key distinctions in risks of infection or patterns of mixing between groups, consider representing this in the model if sufficient data are available.

*Model validation.* Compare the MoT model results with epidemiological evidence and findings from the synthesis and triangulation approach, and explain any differences. This may include comparisons to surveillance data, survey data, and case reports. Compare the findings with results from other models, including dynamic transmission models.

### Recommendations for improvements to the Modes of Transmission model:

*Establish minimum conditions to conduct the MoT analysis.* Define minimum data requirements and identify conditions when it is advisable to conduct a MoT analysis. The analysis is intended to strengthen the understanding of an epidemic but countries may already have robust surveillance and empirical data and good knowledge already or, conversely, may be missing too much data for this to be a worthwhile exercise. [Note: if a full uncertainty analysis is possible, this will automatically show that no conclusions can firmly be drawn if there are insufficient data.]

*Strengthen the uncertainty analysis.* Allow for correlated errors in input data. Extend the uncertainty analysis to examine, where possible, the influence of key modelling assumptions such as assumed mixing patterns and any heterogeneities represented within risk groups. Ensure that the uncertainties are fully reflected in the presentation of results.

*Be clear about what the model results mean.* The MoT model estimates the distributions of new infections in the short term, which does not necessarily reflect the most important drivers of the epidemic.

A strength of the MoT model is its simple design and flexibility for use across a range of very diverse settings. In countries with particularly strong epidemiological surveillance, country-specific models or modified versions of the MoT which expand the model structure to disaggregate subpopulations and incorporate multiple sources of risk (375) may offer a better balance between model complexity and data availability and provide more actionable information, but will require additional effort, technical expertise and time to develop.

Looking at new infections over one year may not highlight the underlying factors that drive an epidemic and if the contribution of high-risk groups to the epidemic is underestimated in static, short-term modelling, then a portfolio of interventions based on these results may be sub-

optimal for long-term control (383). Comparing the short-term predictions of the MoT with dynamic transmission models could suggest how decision making may have differed had a different method been used that examined determinants of long-term epidemic spread. One such comparison, in two distinct epidemics, illustrated how the MoT model can overestimate the contribution of low-risk groups, underestimate the contribution of commercial sex, and thus underestimate the preventive potential of targeted interventions for commercial sex workers in the longer term (389). Moving forward, the current MoT process can be strengthened through greater understanding of the limitations of the model and the data, and careful and considered application and interpretation of the results.

This chapter demonstrated the use of a mathematical model at the national level to inform policy decisions for HIV prevention and programme planning, addressed policy-relevant issues from international applications of this model and developed guidance and recommendations for improved use of this tool. This chapter also moved from the pure desk analysis in Chapter 3 to a country-supported process using this tool, which provided initial insight into how these models are practically applied. However, it is still not apparent how decision makers and key stakeholders actually use the results from these models, and the role that this information has in programme planning and decision making. In the next chapter, these questions are examined with case study investigations in Zambia and Malawi.

## **Chapter 5**

### **Multi-case study investigation: Zambia and Malawi**

## Summary

This descriptive multi-case study explores the use of mathematical models in guiding national policy with respect to HIV interventions. The aims are to identify how models are used to inform HIV planning and decision making, to identify the barriers and facilitators to their use, and to map the key stakeholders in each setting. Two countries in sub-Saharan Africa substantially affected by HIV are opportunistically chosen for the study. A qualitative approach is used which draws on principles from grounded theory and a theoretical framework is used to guide and provide structure for the case study investigation. Data collection occurred via literature and document review and key informant interviews. Purposive sampling was used to target individuals with high levels of local knowledge, those in positions of influence, those with power of decision making, and those involved in mathematical modelling analyses – both model users and the consumers of information from models. The findings illustrate that a fundamental condition for use in both settings was demand from international stakeholders. In the policy environment, results from models were used to raise knowledge and general awareness, used to advocate for specific policies or programmes, and used to confirm or validate decisions already made on other grounds, aligning more with conceptual and symbolic use than instrumental use. Data availability and data quality remain key barriers to the use of results from models. Strengthening the quality of the data collected is necessary to enable the role of modelling to inform national programme planning. Development of local technical capacity is needed to support the use of models, interpretation and local ownership of modelling analyses and results. However, a sustained demand from programme planners for the use of this information is needed for investments made in strengthening local technical capacity to reach its full potential.

## Contributions

Funding to support the research in the chapter was received from the Bill and Melinda Gates Foundation (BMGF). I am very grateful to the study participants in both Malawi and Zambia and the pilot study participants from the southern Africa Regional Estimates Workshop; this work would not have been possible without their valuable contributions. I am also grateful to BMGF colleagues who facilitated access to study participants and inclusion in stakeholder meetings, including Felice Apter, Geoff Garnett, Marty Gross and Damian Walker. The preliminary data obtained were discussed with these same colleagues in the field. I received constructive queries and comments from my supervisors on the methods used, the results obtained and their interpretation.

## **5.1 Introduction**

In Chapters 3 and 4, mathematical models – the Goals model and the Modes of Transmission model (MoT) – were used to investigate the potential short and long-term future of HIV epidemics and the impact of interventions in order to inform HIV programme planning and policy decision making. The scenario modelling in Chapter 3 illustrated how the Goals model could be used to investigate the effect of different intervention strategies in specific contexts, identifying key prevention interventions for scale-up and the potential impact of expanding treatment coverage. Chapter 4 illustrated the use of the MoT model to predict the subpopulations in which HIV infections were expected to occur and addressed concerns raised at the international level regarding use of this model to inform HIV prevention planning. Both chapters illustrated the potential usefulness of models to inform HIV policy decision making and generated recommendations to further improve the use of these models for this purpose. Throughout this process, it became readily apparent that very little was known regarding how this information was actually used on the ground by decision makers in the countries substantially affected by HIV. As a result, the aim of the work in this chapter was to investigate how mathematical models and the outputs from these models are actually used in two high-burden countries in sub-Saharan Africa. Specifically, to identify who uses the models and the results from models, how they are used and the conditions for use – including barriers and facilitators to their use – and the role that they play at the national level for HIV agenda setting and policy formulation. Prior to this investigation, there were no other case studies identified in the literature on this topic in sub-Saharan Africa.

In this chapter I present the multi-case study investigation conducted in Zambia and Malawi. The chapter begins with brief country profiles to illustrate the two settings – epidemiologically and politically – at the time of investigation. Summary characteristics for each country are presented in Table 5-1. Next, the methods used are described, including the application of the theoretical framework and the initial pilot study, followed by the multi-case study. The results are then presented encompassing both country investigations, followed by the discussion.

## **5.2 Country settings**

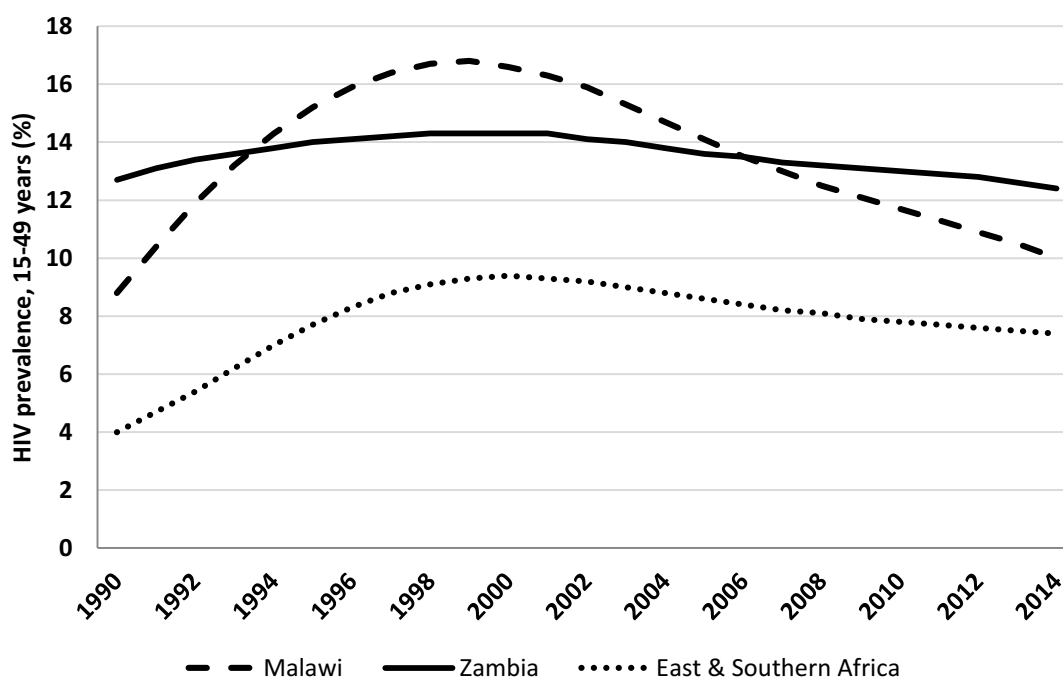
### **5.2.1 Country selection**

The study settings are two countries in sub-Saharan Africa substantially affected by HIV – Malawi and Zambia. These countries were opportunistically selected because they are widely English-speaking, alleviating barriers to access due to language issues, and because they both had multiple modelling analyses underway at the time of investigation. Importantly, they were also

selected because access to a wide spectrum of high-level stakeholders would be achievable in collaboration with the Bill and Melinda Gates Foundation (BMGF) allowing for the collection of a rich dataset. The timing of this analysis coincided with BMGF considering investments in Zambia and Malawi to support the government and partners of each country to facilitate and strengthen the use of data and strategic information for HIV-related decision making. This opportunity allowed the researcher to work with BMGF and coordinate field visits to gain additional access to government officials and key partners.

The geographical proximity and similar cultures and government structures of these two countries, both former British colonies and united for a decade as the Federation of Rhodesia and Nyasaland (390), may arguably also facilitate comparison and contrast. There was also an anecdotal perspective of different interaction between the government and donors in the two settings. Both countries have been substantially affected by HIV and may today be considered to suffer from mature epidemics. HIV prevalence in these countries exceeds the regional estimates of HIV prevalence from eastern and southern Africa, Figure 5-1.

**Figure 5-1 Estimates of adult HIV prevalence in Malawi, Zambia and East and Southern Africa (391)**



Zambia and Malawi have both used mathematical models to generate national estimates of HIV, with technical support from UNAIDS, since early 2000. Both countries completed Modes of Transmission analyses in 2008 (172, 292) and were updating these analyses in 2013 at the time of the case study investigations described here. At the same time, each country was using the

Goals model to generate HIV projections which consider different scenarios of intervention scale-up to inform strategic resource allocation. These analyses were occurring with the support of UNAIDS and the World Bank as UNAIDS Investment Case countries. The Investment Case represents the use of a strategic framework – the UNAIDS Investment Framework – to support more strategic decision making and resource allocation for HIV (392). These same analyses were also occurring to support country funding proposals to the Global Fund.

### **5.2.2 Zambia - Country profile**

The Republic of Zambia is a lower middle-income country situated in southern Africa with a population just over 15 million (393). Geographically, it is an expansive, landlocked country with diverse terrain. As such, nearly half of the population is concentrated in urban areas and along the major transport corridors while the rural areas are sparsely populated.

HIV has had a significant impact in Zambia. The first case of AIDS was identified in 1984 and estimates of HIV prevalence illustrate a rapidly increasing epidemic that peaked in the mid-1990s and has remained fairly stable in the past decade (394). In 2014, prevalence of HIV was estimated at approximately 12.4% (adults 15-49 years) with approximately 1.2 million adults living with HIV (395), Table 5-1.

Politically, Zambia is a democratic republic with a multi-party system since 1991. The president is both head of state and head of government. The recently deceased president, Michael Sata of the Patriotic Front, was elected in 2011, succeeding Rupiah Banda. With the arrival of the new government in 2011, a new Ministry of Community Development, Mother and Child Health (MCDMCH) was created, essentially splitting the Ministry of Health (MoH) in two. Priorities, budgets and staff were reallocated across the two ministries with the roles of the MCDMCH concerned with maternal and child health, social welfare, community and local level issues (and facilities), while the MoH roles include hospitals, public health, clinical services and disease surveillance. This transition was still in progress and not yet precisely defined during the study visits in 2013. The transition in personnel reapportioned across the two ministries had affected both capacity and coordination at the Ministry level.

Zambia was also in a decentralisation process at the time of the study visits. The stated aim of the devolution was to empower local level decision making, to facilitate greater community involvement and to provide better care for vulnerable populations, children and elderly. As part of this process, political decision making and resource allocation powers moved from the central state level to the municipal authorities. The decentralisation was still in early stages at the time of the case study investigation and there was substantial confusion and lack of clarity expressed

from government, donors, international organisations and other partners regarding precisely how this would occur and how resources would be distributed.

### **5.2.3 Malawi - Country profile**

The Republic of Malawi is a low income country with a population of nearly 17 million people (396). Geographically, it is situated in south-eastern Africa, landlocked, and comprised of diverse terrain with the vast majority of the population living in rural areas. Malawi shares a border with Zambia and the two countries share similar values, culture, and languages (Zambians and Malawians often refer to each other as “brothers”), and there is a high level of migration between the two countries.

Malawi is a democratic republic with a multi-party system since 1993. The president is both head of state and head of government. There is a presidentially appointed cabinet and ministers, and deputy ministers direct, coordinate and supervise the activities of their assigned ministries and government bodies. At the time of the study visits, Joyce Banda was the country’s fourth president since the reintroduction of the multi-party system, and the first female president. President Banda was the Vice President under President Bingu wa Mutharika who died in April 2012 during his second term in office. Banda’s two-year presidency was marred by the largest financial scandal in the country’s history, “Cashgate”, uncovered in September 2013 with the shooting of the Budget Director at the Ministry of Finance followed by public allegations of massive embezzlement by government officials (US \$100 million). At the timing of the second visit (November 2013), donors had suspended approximately US \$150 million in aid and investigations were underway (397).

HIV has had a substantial impact in Malawi. The first case of AIDS was identified in 1985 and estimates of annual new infections illustrate a rapidly increasing epidemic that peaked in the late 1990s and remained fairly stable before declining around 2004 (398). In 2014, prevalence of HIV was estimated at 10% among adults (15-49 years) with just over one million people living with HIV in Malawi (399). The prevalence of HIV varies by geographical setting with higher prevalence in urban versus rural areas and higher prevalence in the southern region than in the central and northern regions (400). One of the least-developed countries in the world, Malawi has minimal capacity for contributing its own resources to the HIV response. Over 65% of health expenditure in Malawi is funded by donors (401).

**Table 5-1 Characteristics of the case study countries, 2014**

|                                                                 | <b>Zambia</b>                      | <b>Malawi</b>                      |
|-----------------------------------------------------------------|------------------------------------|------------------------------------|
| <b>Population size</b> (393, 396)                               | 15.02 million                      | 16.83 million                      |
| <b>Population area (402)</b>                                    | 743, 398 km <sup>2</sup>           | 94,080 km <sup>2</sup>             |
| <b>HIV prevalence</b> (15-49 yrs)(395, 399)                     | 12.4%                              | 10.0%                              |
| <b>PLHIV</b> (all ages)(395, 399)                               | 1,200,000                          | 1,100,000                          |
| <b>GDP per capita</b> (USD)(403)                                | \$1,802                            | \$253                              |
| <b>World Bank income classification</b> (404)                   | LMC                                | LIC                                |
| <b>Health expenditure per capita*</b> (USD)(405)                | \$93                               | \$26                               |
| <b>Nurses &amp; midwives per 1,000 people<sup>†</sup></b> (406) | 0.8                                | 0.3                                |
| <b>Government</b>                                               | Multi-party democracy (since 1991) | Multi-party democracy (since 1994) |

*LMC = lower-middle income*

*LIC = low income*

*\*2013, <sup>†</sup>2010*

### 5.3 Methods

A qualitative case study design was used to allow for in-depth investigation and exploration of more complex questions within the local context. Moreover, a multi-case study design, restricted for practical reasons to a two-country comparison, was used to reduce over-generalisation and potential context-specific effects with only a single case, and to allow for comparison and contrast between the countries. There were three key components of the case study investigation process (i) the development and application of the theoretical framework, (ii) the development and execution of the pilot project, and (iii) the case studies conducted in Zambia and Malawi. The methods for each component are described herein and draw predominantly from Yin (407), Corbin & Strauss (301) and George & Bennett (354). The methods used draw on principles from grounded theory, using simultaneous data collection and interpretation as part of an ongoing and iterative process. Figure 5-2 illustrates the timing for each component of the case study investigation.

The primary research question under investigation in the case studies:

- **How are mathematical models, and results from models, used (or not used) to inform HIV programme planning and decision making at the national level?**

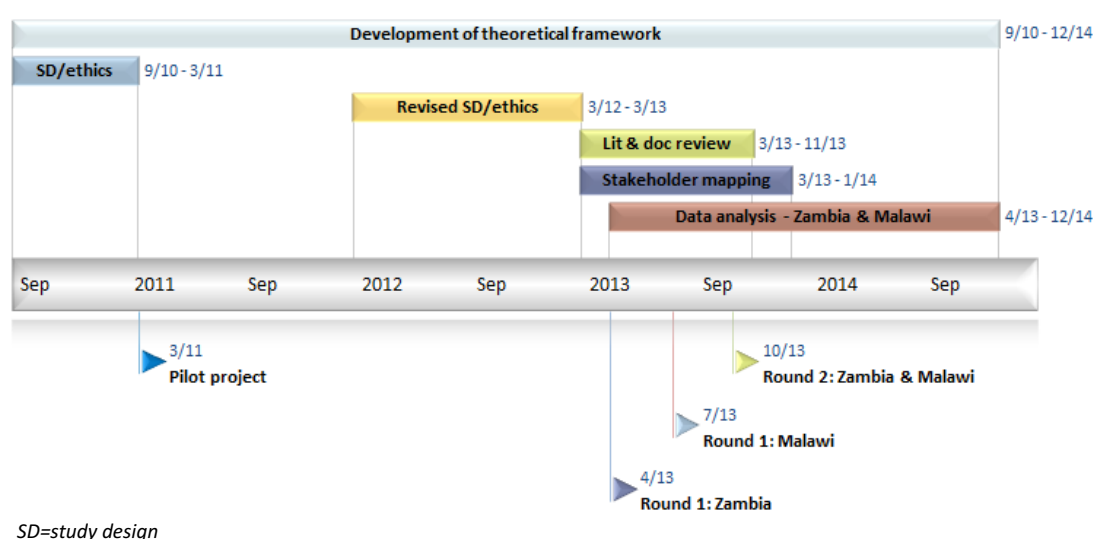
The associated study questions include:

- Who are the key stakeholders involved in HIV programme planning and decision making for HIV? What is their level of interest in modelling processes, and level of potential influence for HIV-related decision making in country?

- What are the barriers and facilitators to the use of mathematical models and the results produced – under what conditions are results from mathematical models used to inform decision making for HIV? What types of modelling results are used as evidence and what role do they play in decision making?

Ethical approval was granted by the Imperial College Research Ethics Committee. The approved ethics application is included in full in Appendix 5-1.

**Figure 5-2 Timeline of the case study investigation**



### 5.3.1 Theoretical application for examining research utilisation in the case studies

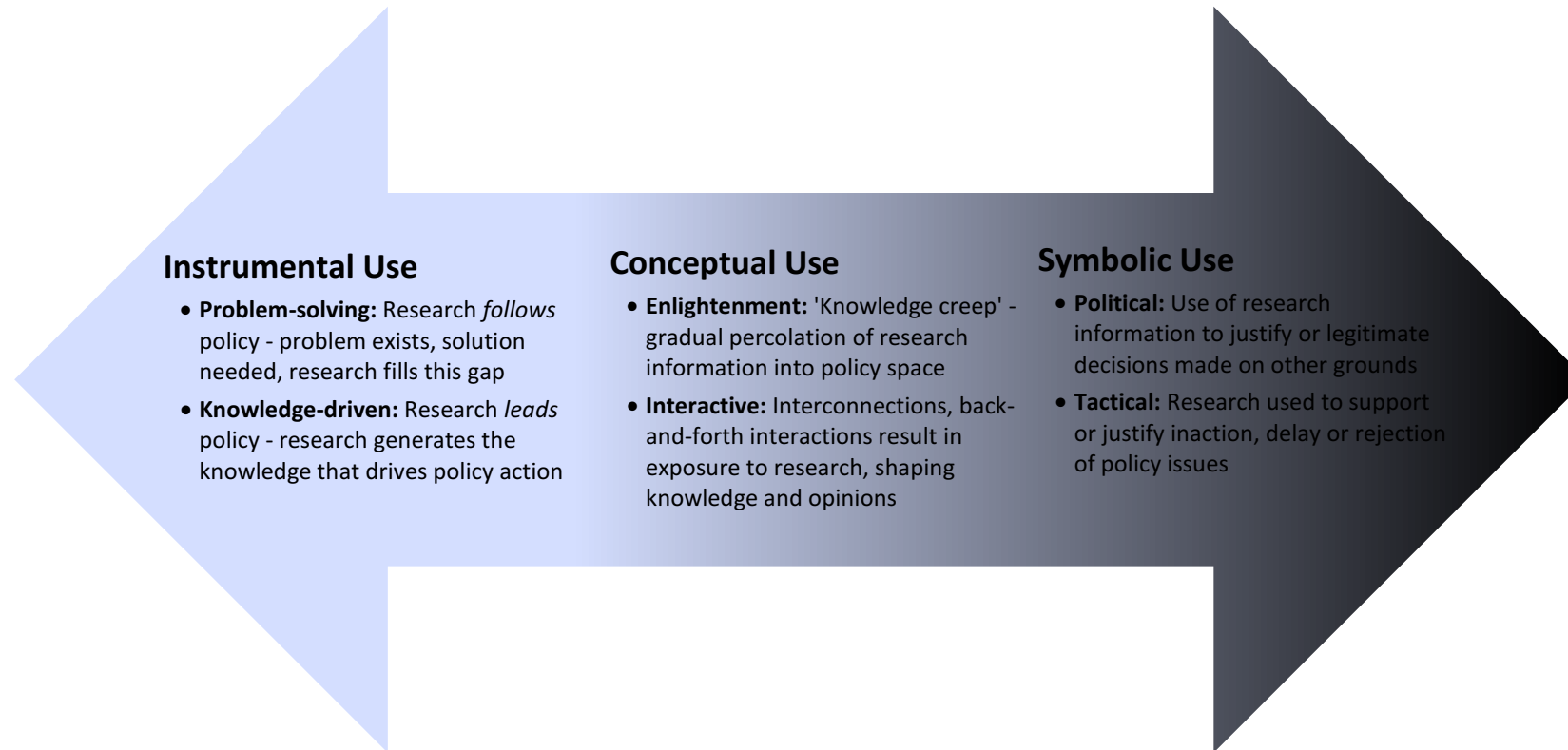
The theoretical framework developed and described in detail in Chapter 2 was used to organise and guide the research inquiry. The multi-case study examines research utilisation at the national level in two low- and middle-income (LMIC) countries in sub-Saharan Africa. Research utilisation is defined here as the use of mathematical models and results from models to inform HIV programme planning and decision making. The scope of the analysis is the national level, the level at which results from the Goals, MoT and EPP/Spectrum models were produced, and focuses on research utilisation in the agenda setting and policy formulation stages of the policy cycle.

In order to address the primary research objective, the focus was to analyse the data from the lens of the research utilisation spectrum – conceptual, instrumental and symbolic use – applying the theory to the data, in this case considering the different types of research use and applying

the different explanatory models of research utilisation, Figure 5-3. The explicit intention was to maintain a broad perspective and to not be prescriptive with the underlying theory in order to remain open to new findings, comparing how the findings aligned, opposed or diverged with and from the explanatory models within the theoretical framework. This approach is distinct from pure grounded theory whereby the research process is entered entirely naively and theory is developed from the data collection and interpretation process.

The theoretical framework provided three interpretations of research utilisation. Each interpretation included different explanatory models of research utilisation for consideration (Figure 5-3). It was initially hypothesised that results from mathematical modelling would be of direct and instrumental use to inform resource allocation, HIV programme planning and policy decision making. This was based on (i) the global focus on evidence-informed decision making and the need for more strategic and efficient HIV programmes in an environment of limited resources, and (ii) the substantial increase in mathematical modelling applications and donor and country-supported modelling processes. As such, examples of knowledge driven or problem solving explanatory models of research utilisation could be expected. Following the review of theoretical perspectives on research utilisation, the literature highlighted that conceptual use of mathematical models may be a more realistic expectation in light of political realities and the many factors involved in decision making. Thus, it was alternatively hypothesised that the influx of different mathematical models and modelling processes over time would have gradually gained traction and would slowly and incrementally result in changes to the status quo, aligning more with the enlightenment explanatory model. Or that the back-and-forth interactions between model users and donors, and between model users and the government, would result in changing awareness and more general knowledge building, again conceptual use of models. In contrast, the alternative hypothesis for consideration was that there may be more symbolic use of mathematical models. Both countries are fairly new democracies, and may perhaps be characterised by elitism with power more centrally concentrated, or characterised by elite pluralism given the potential for substantial donor influence. As a result, the political or tactical explanatory models may have relevance in these settings.

Figure 5-3 Types of research use and explanatory models of research utilisation



### **5.3.2 Pilot project**

A pilot project was conducted in advance of the multi-case study to develop the line of questioning in the semi-structured interviews, identify emergent themes and provide initial mapping of key stakeholders. Selection of the pilot project setting and participants was influenced by relevancy to the multi-case study and access to key informants. The Joint United Nations Programme on HIV/AIDS (UNAIDS) supports countries to generate national estimates of HIV and related indicators published in the UNAIDS Global Report (288). Countries participate in regional training workshops to obtain technical guidance on the model used to generate these national estimates (EPP/Spectrum). In cooperation with UNAIDS, the pilot study was incorporated into a UNAIDS HIV Estimation Workshop for the southern Africa region in March 2011. The role of the researcher at this workshop was both as a PhD student conducting the pilot study and as a workshop facilitator for UNAIDS providing technical advice and support to countries on the use of EPP/Spectrum.

The objectives of the pilot were broadly consistent with those for the multi-case study. Lead members of each country technical team were contacted via email in advance of the workshop, notifying them of the exploratory study and requesting an interview time during the country workshop. Interviews occurred both in small groups and one-on-one. All interviews were conducted by the researcher. Semi-structured interviews were conducted with 17 individuals from seven different country programmes over the course of three days, 21-23 March 2011. Interviewees predominantly had technical backgrounds including monitoring and evaluation, epidemiology and statistics. They worked in the Ministry of Health, with international organisations, NGOs and donor organisations. To encourage free speech and flow of information, the interviews were not recorded but detailed notes were taken and entered into Microsoft Word and then uploaded into NVivo 10 software which was used for storing and coding the data and a general thematic analysis.

The results from this study were presented October 20<sup>th</sup>, 2011 in Seattle, USA at a meeting of the UNAIDS Reference Group on Estimates, Modelling and Projections (408). The information gleaned from the pilot study was used to refine the semi-structured interview schedule, to identify key potential stakeholders (donor groups, technical and Ministry contacts), and used to generate a preliminary list of emergent themes. This provided a foundation level of knowledge and understanding of how mathematical models and results from models are perceived by different stakeholders – technical, Ministry, donor, international community. The pilot study also provided the opportunity to become familiar and comfortable with the interview schedule and to establish a rapport with the interviewees.

### **5.3.3 Multi-case study investigation**

A descriptive multi-case study design was used for the case study investigations in Malawi and Zambia. The original intention was for a prospective analysis of research utilisation, to follow an unfolding process in real time from use of a mathematical model in-country (Modes of Transmission model or the Goals model), obtaining results and generating programme and policy recommendations for key stakeholders. In the field it became apparent that it would be both more feasible and insightful to conduct a retrospective analysis (past 5 years), incorporating any HIV modelling processes, but with particular focus on the Goals, MoT and EPP/Spectrum models. The methods used were replicated in the same manner for each country.

#### *Data collection*

Data collection occurred in three ways:

1. Literature and document review
2. Face-to-face informational interviews (Round 1)
3. Face-to-face, in-depth, semi-structured interviews (Round 2)

The literature and document review process for each case study investigation was ongoing March-November 2013 and included both published and grey literature, the latter which comprised country progress reports, donor programme reports, presentations, minutes and reports from stakeholder meetings, grant proposals, draft analyses, operational plans, internal memos, and other internal communication documents from stakeholders and key informants. The document review process began first with a review of documents available in the public domain identified through literature searches, online searches and via the websites of key stakeholder agencies. Internal documents were then obtained during the case study investigations directly from key stakeholders and key informants. Local newspapers published online were also reviewed throughout the study investigation period to provide background information on local and national topics of contemporary political interest.

The purpose of the literature and document review was to gain a general understanding of: (i) past programme and policies in each country (ART and PMTCT guidelines, prevention programmes and programmes for key populations), (ii) different mathematical models and modelling processes conducted (or underway) in each country, and (iii) the different key individuals, groups and organisations working in HIV in each country. This process served to provide background information for each context, to familiarise the researcher with the projects and organisations in each country, to identify key stakeholders for interviews and to inform the stakeholder mapping conducted in each country. The document review also provided the

opportunity to identify the level of consistency (through triangulation) between the information obtained during the interviews and what was reported in both national and international literature.

#### *Stakeholder mapping*

The stakeholders involved in HIV programme planning and decision making are broadly classified into government, local non-government organisations (NGO), intergovernmental (e.g. United Nations), international organisations, academic and civil society. The stakeholder mapping represents a cross-sectional view of an ever-evolving situation, illustrating relationships and defining interests and influence of the different individuals, groups and organisations in order to provide a better understanding of each context. For this study, stakeholder mapping was used to identify key stakeholders for HIV programme planning, policy decision making and resource allocation in each country. Additionally, the information obtained from the stakeholder mapping was used to inform an interest and influence matrix, which adapted methods used by Varvasovszky (409) and the Research and Policy in Development (RAPID) team at the Overseas Development Institute (410) to present position maps for each country. These position maps are a qualitative assessment of the influence (defined by the level of funding and engagement with decision makers) and interest (in relation to mathematical modelling using a scale quantifying the direct involvement with mathematical modelling analyses and processes) of key stakeholders. The purpose of the position maps in this chapter is to provide an illustrative representation used to frame the results from the stakeholder mapping. The stakeholder mapping was conducted independently and updated throughout the case study investigations, initially drawing from the pilot study and document review and then updated with each round of key stakeholder interviews. The stakeholder mapping was also used to inform the initial sampling frame for the informational interviews (Round 1).

#### *Informative and investigative interviews*

Purposive sampling was used for the interview sampling frame in order to allow for a detailed investigation of the study questions. This allowed for the targeting of individuals with high levels of local knowledge, those in positions of influence, those with power of decision making, and those involved in the modelling processes of interest – both model users and the consumers of information from models. The initial sampling frame was informed by the document review and stakeholder mapping, those identified in the exploratory pilot study, and importantly those identified by a local informant in-country. The local informant, a BMGF consultant based in Lusaka, played a critical role in organising interviews. As an “insider” based locally and actively engaged with donors and government, she was able to facilitate and secure meetings with high-

level individuals including country programme directors and Ministry officials. The sampling frame was further expanded as additional individuals were identified in interviews, and in order to provide alternative viewpoints. This sampling frame allowed for a detailed and efficient exploration of the research questions and provided a wide range of perspectives.

Two field visits were conducted in each country, with initial informative interviews (Round 1) occurring in Zambia over five days in April 2013, and occurring in Malawi over seven days in July 2013. The purpose of the initial visit was to meet with the government, organisations, partners and individuals working on HIV-related projects and programmes in these countries. These interviews provided a detailed view of the landscape of HIV-related projects and programmes (recently completed, in-progress and planned), the key organisations and stakeholders involved, and sought to identify the organisations and individuals in each country using mathematical models, and the modelling processes and analyses in progress. These interviews provided a broad but detailed overview of each country context from the lens of HIV programme planning, decision making and resource allocation.

The subsequent in-depth, semi-structured interviews (Round 2) were conducted during a second field visit to both Zambia and Malawi at the end of October and beginning of November, 2013. These interviews were more specific and technical, probing in greater detail on the use (and disuse) of mathematical models including the Goals and Modes of Transmission models (described in Chapters 3 and 4 respectively) and EPP/Spectrum. A semi-structured interview guide with open-ended questions was used in order to obtain the viewpoint and perspective of the interviewee with an emphasis on their experience and understanding while still covering a set of identified topics which aimed to address the key study questions. These topics focussed on the models used, how they were used (or not used), perceived importance of the modelling process and results obtained, quality of the results obtained, the key issues encountered as part of the modelling process (as model user or consumer of model results) including barriers and facilitators to the use of models, and the key stakeholders in each setting including those with power of decision making, those with potential influence as a result of funding and donor support, and those with direct involvement as model users, consumers, or supporters of modelling exercises (Appendix 5-1).

For both rounds of interviews, the position of the researcher was both as an Imperial PhD student and a BMGF consultant which was explained to each interviewee. To encourage free flow of information, the interviews were not recorded. Detailed notes were taken and transferred into MS Word after each interview. The researcher additionally attended high-level

meetings with Head of State, Ministry officials, BMGF colleagues and key stakeholders, but participation at these high-level meetings was predominantly from an observation perspective.

#### *Data storage, coding and analysis*

The researcher reviewed the data directly, or shortly after, each interview and compiled key findings and any items for further follow-up or investigation. In Zambia, the initial interviews were followed by de-brief with the local informant to reflect upon the information gleaned and to further contextualise the key findings. In Malawi, the initial interviews were followed by de-brief with a BMGF colleague. The detailed interview notes were transcribed into MS Word and then again analysed (content analysis) and roughly coded into broad emergent themes (initial coding) (300). The MS Word transcripts were then imported into NVIVO 10 where they were electronically coded (focused, selective coding) using a thematic coding scheme initially devised from the content analysis and the theoretical framework but continually evolving as new information was obtained (300). Whenever a new code was identified, each prior interview was then re-coded in specific relation to the new code. After completion of the thematic coding, all data were then coded specifically from the lens of the theoretical perspectives, first with regards to the utilisation spectrum, and then with regards to each explanatory model of interest. Ongoing memoing and synthesis of the information obtained occurred throughout the data collection process.

The overarching analytic strategy was to use the theoretical framework to guide the analysis, applying the theory to the data and relating the different explanatory models, and alternative hypotheses, to the findings. While rooted in grounded theory, the analysis was less of a naïve process than would be used with pure grounded theory, informed by the knowledge obtained during the document review and the pilot study, and guided by the theoretical framework. The analysis of the interview data was further complemented with triangulation of other data sources including published and grey literature.

## **5.4 Results**

In Zambia, initial interviews (Round 1) were conducted with 45 individuals from 19 different organisations. In Malawi, initial interviews were conducted with 43 individuals from 21 different organisations. Across both countries, in-depth interviews (Round 2) were conducted with 22 participants from 15 organisations. Table 5-2 describes the distribution of interviewees by type of stakeholder in each setting. There were more overall interviews conducted in Zambia. Across settings, there were comparable numbers of government and civil society stakeholders interviewed in each setting. In Zambia, there were more intergovernmental and academic

stakeholders interviewed compared to Malawi, while in Malawi a greater number of stakeholders from international organisations were interviewed than in Zambia. The interviewees were high-level individuals within each organisation, individuals with position of influence in government or technical experts. The interview schedules are included in Appendix 5-2, but for confidentiality the names of the interviewees and the specific organisations have been removed. Because of similarities and comparisons to be made across contexts, the results are presented for each study question as opposed to presenting the results separately for each country. The results from the stakeholder mapping are presented first, followed by the investigation on research utilisation, and finally, the barriers and facilitators to the use of models identified.

**Table 5-2 Distribution of interviewees by stakeholder type**

| <b>Stakeholder Type</b>  | <b>Zambia</b> | <b>Malawi</b> |
|--------------------------|---------------|---------------|
| <b>Government</b>        | 23            | 22            |
| <b>Intergovernmental</b> | 14            | 4             |
| <b>International</b>     | 12            | 17            |
| <b>Academic</b>          | 7             | 3             |
| <b>Civil society</b>     | 2             | 2             |
| <b>Local NGO</b>         | 3             | 1             |
| <b>Total</b>             | <b>61</b>     | <b>49</b>     |

#### **5.4.1 Stakeholder mapping**

The stakeholder mapping was conducted to generate and document knowledge about the actors involved in HIV-related research and decision making in each setting in order to better understand the environment within which programme planning and decision making for HIV occurs, and to better understand those actors involved with mathematical modelling analyses in each context. This descriptive approach included the identification and characterisation of each organisation, the HIV-related projects planned, underway and recently completed (past five years), the potential stakeholder influence (defined via funding and engagement and relationships with decision makers), and their interest as it pertains to mathematical modelling, defined by quantification of involvement in modelling processes or use of model results in the local context. The stakeholder mapping, which includes all stakeholder organisations identified, is presented in full in Appendix 5-3.

In Figure 5-4 a position map illustrates the key stakeholder organisations identified with respect to interest and influence. The position map provides an overview of a qualitative assessment of both the potential influence in the HIV programme planning and decision making environment and interest as it pertains to mathematical modelling elucidated during the two rounds of interviews and complemented by the document review. The key stakeholders are categorised into five types of organisations: government, academic, international, intergovernmental and civil society. Further justification for the qualitative assessments of the level of interest and influence for each stakeholder is included in Appendix 5-3.

Across the two contexts, the mapping illustrated some broad similarities in the level of interest and influence of key stakeholders. With regards to mathematical modelling, the same organisations in each context were involved with, and leading, the modelling analyses under focus, while other international organisations were providing support for these analyses and conducting their own modelling analyses. In both countries, UNAIDS is the lead organisation for the HIV models under focus, providing both technical and financial support for the analyses. UNAIDS guides the Investment Framework (Goals), MoT modelling, and the national estimates process (EPP/Spectrum), but with an aim for local ownership of modelling applications. Local ownership (government) is facilitated with technical support from UNAIDS and international consultants. UNAIDS works closely with NAC (the National AIDS Council in Zambia and the National AIDS Commission in Malawi) which has the mandate to coordinate the HIV/AIDS response, in order to support the use of these modelling analyses in-country.

In Zambia, NAC was created by Parliament as a separate organisation which sits across all ministries (411). At the time of the study, a re-structuring of this organisation had resulted in diminished capacity and weakened influence. NAC was also subject to funding cuts (412) and international and intergovernmental stakeholders indicated the future existence and structure of the organisation was in question (411, 413, 414). International stakeholders reported there was a need for a stronger link between NAC and the MoH (415). Similarly, in Malawi the NAC is multi-sectoral, responsible for coordination of the HIV/AIDS response across all ministries and also the principal recipient of Global Fund grants (416). At the time of investigation, NAC in Malawi was regarded by international stakeholders as weaker than it had been under previous leadership and exhibiting a lack of engagement (417, 418). In both countries, NAC plays a lead role in the key modelling processes under focus – the Investment Framework analysis using the Goals model, the MoT analysis and the national estimates using EPP/Spectrum.

The Clinton Health Access Initiative (CHAI) is an international stakeholder that aims to align itself directly with country governments. In both countries CHAI was working directly at the Ministry level – with the MoH in Malawi and with both the MoH (national level projects) and MCDMCH (local level projects) in Zambia. The government in Zambia expressed this close working relationship citing CHAI as a strong technical partner (419). CHAI has its own models and modelling processes, used with the objective to improve efficiencies. It was noted by international stakeholders in both countries that CHAI is the technical force behind many of the HIV-related outputs from the government (420-423).

The United States Centers for Disease Control and Prevention (CDC) has substantial investments in both countries and funds (and leads) a wide range of HIV surveillance, survey and data-driven endeavours which in turn are used to inform the mathematical models. The US CDC also supports and leads in local technical training programmes in Zambia and funds technical placements within the Ministry of Health in Malawi (417, 424, 425).

The Bill and Melinda Gates Foundation fund partners and multi-lateral organisations to conduct work central to its own internal strategy. In both countries, BMGF was funding the key partners that support the modelling work that was being used by UNAIDS, the US Government, and the Global Fund, amongst others. The foundation was also funding different costing analyses subsequently used to inform the mathematical modelling, for example facility-level costing of antiretroviral treatment (426, 427). At the time of investigation, the foundation was also in the planning stages for providing grants directly to each government in order to support improved data use for decision making.

In both countries, civil society organisations are actively engaged and have direct and indirect links to government officials (428). Many of the groups are faith-based, focusing at the community level and working through religious leaders (429). Advocacy is a key focus, addressing stigma, discrimination and issues surrounding HIV prevention, testing, treatment, treatment adherence and care (430). A representative from civil society sits on the Global Fund country coordinating mechanisms (CCM), the multi-stakeholder partnerships that work to develop and submit country proposals to the Global Fund. Civil society representatives are also engaged with UN and international organisations working in country including UNAIDS, WHO, StopTB and the Vaccine Alliance (Gavi) as board members and representatives (428).

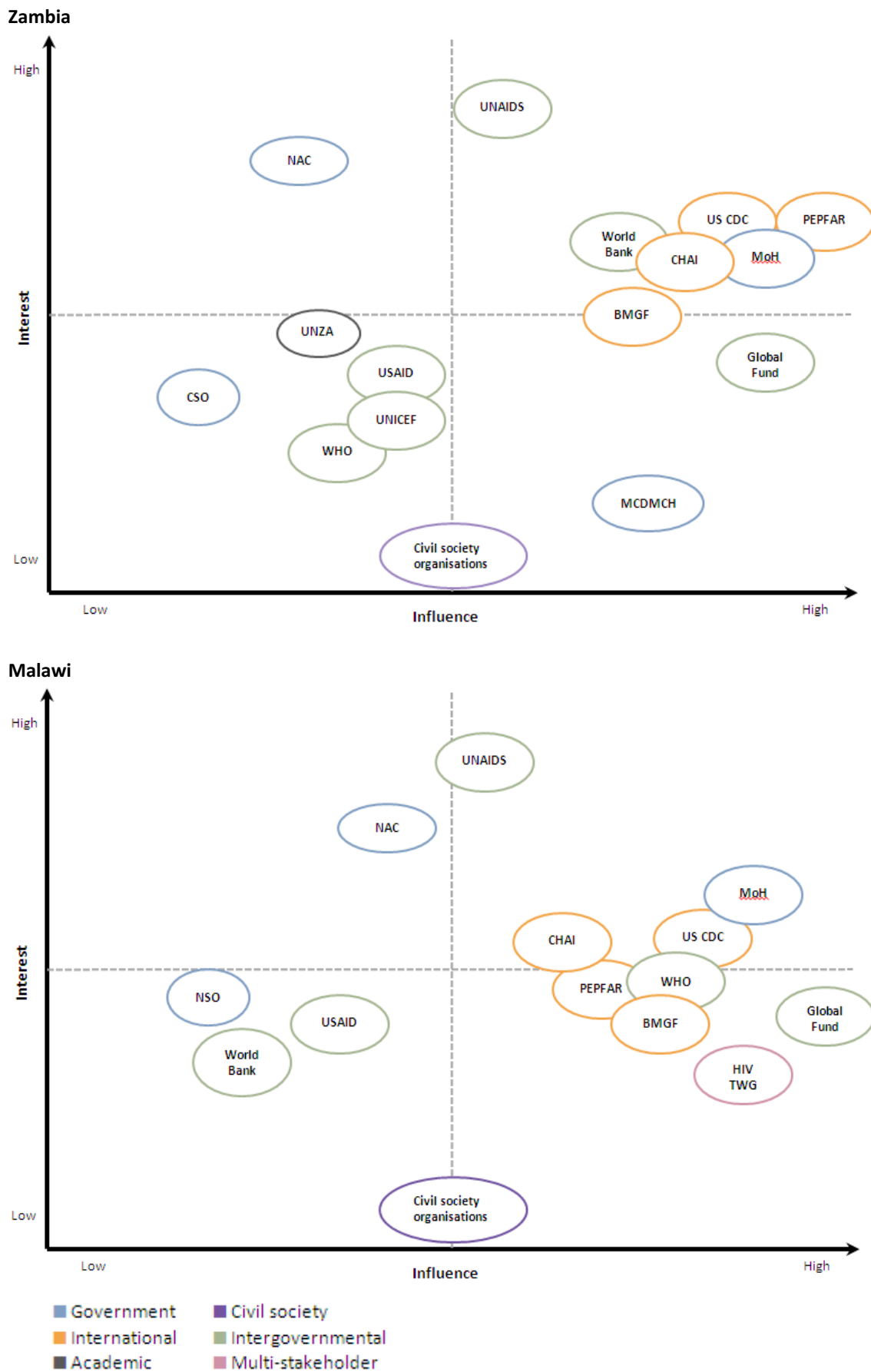
While there are many broad similarities across the two landscapes, there are a few key differences. The major funder in each setting differed as did the role of PEPFAR. In Zambia, PEPFAR was reportedly the largest donor at the time of the study visit with over US \$300M in

planned funding for 2013 (431) and was estimated to be funding the vast majority of HIV treatment in Zambia (432). The Global Fund was cited as the next largest donor (412), providing substantial financial support with approximately US \$100 million disbursed in 2012 (433, 434). PEPFAR supports and conducts many of its own modelling processes. Country funding applications to the Global Fund (concept notes) necessitate modelled projections of the estimated future disease burden and need for ART and PMTCT. Both PEPFAR and the Global Fund partake in regional EPP/Spectrum modelling workshops to provide technical support for countries as they produce their national estimates.

In Malawi, it is the Global Fund that is the major funder with the strongest donor influence, supporting the core components, and the vast majority, of the national HIV response (416, 435). With the strong reliance on the Global Fund, PEPFAR has less influence compared to Zambia and other countries in sub-Saharan Africa. There are no PEPFAR clinics or facilities in Malawi, and PEPFAR plays more of a support role here, with US \$75 million in planned funding in 2013 (436). PEPFAR supports the Malawian government's national HIV/AIDS response providing technical guidance at the national level in support of ART scale-up, implementation of HIV prevention programmes, and health system strengthening (435).

The World Bank also had different roles in each context. In Zambia, intergovernmental stakeholders indicated that the World Bank works directly with NAC and the government to provide assistance on projects led by the government (437). The World Bank plays an active role in modelling analyses and was in charge of the scenario analysis for the UNAIDS Investment Framework analysis (438). In contrast, the World Bank does not have a country office or a lead presence in-country in Malawi, and here the funding from the World Bank goes directly to NAC (439, 440).

Figure 5-4 Key stakeholder mapping: Zambia and Malawi



There were also differences in the political environments during this time. In Zambia, the case study occurred soon after the Ministry of Health had been divided into two ministries with a newly formed Ministry of Community Development, Mother and Child Health which resulted in the re-allocation of MoH staff to MCDMCH (see Section 5.2.3.) The roles of the MCDMCH were still being defined at this time, but the intention was to focus on community health (at the district and facility level) and service delivery, while the MoH would focus on hospitals, disease surveillance and research (441). Academic stakeholders cited interest from the MoH and MCDMCH in spatial mapping exercises (424).

As mentioned previously, Malawi was in the midst of the 'Cashgate' scandal with investigation into public allegations of substantial embezzlement by government officials (442-445). This had resulted in many donors freezing funding while the investigations were underway (446-448). Malawi has minimal capacity to contribute financially to the HIV response (440) and is heavily reliant on donor funding which accounts for over 90% of the national response (435) thus donor relationships were a key area of government focus at the time of investigation. There was also a presidential election on the horizon occurring in May 2014.

In Malawi, the Office of the President and Cabinet (OPC) has the mandate to provide policy advice and support to the President and Cabinet. Within the OPC, the Ministry Department of Nutrition, HIV/AIDS, is responsible for policy and high level advocacy for HIV/AIDS (416). The MoH in Malawi drives the overall health programme and it is also the primary sub-recipient of Global Fund grants. Within the MoH sits the HIV Unit which collects, analyses and reports all of the national HIV data – collecting the HIV data directly from clinics and widely distributing the updated reports on a quarterly basis (440, 449). This is a separate data collection process from the national Health Management Information System (HMIS) and is viewed as arguably the highest quality national data collection in sub-Saharan Africa (450). The HIV Unit in Malawi is regarded by stakeholders as very strong (418) but there are concerns regarding the longer-term sustainability of the strength of this Unit in terms of technical capacity across different levels (451). Key technical and analytic support within the HIV Unit is provided by the International Training and Education Center for Health (I-TECH), a center in the Department of Global Health at the University of Washington that works globally to support the development of health work forces and health delivery systems (452). HIV/AIDS is the key focal area for I-TECH in Malawi and quantitative technical assistants are seconded to the Ministry, most notably in the HIV Unit, to provide key technical, analytical and systems support.

Unique in Malawi was the role of what was described by both government and international stakeholders as a highly functioning, and highly organised technical working group (TWG) for

HIV (416, 420, 440, 453). This multi-stakeholder group, comprised of technical experts, exists as a forum to review and discuss clinical trial results, global and regional guidelines and works for consensus to produce policy recommendations (416). The strategies and recommendations produced by this group go to the Permanent Secretary in the Department of HIV/AIDS for endorsement and then go on to the OPC (453). The strategy that is now called 'Option B+' for the prevention of mother-to-child transmission – lifelong antiretroviral treatment for all HIV+ pregnant women regardless of CD4 count – is an example of a policy recommendation generated by this HIV TWG and subsequently adopted as national policy in Malawi (454). However, one government stakeholder did express the belief that the creation of Option B+ “was unique” and that other decisions, particularly non-biomedical decisions, are not as simple as they cut across many different policy-making bodies and there are not systematic or established structures of policy making in place to facilitate this process (455). A similar sentiment was expressed in Zambia with the desire for more transparency surrounding policy decision making. The Public Health Information Act has been proposed in Zambia which would be an open record of how public health and education decisions are made in government. It was expressed that there have been ongoing discussions regarding this act with little progress moving it forward (456).

#### **5.4.2 Research Utilisation**

Research utilisation, defined here as the use of mathematical modelling or results from modelling to inform HIV programme planning, decision making and resource allocation, is considered from the perspective of the research utilisation spectrum. The analysis focuses predominantly on the use of three mathematical models – the UNAIDS Modes of Transmission (MoT) model used to estimate the predicted distribution of new HIV infections in the next year, the Goals model used to generate projections and conduct scenario analyses for the UNAIDS Investment Framework analysis, and EPP/Spectrum used to produce national estimates of HIV and related indicators. The use of any other mathematical models to inform decision making was also queried.

##### *Instrumental and Conceptual Use*

Instrumental use of mathematical modelling represents use in a very direct and specific way, whereby a specific decision or action is directly attributable to the use of mathematical models. In both Zambia and Malawi, there were no concrete examples of instrumental use of the Goals and MoT models – exemplified by the knowledge driven or problem solving explanatory models (discussed in 2.2.1) and corroborated by multiple stakeholders – that were identified to inform HIV programme planning and decision making in the case studies. Despite there being no concrete examples, there did appear attempts by key stakeholders for modelling information to

be used instrumentally. These examples further illustrate the relevance of viewing utilisation as a continuum.

In Zambia, it was stated by intergovernmental stakeholders that a key aim was to use the potential policy window of the Joint Mid-Term Review (JMTR) of Zambia's National HIV/AIDS Strategic Framework (NASF) to allow evidence to inform policy (425, 438). The NASF guides Zambia's national response to HIV and the purpose of the JMTR was to review the available evidence base, in conjunction with the NASF, halfway through the five-year plan and identify necessary revisions in order to further improve this response. One intention, stated by both intergovernmental and international stakeholders, was for results from the Investment Framework analysis (conducted using the Goals model) and the MoT model to be able to directly inform the JMTR – to identify where successful HIV responses were occurring and the key populations in which programmes and services were needed (425). The JMTR occurred during the second study visit (November 2013) and it was reported that due to delays in implementation of the national survey (DHS) and the behavioural and biological surveillance survey amongst key populations (BBSS) both the Goals and MoT modelling analyses were conducted using the very out-of-date data available at that time to inform the models. In addition, there were no data available for many of the key model inputs (425, 456). As such, the MoT results “could only be taken with a grain of salt” due to the “wild assumptions” that were made in the absence of nationally-representative data (425). There were also many key indicators missing thus international and intergovernmental stakeholders felt that the JMTR was a missed opportunity to inform policy change (425). Nevertheless, it was reported post-hoc that one of eight key recommendations arising from the JMTR was to “align NASF interventions to the UNAIDS Investment Framework” (457).

It was described by an intergovernmental stakeholder that the MoT model was further used to identify potential high-impact interventions in different key populations at risk of HIV infection, in response to the distribution of new infections estimated using the MoT (458). Here, this type of use was to raise knowledge and awareness, more akin to the enlightenment model (discussed in 2.2.2) and aligning more with conceptual use as opposed to instrumental use.

In Malawi, an attempt was made to additionally produce EPP/Spectrum estimates at the zonal level, as opposed to producing estimates solely at the national level. It was stated by an international stakeholder that “the MoH buy-in for the zonal estimates was because they did not have the information that they wanted and needed for planning purposes” (459). In order to support planning processes, notably procurement, the Ministry needed data at the appropriate level for decision making. This required an understanding of the different epidemics

occurring in different geographical areas of Malawi, and the level of HIV prevalence, trends in incidence, and treatment coverage in each area.

It was observed that stakeholders may position themselves in order to support more instrumental use. CHAI is a stakeholder that aims to align itself directly with country governments to address specific policy and programmatic questions with the objective to improve efficiencies. This includes bringing regional policy and programme questions of interest directly to national governments (ministries), and using the technical expertise within the organisation to respond to questions raised by governments. In Zambia, CHAI has a history of using different models to inform resource allocation decisions and efficiencies in country, including models to inform the running of labs (diagnostics and drugs), running health clinics (staffing and systems flow modelling). More recently, models have been used for impact evaluation, for example PMTCT and costing analyses to inform the NASF. In Malawi, CHAI's work has similarly included resource mapping in the health sector in an effort to better inform resource flows and proposed health spending. Examples of stated use of this work include use for financial negotiations between the Ministry of Finance and the Ministry of Health to illustrate gaps in HIV funding not readily apparent due to the complicated donor situation. This work was also cited in reference to informing the use of Global Fund funding where the resource mapping identified that all available funds were needed to secure commodities (422).

The above examples exhibit perhaps a spirit towards instrumental use of mathematical models, but the resultant use may be more appropriately classified as conceptual use – use to highlight issues and a more general shaping of knowledge and awareness or enlightenment, and one component of a variety of sources of information and factors taken into account for decision making. Accordingly, many of these examples align with the interactive model (discussed in 2.2.2), a back and forth process of interaction and exposure to each other's world – CHAI's alignment with the Ministry, for example – and modelling as one of many sources of information and factors feeding into the decision making process.

While not specific to mathematical models, the Zambian Ministry did express a desire for accurate data and information, “[we] desperately need the good evidence” (460). Government and academic stakeholders in both countries corroborated this appeal, indicating that in Malawi “government realise the importance of data” (461) and that in Zambia there “definitely seems to be a shift” at the Ministry level in terms of use of data (462). The Malawian government further expressed that they “need a strategy for data use to decision making” in order to better support this objective (463).

In addition, there was a desire expressed, particularly from the government, for information on the cost effectiveness of different interventions, and tools which quantified costs associated with implementation (455). For example, in Zambia the Ministry requesting the “value for money” of specific programmes (462), and having information on the resources required for different policy options, for example the resources required to adopt, or adapt, updated WHO treatment guidelines, a theme that was expressed in both countries (454, 464).

### *Symbolic Use*

There were several examples that may be described as more symbolic use of mathematical modelling. Examples of political use (discussed in 2.2.3) of modelling included the viewpoint from stakeholders in Zambia that the usefulness of the results from the MoT modelling analysis was that it “can be used as an argument” or can be used for advocacy and cited to support or make a case for specific policies or programmes, for example programmes for sex workers (425). In Malawi, MoT and Investment Framework analyses were used in planning purposes “in the sense that it can be cited” (454). This type of use was defined by an academic stakeholder as “cosmetic use”, which was further described as data use without thinking through the problem and instead “simply citing the figures” (456).

The use of modelling results to support decisions that have already been made on other grounds is another example of what can be considered political or legitimative use. In Zambia it was acknowledged by a government stakeholder that results and recommendations from the MoT analysis were in agreement with the key programmatic areas of focus that had already been identified for the national response – condom use with casual partners, reducing casual partnerships and male circumcision (464). Stakeholders here also cited there were other examples where modelling analyses were requested to support decisions that appeared to have already been made. This included the removal of healthcare user fees which was a presidential directive that was followed by a request for evidence in its support, and the introduction of Option B+ in PMTCT (treating all HIV+ pregnant women with antiretrovirals for life regardless of CD4) in which the request for evidence from modelling appeared to occur in order to support a position already taken (423, 465).

There was also the description of what has been described as tactical use (discussed in 2.2.3) of research evidence, using the lack of information to justify a delay in decision making or inaction. This was described by an intergovernmental stakeholder in Zambia in specific reference to the MoT analysis and the implementation of programmes for most-at-risk-populations. “Not having information empowers people to do nothing” or “provides an excuse” to not make policy and

programmatic changes (438). This reference was in specific relation to The MoT analysis which was missing key model inputs due to lack of data for many of the at-risk populations.

While the examples above can all be classified as symbolic use, this use was perhaps less calculated, strategic and deliberate than originally described by Weiss (318) and may have reflected more of a general understanding and desire (but perhaps also pressure) to have evidence in support of policy decisions. The notion of 'cosmetic use' is illustrative of this argument, suggesting use that is at a more superficial or surface level, a somewhat different connotation than political use, and seemingly a more representative description.

### **5.4.3 Barriers and facilitators to the use of models**

The barriers to the use of models were consistent across both countries. The key themes that emerged from the data analysis in relation to barriers to use include: data availability and quality; capacity to conduct modelling analyses; model assumptions, parameters and results; and the timing and scope of modelling analyses. In Table 5-3 the barriers and facilitators to the use of models identified in both settings are presented. The key barriers are discussed here in turn followed by conditions for use of models identified, and finally the types of models used in these settings.

#### *Data availability and data quality*

Both data availability and data quality were key factors identified for the use of model results. Confidence in the data going into the models is needed for confidence in the results coming out of the models. However, in both settings there are often limited data available to robustly conduct modelling analyses. Assumptions made in the absence of data, and their perceived validity, can result in limited use or disuse of model results (425). Similarly, borrowing data inputs from other countries to input into models to fill these data gaps can result in a lack of ownership or acceptance of the model results (455). The use of out-dated data to inform models intended to illustrate the current situation (MoT, EPP/Spectrum), can lead to distrust of model results (414). A preference was stated by one international organisation for use of actual data as opposed to modelling, to better understand what has occurred, as opposed to only having modelling to illustrate different potential effects and to consider different scenarios (417).

Issues surrounding data quality were of paramount importance. The HIV data in the central HMIS systems are collected locally and aggregated upwards. Errors can occur at each level of aggregation, accumulating as the data are reported upward (414). As stated by a local NGO, this central reporting and the focus on pushing the data upward through the system to report at the national level does not encourage or help to build a culture of local use of the data or the

production of high quality data at the local level (466). Insufficient data quality at these lower levels can directly result in disuse of modelling results. In Zambia an attempt was made to produce HIV estimates at the sub-national level but as described by a government stakeholder, the “process failed” because of the poor quality of the data, “viewed as garbage” which were used to inform the estimates (464).

The data collected may also not accurately reflect what is occurring on the ground. In Zambia, an intergovernmental stakeholder cited the example of out-dated data reporting forms in circulation which did not reflect the policies adopted and implemented and thus simply did not allow the opportunity for accurate reporting. It was described that the key challenge “is often not the actual model, but getting the data right” (414).

#### *Capacity to conduct modelling analyses*

The lack of in-country technical capacity was cited by the vast majority of stakeholders (417, 438, 440, 453, 463, 467-470). There was limited technical capacity to both conduct modelling analyses and interpret results from models, further exacerbated by minimal local institutions (colleges, universities) to develop this technical capacity. The academic systems in these two settings are described as more consultancy based, and with limited numbers of local individuals in both countries able to conduct modelling analyses the same consultants are often used, and often over-burdened (438, 440). It was further expressed by an international stakeholder that the one-off modelling analyses (for example, Investment Framework, MoT) have a limited role in actually building local capacity, that the current motivation is to simply complete the exercise (469).

All of these factors contribute to modelling analyses being conducted primarily by overseas researchers. As expressed by an intergovernmental stakeholder in Malawi:

*“It doesn’t really help having external people coming with the ‘black box’ and then leaving. We need locals doing this and capacity building for this to occur” (440).*

This sentiment was further expressed by the government, that there was a need to build the technical capacity of Malawians and combine these skills with their local experience on the ground (463, 471). However, with a lack of technical “leads” in-country there is, at present, a need for external assistance in order to conduct modelling analyses in-country.

#### *Model assumptions, parameters and results*

Somewhat overlapping with technical capacity, but focusing more on the model structure, assumptions and parameters, referred to as the ‘black box’, was the stated need to more thoroughly understand the models used. This includes an understanding of both the model

parameters and more detailed information on how the model actually works in order to be able to make informed judgments regarding the outputs. It was described by an academic stakeholder that a lack of full understanding of models leads to a perception of “mistrust” of models, and results from models, and can result in the model being “used as a scapegoat” for limitations in understanding (456). This lack of in-depth understanding can result in simple errors when using models which can further exacerbate disuse of models. In Zambia, an international stakeholder described an example with using EPP/Spectrum (for national estimates) where the PMTCT prophylaxis inputs had not been entered resulting in substantial overestimates of child infections. This went unnoticed until presented to the PMTCT programme coordinator who wrote off all of the model results entirely, as a result of no one catching this simple omission in data entry (469).

Results changing over time can also present barriers to use of model results, for example, changes in estimates solely due to changes made to model parameters and assumptions. With each new round of EPP/Spectrum estimates, the previous estimates also shift, it “changes what you know in the past” as described by a government stakeholder in Zambia (464). In Malawi, this same experience was described as very confusing for government officials who want to know, “what is the official number?” and presents challenges for communication of the model results to both politicians and lay persons (455).

If model outputs are not in agreement with country programme or surveillance data, this can result in dismissal of all the model results (469). Examples included modelled estimates of PMTCT coverage over 100% in Zambia, and the 2002 HIV prevalence estimates in EPP/Spectrum that were in disagreement with the 2001-2002 Zambian Demographic and Health Survey (414, 456). Unexpected results were also described as problematic in Malawi with the example of the Investment Framework analysis which modelled different future scenarios of the HIV epidemic given intervention scale-up and linked these results with a costing analysis. The preliminary results from this analysis illustrated future projections that continued to increase resulting in unrealistically high costs leading to substantial concerns with the analysis (417, 455).

**Table 5-3 Key barriers and facilitators to the use of mathematical models identified in Zambia and Malawi**

|                                                  | <b>Barriers to use of mathematical models identified:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Facilitators to the use of models identified:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Data availability</b>                         | <ul style="list-style-type: none"> <li>• Limited data available to robustly conduct modelling analyses</li> <li>• Inability to produce results at lower levels (i.e. subnational)</li> <li>• Out-dated data (e.g. DHS) driving models representing current situation</li> <li>• Assumptions used (and their perceived validity) when country data unavailable</li> <li>• Borrowing data from neighbouring countries to fill data gaps</li> </ul>                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>• Out-dated data and borrowed regional data allows completion of a draft model, further refined when local data become available</li> </ul>                                                                                                                                                                                                                                                                                                                            |
| <b>Data quality</b>                              | <ul style="list-style-type: none"> <li>• Key challenge is often not the actual model but getting the data right</li> <li>• Aggregate HMIS data, with errors occurring at each level of aggregation which accumulate as reported upward</li> <li>• Outdated data collection forms do not allow for appropriate data collection</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>• Confidence in the data going into models needed to provide confidence in the results coming out</li> </ul>                                                                                                                                                                                                                                                                                                                                                           |
| <b>Technical capacity</b>                        | <ul style="list-style-type: none"> <li>• Limited local individuals available to conduct these analyses; often same consultant used for all projects</li> <li>• Lack of technical "leads" in-country, need for external assistance to conduct analyses (scenario analyses)</li> <li>• One-off modelling exercises have limited role in building local capacity</li> </ul>                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>• Increased in-house trainings</li> <li>• Build in partnerships and mentorships to further develop technical capacity</li> <li>• Consider building-in modelling processes as routine instead of one-off exercises</li> </ul>                                                                                                                                                                                                                                           |
| <b>Model assumptions, parameters and results</b> | <ul style="list-style-type: none"> <li>• Need for confidence in "black box" (model assumptions, parameters) aspects of modelling in order to have confidence in the outputs</li> <li>• Not understanding core fundamentals of a model (including parameters and assumptions) can result in mistrust of the model and results</li> <li>• Model results inconsistent with programme and surveillance data can lead to distrust in the entire modelling process and all resultant outputs</li> <li>• Unrealistic model results – e.g. PMTCT coverage &gt;100%, very high estimates of child infections</li> <li>• Change in historical estimates solely due to changes made to model parameters/assumptions</li> <li>• Unfavourable results</li> </ul> | <ul style="list-style-type: none"> <li>• Models provide estimates of HIV incidence, "only way to do so"</li> <li>• Build in collaborative process, programme and surveillance, complete team including those who know the data</li> <li>• Involve programme data managers and key individuals on the ground to review data inputs and model results</li> <li>• More thorough understanding of models used in order to spot "red-flags" and unintentional errors that result in unrealistic results</li> </ul> |
| <b>Timing and scope</b>                          | <ul style="list-style-type: none"> <li>• Modelling analyses take time, government need for answers often not aligned with timing of model results (govt needing more rapid answers)</li> <li>• Model results at appropriate level for policy relevance – to understand key issues by geography, for procurement, health care delivery. Results at national level, while planning and target setting occurs at lower levels.</li> </ul>                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>• Better alignment and liaison with government planning and budgeting cycles</li> <li>• Involvement of the government from the beginning and throughout</li> </ul>                                                                                                                                                                                                                                                                                                     |

### *Timing and scope*

In both countries it was indicated that model results are needed at the appropriate level for policy relevance in order to understand and respond to the different issues in different areas, for procurement, and for health care delivery. Model results are often produced at the national level, while planning and target setting occurs at lower levels (459). Modelling analyses take time and the government's need for answers is not always aligned with the timing of model results. In addition, the government often needs more rapid answers than modelling is able to provide (465).

### *Conditions for use*

There were several key conditions identified for use of models, and model results, which were also broadly consistent across both countries. The demand from intergovernmental stakeholders to use models is perhaps the fundamental condition for use. The use of EPP/Spectrum is a requirement for generating national estimates as part of the UNAIDS Global Estimates (288). As stated by an intergovernmental stakeholder in Zambia “we have to do international reporting, a long time ago this was cleared [there is] no choice” (414). The submission of funding applications to the Global Fund also necessitates modelled estimates and projections, and now requires an Investment Case for HIV (the Investment Framework analysis) or another fully costed, disease-specific national strategic plan (472). These Investment Cases had just begun at the timing of the study visit and a government stakeholder in Malawi described that they “kind of had to do the Investment Case, came from high level” with reference to intergovernmental stakeholders (455).

Conditions for the use of results from models include model results that are in line with local programme and surveillance data, or “what is known on the ground” as stated by an international stakeholder (469). In addition, having high quality data informing the models and models populated with national data “not borrowed” from other countries or regional values (455, 459). Models are particularly useful for providing estimates of HIV incidence, “the only way to do so” as expressed by a government stakeholder in Malawi (455).

Conditions that may further facilitate use may include the availability of a policy window. This intention was expressed in Zambia where there was a potential opportunity for modelling to inform the mid-term review of the national strategic plan for HIV (438). Results that are advantageous or deemed favourable may also further facilitate use (461).

Finally, the importance of model results representing the level at which decisions are to be applied was expressed in both countries – for Malawi, resource allocation decisions are made

at the zonal level Malawi while in Zambia the decentralisation process will result in decision making at the district level and thus results are required at these lower levels (414, 459). In both countries, robust estimates and projections at the subnational level, while attempted, had not been made.

#### *Types of models used*

While the main focus was on the MoT, Goals and EPP/Spectrum models, it was actually different types of costing and resource allocation models that were most often cited, particularly outside the handful of stakeholders directly involved in the MoT, Goals and EPP/Spectrum analyses. Some stakeholders were not aware of these HIV models or familiar with these analyses, thus the semi-structured interviews focused on any other modelling analyses conducted. Overall, resource allocation and cost effectiveness analyses were highly cited amongst all stakeholders, but particularly from government stakeholders, as useful models to inform decision making, as opposed to solely epidemic modelling (415, 419, 433, 437, 458, 473). Here, it was information to inform the practicalities of planning and health service delivery – identifying the resources needed, supplies needed, health system requirements, all at the appropriate geographic level of interest – that was of utmost importance and where information from models was desired (421, 422, 432, 450, 469, 474).

## **5.5 Discussion**

The multi-case study presented herein captures a cross-sectional viewpoint of an evolving situation. The stakeholder mapping process provided an overview of the policy environments within which HIV programme planning and decision making occurs. This was a constructive approach to systematically describe and organise the stakeholder environment in each country which illuminated that the majority of the modelling engagement and expertise was concentrated across a handful of organisations. The impetus for the modelling analyses described (Goals, MoT, EPP/Spectrum) was largely driven by intergovernmental organisations, notably UNAIDS. These analyses were led by local government, the National AIDS Council in each setting, with support from local consultants, and were generally dependent on additional technical support from international organisations and international consultants. Modelling analyses that were more academic or research-based were not occurring at the local universities or within the local context but were instead conducted by overseas researchers.

The US Government and the Global Fund were the key stakeholders financing the HIV response in each setting. role of the US Government differed with PEPFAR playing a direct and substantial role in Zambia which is one of its 15 focus countries (475), while playing a support role in Malawi.

Both organisations are proponents of the use of modelling to inform decision making. The HIV stakeholder environment in both countries was complex and with the limited time spent directly in-country it was difficult to get a strong sense of the relationships between stakeholders, particularly the interrelationships with and among donors and government stakeholders. The general sense in Malawi, also iterated by an intergovernmental stakeholder (440), was that despite this busy stakeholder environment, the various organisations get along well. In contrast, the stakeholder environment in Zambia was somewhat chaotic at the time of investigation, compounded by the split of Ministries which had resulted in confusion among partners and donors regarding the roles and responsibilities of each Ministry, and a lack of coordination across Ministries. Decentralisation, which was also underway and would move decision making and resource allocation from the national level to local authorities, further complicated the stakeholder environment and thus it was particularly difficult to get a sense of the relationships between stakeholders in Zambia as they were in transition throughout the investigation. This was exemplified by a longstanding academic stakeholder who remarked that it might be worth stakeholders waiting to see how this process evolved at the government level because it could all simply be reversed with the entry of a new government (470).

The two policy environments under investigation are more recent democracies, but with the strong dependence on donor funding for HIV, the resulting power structures may also be considered elite pluralism (330). The influence of donors has been cited in other studies in this region as both the single strongest impetus and impediment to national policy change (476). Donor-driven priorities may also dominate over government priorities. Research agendas, and subsequent policies, are often driven externally by donors who fund the research which in turn can shift the focus at the national level (477). Donors and global agendas identify the “issues” and external agencies come to countries with their questions and funding as opposed to national governments internally identifying the key issues and being in charge of developing and owning the local research agenda (476). This was a theme further iterated by both academic and government stakeholders in the investigations in Malawi and Zambia (424, 433, 463, 470).

#### *Investments from the ground up*

In both countries, a lack of local technical capacity and the need for strengthening this capacity was a strong theme that emerged from the data. This included technical capacity to carry out the modelling analyses, to appropriately interpret the results, and to better understand the model assumptions and how the results were obtained. Strengthening local technical capacity may further enable local ownership of the modelling process and the results. There may also be more instrumental use of mathematical models and model results that have local ownership.

South Africa is an example of a country where South Africans themselves have led the development of country and province-specific mathematical models to evaluate the impact of HIV/AIDS. These include the AIDS and demographic models developed by researchers from the University of Cape Town and the Actuarial Society of South Africa (ASSA) (478), and more recently the THEMBSA model (479). In contrast, the predominant mathematical modelling processes occurring in Zambia and Malawi were developed by external organisations and were approaches that could be adapted for use across any setting. A benefit of the use of these more general models is that use of the same methods (and model structure and parameters) allows for comparison across different countries. However, this may come at the expense of direct engagement in the model development process, building technical capacity and strengthening local ownership of models and model results, investments which could yield much longer term benefits.

The investigation focussed on the use of mathematical models, but what was uncovered in-country through querying the barriers and facilitators to the use of models is a more systemic problem – that it is the underlying data inputted into the models that remain a key issue. Data quality was a key condition identified for use of model results. An important initial step to facilitate the use of models is to strengthen the quality of information collected. The suggestion that central level reporting (HMIS) may contribute to poorer quality data collection, in addition to less use of these data, is supported by earlier research conducted in Malawi (480) which indicated that the implementation of electronic data systems, which encouraged the “reporting upward” of information into national HMIS, contributed to establishing less use of this information at local levels. It was described that the switch from tallying and reporting at the clinic level (which involved programme coordinators compiling and reporting on the data specific to their departments), to a computerised data processing system resulted in programme coordinators being passive consumers of information (480). Moving forward, it will not only be important to strengthen the quality of data collection, but to also establish routine processes for using, analysing, and disseminating data at the local level, establishing ownership and credibility of the information collected from the ground upward.

It is only with better quality inputs to the models that model outputs will be seen as valid and useful. As such, it can be argued that both countries may currently have the right approach towards the use of modelling to inform decision making. Legitimate use of the model results – use as an additional piece of evidence to confirm or validate decisions – may be the appropriate type of use at present given the valid concerns raised about the data. Other studies and scholars have similarly found that research is more likely to be used if it supports one’s own views and is

in agreement with what is already known, or if it supports the general consensus, used to confirm, as opposed to inform, policy directives (326, 477). If it does not, it has been suggested it may be more likely to find fault with the methods or find other reasons for disuse (481). Applied to the current study, it is possible that data quality may also be used to justify disuse of mathematical models when the results produced are unexpected or not in agreement with the general consensus towards HIV programme decisions.

#### *Utilisation across the spectrum*

It has previously been argued that focuses on evidence-based practice may be at risk of over-emphasising instrumental use, at the expense of not fully recognising the potential influence of other types of use (315). Instrumental use is likely a rare occurrence while conceptual use, often overlooked, is more broadly applicable and has the potential to offer vital contributions, working across many levels to change attitudes and enhance knowledge. Tulloch, et al (345) elaborate on this concept in case studies on research utilisation to influence sexual and reproductive health practice in sub-Saharan Africa, and emphasise the importance of conceptual use in order to establish an environment to facilitate instrumental use. They use the example of male circumcision and illustrate that to have direct, instrumental use of the research evidence, it is essential to address the surrounding issues associated with this policy decision, a process that may begin with, and necessitates, more conceptual use of research information. They found that it was only with first changing attitudes and creating awareness and knowledge surrounding male circumcision, that the research evidence for the protective effect of male circumcision could be used instrumentally (345).

The Clinton Health Access Initiative promoted their own analyses and described use of the results at the national level. These analyses are generally simpler than the key models under investigation but are directed at very specific problems raised by, or to, the government. This could indicate that for models to be used more instrumentally they either have to be more closely tailored to explicitly expressed needs, or that a supporting relationship has to be in place between the model promotor and local decision makers.

In both investigations, mathematical models were predominantly used conceptually and symbolically as examples of research information that could be cited, used to confirm decisions made on other grounds, or to further a point. Modelling results were also used for advocacy purposes, cited as an argument to support or make a case for specific policies or programmes. This more symbolic use has been previously explained as political or tactical use, but is perhaps better described in these two contexts as ‘cosmetic’ use as reported by one stakeholder. It is possible that symbolic use, particularly legitimative use or the ‘cosmetic’ use described, may

demonstrate a foundation for use of modelling results, representing an initial step in a pathway for research utilisation, one which can pave the way for conceptual and instrumental use. This may be particularly relevant for more novel or less familiar types of research information. Other studies have found that the *type* of research information has important implications for how it is used (334, 482). In the settings under investigation, mathematical modelling, and the models themselves, may need to first be established as credible and legitimate in order to support instrumental use. In addition, different stakeholders will have different opinions regarding the usefulness of research information in general, and of the perceived value of different types of research information (483). This may be particularly relevant for mathematical models which are a more novel form of research information used in the policy environment and these varying opinions may account for the varying levels of interest in mathematical modelling observed across stakeholders.

#### *Data use for decision making*

While the focus of the investigation was on the use of mathematical models to inform HIV programme planning and decision making, it was quickly realised that outside the handful of individuals directly involved in these processes, respondents often had very limited knowledge, and often limited direct experience, with these modelling processes. As such, the line of questioning was expanded to the discussion of any modelling applications. This is an indication that the original narrow focus on exploring the use of mathematical models for HIV may have reflected too many assumptions from a modelling and research perspective and overstated the perceived importance of these modelling processes at the national level.

Broadening the scope beyond mathematical models, the expectation of instrumental use of research evidence may be generally problematic, particularly in settings where the use of data and evidence for decision making is a more recent concept and where established structures and systems to promote this process do not exist. Stakeholders from both countries illustrated, at the government level, a desire for evidence-informed decision making, but were perhaps conflicted with how this should occur. In both contexts there was a lack of established systems for policy making, and at the same time, desire from non-governmental stakeholders for more accountability and documentation of why and how policy decisions are made. In Malawi, the role of the HIV Technical Working Group was highly cited as a key forum for routine dissemination of research results, discussion and reviews of research and evidence, and cited as the technical forum used to generate HIV-related recommendations communicated to the government. While this may be a context-specific finding, and perhaps facilitated by the small country size, the establishment of a highly-functioning technical forum to review and discuss

research results, which also produces policy recommendations, may be a key strategy to better facilitate the use of research information, including mathematical models, to inform decision making in other countries. In Zambia, it was explicitly expressed that a process to promote more strategic use of research information for decision making is needed, in addition to greater transparency regarding how policy decisions are made (456).

The absence of routine reporting mechanisms for policy decisions in these settings is not unexpected. Financial and budget reporting is often the most accessible route to follow decision-making processes, thus the original intention of the case study investigations was to use resource allocation as the main outcome and to compare resource allocation decisions before and after the modelling analyses (Goals, MoT) were conducted. However, it was readily apparent this would not be feasible, that the complex donor space and many different streams of funding for HIV resulted in a highly disconnected and very non-transparent budgeting environment.

#### *Programme and policy implementation*

A further theme that emerged from the data was the fundamental importance of *implementation* of programmes and policies in these resource-poor settings. The operational issues surrounding healthcare delivery in these countries was critical and warrants further consideration with regards to the design of this investigation on research utilisation. The division of the policy process into distinct stages and focusing on the agenda setting and policy formulation stages overlooked the fact that implementation issues and programme delivery are paramount to the decision-making process, a finding that is further supported in a similar case study investigation recently conducted in Uganda (484). Planning and decision making in these contexts inherently focuses on operational and implementation considerations, as opposed to addressing these issues further down the line. This was an oversight that occurred as a result of framing the investigation from the theoretical perspective of the policy process defined by distinct stages, with implementation separate from planning and policy formulation, as opposed to an integrated perspective that recognises these stages do not occur in a linear or discrete fashion. Further, the mathematical models under investigation were developed with the aim to support an improved understanding of HIV epidemics and the planning of strategic and efficient interventions. They were not specifically designed to answer key questions surrounding implementation or to inform operational needs and healthcare delivery. These issues are often the key focus of national governments.

In Malawi in particular, the realities of healthcare delivery were critical, with stakeholders emphasising the importance of HIV policies emerging from the country, not based solely on the

available research evidence, but taking into account “the realities on the ground”. The creation of Option B+ in Malawi was a key example, the need to develop policy to prevent mother-to-child transmission of HIV in a setting where there is often infrequent contact with health systems and very limited access to CD4 testing. Here, it was the need to overcome the barriers women face in accessing PMTCT and treatment services that was paramount (485). Other studies on research utilisation echo this theme of the important consideration of implementation issues and health care delivery, for example in Zambia where the national scale-up of a cotrimoxazole policy for preventive therapy was delayed until after a general infrastructure for delivery of antiretrovirals was in place (486). Similarly, the WHO treatment guidelines and the subsequent regional and national process which was described as “domestication” whereby the guidelines are modified and adapted to better suit healthcare delivery within the local context (464). This has similarly been referred to as “contextualisation” of international guidelines in other studies (477).

### **5.5.1 Limitations**

The study is not without limitations which are discussed in turn. The research was conducted in parallel to the formulation of potential planning grants from BMGF to the governments of each country to devise strategies to facilitate the use of data to inform decision making. It is plausible that some participants may have felt there was potential incentive to report either use, but perhaps equally, disuse of modelling information in order to justify the relevance or need for this potential funding opportunity. At the same time, the research occurring in conjunction with this potential BMGF planning grant, or perhaps simply the BMGF position and reputation in-country, seemed to greatly facilitate access to key stakeholders. Nearly all stakeholders contacted were readily willing to make time to meet with the researcher and provided candid interviews.

The researcher’s position was not only as a BMGF consultant, but also an Imperial College London PhD student both in the Department of Infectious Disease Epidemiology and the Centre for Health Policy, and as the Research Manager for the UNAIDS Reference Group on Estimates, Modelling and Projections. All participants were familiar with BMGF, and the vast majority were aware of either the modelling work conducted at Imperial College London, or the UNAIDS Reference Group. Some participants were previously known to the researcher. These different roles further facilitated access to interviews, provided additional opportunities to participate in various technical and political meetings, and provided different perspectives from which to approach the data collection, analysis and interpretation.

It is possible that participants may have felt conditioned to cite examples of model use in order to “please” the researcher, a social desirability bias. However, if this was the case we would expect over-reporting of examples of modelling use elucidated and would anticipate over-emphasis on the usefulness or use of the modelling applications, which was not the case. Inaccurate recall is also plausible. This was controlled for by focusing predominantly on modelling analyses that were ongoing or recently completed at the time of the study visit before expanding to additional analyses conducted in the past 5 years.

From the perspective of the researcher, there is a danger to overstate the performance of a favoured hypothesis. The qualitative research process can have a level of subjectivity with the findings representing the researcher’s construction of coding, definition of what is significant, and interpretation and translation from their own viewpoint (300). In order to address this issue, multiple hypotheses were investigated, including opposing or contrasting hypotheses, querying from different perspectives, allowing the data to lead and remaining open to different interpretations. Data triangulation was used to further complement this approach. In Zambia, the findings and interpretations were first discussed with the local informant to assess level of agreement and obtain additional contextual or background information, and further discussed with senior BMGF colleagues present in both countries. Findings were also raised with subsequent stakeholders holding varying viewpoints and positions to corroborate or obtain alternative perspectives and build variation into the analysis. The triangulation process also helped address the positionality of the researcher as an “outsider” thus carrying a different perspective than an “insider” or that of a local stakeholder. One advantage of being an “outsider” is that the researcher was better able to remain independent, to directly probe sensitive questions and to extract more information as a result of requiring detailed explanations (303). In Zambia, this was complemented by the “insider” perspective from the local informant.

The results are presented from a national perspective, but the interviews took place in the two capital cities – Lilongwe and Lusaka – where the majority of stakeholders were situated. It is possible that additional perspectives may have been missed as a result. This may be more relevant for Malawi where researchers and stakeholders also resided in the administrative capital of Zomba. While the researcher did travel to Zomba for a high-level meeting, in-depth interviews were not able to be conducted in this setting.

There is a risk of bias in the stakeholder mapping, defined entirely based on the researcher’s findings, and again from the viewpoint as an outsider which may differ from that of an insider. Further feedback of the summaries and viewpoints ascribed to stakeholders can clarify or

validate the positions and deductions ascribed, but may also introduce additional bias, particularly if the assessment made is less than favourable (409). The assessments of influence and interest were also conducted at a cross-sectional point in time but in reality are transitional and expected to change over time, thus require continual reflection and revision.

The results of these investigations are context-specific and not directly generalisable to other settings. However, the inclusion of two countries as opposed to a single case study allowed for comparisons to be made across countries which can form a basis for further investigations in this region. Malawi and Zambia are similar in terms of the political environment, culture and geographical proximity thus investigation in an “outlier” country, one with a very different political or social environment, may lead to different results and conclusions.

### **5.5.2 Conclusion**

Overall, a better understanding of the policy environment within which decision making occurs in low and middle-income countries is needed. This recommendation has broad applicability for researchers, donors, key partners and national governments. The stakeholder mapping was a highly informative exercise that should be conducted as routine in order to obtain a better understanding of the potential influence and interests of key stakeholders within the policy environment. Stakeholder mapping can also be used to provide information to inform future efforts. For example, it is likely that UNAIDS and the Global Fund will continue to play key roles related to the use of strategic information and will continue as active proponents for the use of modelling to inform programme planning and decision making in the future. The identification of other organisations with similar levels of interest and conducting similar analyses, for example CHAI and PEPFAR, may allow for synergies across organisations, coordination of efforts to address key questions and avoid duplication of efforts, and potential collaboration and cooperation for the development and strengthening of both the demand and supply side of modelling at the local level.

The information obtained in each country takes place within a larger cultural, social, political, and economic context. It is important to remember there are no simple explanations, these are complex environments and thus the aim was to capture as much of the complexity as possible, realising it is not possible to capture all of the complexity. In addition, these are fluid environments with the results obtained reflecting a snapshot in time. The political environment within which planning and decision making occurs is often unstable, particularly in many developing countries where there may be sudden or unexpected transformations.

The focus of this investigation was on use of mathematical models to inform HIV programme planning and decision making. However, the investigation used the opportunity created by HIV modelling, and has scope for much broader application to other disease areas and health system strengthening. The research conducted herein may be seen as an initial starting point for further investigations, in other low and middle-income countries, investigating how both models, and more broadly, research information and data are used to strategically inform programme planning, decision making and resource allocation.

Recommendations from other investigations on research utilisation have been to improve communication and linkages among the evidence base, researchers, and key decision makers with direct engagement and the presentation of information in a way that is accessible to decision makers (337, 349, 487). In addition, to take advantage of policy windows, or to create these windows by working more closely and directly with decision makers (488). While these are reasonable recommendations, in order to enhance the utility of mathematical models to inform programme planning and decision making, it will be important to address the fundamental barriers to use identified. This includes addressing the issues surrounding data quality and availability. To start from the foundation level, getting the data right at the lower levels, the facility and community level, working to improve data quality and data use as routine at these levels. In parallel, to develop local technical capacity in-country to allow for improved country ownership of the analyses and the results. Local technical capacity is also related to local demand and investments made in strengthening local capacity will only thrive if there is a sustained demand from programme planners and decision makers for this information, if use is a more integral component than it is at present. At the same time, it will be important to develop confidence in the tools used and the results produced (489).

Moving forward, it is important for researchers in global health to adopt an integrated view of the policy process, recognising that the focus of programme planning and decision making in low and middle-income countries may heavily rely on the issues surrounding implementation, and the resources required for the delivery of programmes, interventions and healthcare. This will likely require different types of research to inform these decisions, which may include mathematical modelling, cost-effectiveness analyses and budgeting tools. Importantly, the implementation of these programmes and resource allocation increasingly occurs at subnational levels thus this information will be required at the level at which planning and decision making occurs.

## **Chapter 6**

### **Discussion**

## **6.1 Introduction**

The aim of this chapter is to summarise the findings presented in the preceding chapters and to interpret these within the current global health context, to then discuss the research approach, potential future directions, and areas for further research. This thesis sought to investigate the use of mathematical models to inform HIV programme planning and policy decision making. This was done by examining key mathematical models used for this purpose, generating recommendations to advance the utility of these models, and then investigating their use to inform national HIV programme planning and decision making in two countries in sub-Saharan Africa.

## **6.2 Discussion of key findings arising from all chapters**

The time period when this work began in 2009 was one which represented a shift in thinking, moving beyond the emergency response to AIDS and looking towards the future and long-term sustainability (490). The long-term projections generated in Chapter 3 were produced to support this shift and contributed to the dialogue occurring amongst international stakeholders at the global level. Further, the epidemiological projections produced for 22 countries provided the foundation for many related analyses conducted since that time (250-252, 298). The quantification of the potential future scale of the epidemic in this chapter provided initial insight into the potential impact of different policy decisions, and failure to make decisions. In these projections, expanding treatment coverage alone had the single greatest effect (even with the conservative assumptions made at that time), given the immediate impact on AIDS deaths and subsequent reductions in onward transmission. However, the impact of ART has yet to be conclusively supported with empirical population-based evidence. There is evidence in support of reductions in mortality at the population level attributed to ART scale-up in sub-Saharan Africa (491-494), and data from a population cohort in rural KwaZulu-Natal suggests that high population coverage of ART has resulted in reductions in HIV incidence (495). In the very near future, results will be available from large-scale HIV Treatment as Prevention (TasP) trials which aim to definitely identify whether TasP can substantially reduce HIV incidence at the population level in sub-Saharan Africa, (496, 497).

Sub-Saharan Africa will incur the greatest future burden of HIV. This region is also projected to experience substantial population growth, thus inaction in combination with predicted population growth will result in a further increasing burden of infected individuals, even if incidence remains stable. Overall, the magnitude of future AIDS deaths will depend on access to ART, the population effect of treatment on incidence and continued prevention efforts, findings

which are relevant still today. At present, the expansion of access to ART continues with WHO announcing in September 2015, the recommendation to “Treat All”, that anyone infected with HIV should begin ART as soon after diagnosis as possible (498). Research efforts continue in order to understand the effect of treatment on incidence at the population level, and the search for novel prevention options and delivery methods continues. The use of antiretroviral drugs to prevent HIV acquisition (PrEP) has now demonstrated strong evidence of a reduction in risk when taken consistently (78, 79) and WHO has subsequently recommended that PrEP should be offered as an additional prevention option to all individuals at “substantial” risk of HIV infection (499).

### **6.2.1 Strategic planning for a sustainable future**

The findings in Chapter 3 further illustrated, with the examples of South Africa and China, that there is no “one-size-fits all” portfolio of interventions. The most strategic mix of interventions will depend on the local epidemiology within a country and will need to be appropriately tailored to meet the needs of key populations and to address any gaps in the interventions currently employed. This finding, which signifies that countries will need a detailed understanding of the local epidemiology in order to develop a strategically tailored response, was a more novel perspective at that time, but is now established with strong support amongst stakeholders at the global level. UNAIDS has recently outlined a recommended focus on local epidemiology and the geographies and key populations at high risk of infection, in order to support efforts toward achieving Sustainable Development Goals (500). The Global Fund and PEPFAR have also both recently outlined similar strategies (501, 502).

A comprehensive and up-to-date understanding of the epidemic is needed in order to efficiently target HIV prevention interventions. This requires understanding the populations affected, those at risk of infection and aligning these results with the programmatic strategies employed to identify key prevention needs and current gaps. The Modes of Transmission (MoT) was developed in response to this need and was subsequently widely used as a result of support from the World Bank and UNAIDS. A key benefit of this mathematical model is its inherent transparency, with the model assumptions and calculations readily apparent and easily interpretable. However, concern was expressed among international, intergovernmental and academic stakeholders regarding the potential misinterpretation of the model results and the effects this can have on decision making (503). Chapter 4 combined the technical application of the MoT model in Armenia with the debate occurring at the international level surrounding the use of this model. Recommendations were formulated to provide further clarity and enhanced

guidance for more optimal use of the model and interpretation of the results in order to strengthen its contribution to inform decision making for HIV prevention. These recommendations informed the subsequent development of a tool to provide countries with a systematic process to review the data available and data quality to assess whether it is sufficient to conduct an MoT analysis. This data assessment process is now an initial step prior to use of the MoT model in UNAIDS-supported analyses (504). Further, the model output figures have been amended to more appropriately reflect uncertainty and to facilitate validation of the results (505). Finally, a new MoT model with a revised model structure has been developed and was recently piloted in Botswana (506), and there are plans underway for the development of another new MoT model with the specific aim for use in concentrated epidemic settings (507).

### **6.2.2 Demand for modelling analyses to inform strategic decision making**

The timing of the modelling analyses in Chapters 3 and 4 coincided with a transition in the donor funding climate after the global economic crisis, which resulted in a plateau in donor government funding for HIV. At the same time, treatment provision continued to scale-up, and those who are deemed eligible for treatment has further expanded as treatment guidelines evolve toward earlier initiation (508-511). It is estimated that simply maintaining the current investments in HIV prevention and treatment costs US \$19 billion annually, which could nearly double with additional intervention scale-up (512). The need for a sustainable response in this environment of limited resources, compounded with increasing expenditure required to support further scale-up, underscores the importance for countries to develop tailored intervention strategies which support optimum resource allocation. As a result, there has been strong demand at the global level for evidence-informed decision making which has contributed to the rapid growth of modelling, and in particular, scenario analyses linked with economic evaluations.

The recognition of models as tools to enable evidence-informed decision making may have contributed to changes in the perception of models at the international level. There is now an increasingly wide range of models used to support infectious disease control and elimination (112), and there are now proponents of modelling at high levels. For example, Mark Dybul, the Executive Director of The Global Fund for AIDS, Tuberculosis and Malaria has a history of collaboration with modellers and contributing to modelling analyses (206, 210, 513) and has been a strong advocate of policy decision making which maximises health outcomes with the resources available (514). Similarly, Ambassador Deborah Birx, the newly appointed US Global AIDS Coordinator in charge with overseeing PEPFAR implementation has also focused on impact, optimal use of resources, and evidence-informed decision making. For example advocating for

the delivery of high quality HIV programmes in order to achieve long-term impact (515), access to ART for all people living with HIV, and access to Pre-Exposure Prophylaxis (PrEP) for those at high risk of acquiring HIV (516).

However, there may be a disconnect between the demand for modelling at the global level and the demand at the national level. In Chapter 5 it was illustrated that the demand for use of modelling analyses in Zambia and Malawi was driven by intergovernmental stakeholders, notably UNAIDS, the World Bank and The Global Fund. The use of models is required for Global Estimates processes, for funding applications and for monitoring progress towards global goals and targets. However, in the national policy environment, the demand for strategic information is focussed on programmatic concerns, whether different interventions can be implemented in the current health system and the resources required to do so (517). The “value” of different interventions – the costs associated with the implementation of different policy options and the expected health gains as a result. This information is needed not just for HIV, but for all health, and at the level at which target setting and resource allocation occurs. Decentralisation processes have increasingly resulted in decision making occurring at the subnational level, often the district level, a level at which there was not enough data available to support strong modelling analyses in the settings under investigation.

Within the national policy environment, the impact of modelling can be enhanced with robust analyses that incorporate economic aspects, conducted at the appropriate level at which decisions are made, and across different diseases to better represent all health. Direct collaboration and linkage with Ministries of Finance and planning and budgeting departments may further strengthen the value and applicability of modelling, and thus use of this information. Collaborations at the regional level to support the capacity to undertake these analyses at the national level, and learning from the experiences of leading countries in the region – South Africa, India and Thailand, for example – may further enhance the impact of modelling to inform decision making.

The demand for the use of models at the national level could present problems in low and middle-income countries if there is insufficient local capacity, and technical capacity, to support the demand. Particularly if these modelling exercises are forced upon (already overburdened) programme managers, ministry and monitoring and evaluation staff, across all different disease groups and at donor-dictated timing which may not coincide with national planning (518). The investigations in Malawi and Zambia found that at present there is very limited local technical capacity to conduct modelling analyses and a lack of local educational structures in place for development of this technical capacity. Thus, there is a need for strengthening the capacity of

both model users and consumers of models in order to facilitate interpretation and communication of the insights gained from models with appropriate communication of the limitations. However, investments made in strengthening local capacity will only thrive if there is a sustained demand for use of this information, if use is a more integrated component in strategic decision making than at present. Further, increased country ownership of modelling processes and results may be facilitated if modelling analyses are designed and conducted by local technical experts, in coordination with input from decision makers as part of this process.

However, investments in strengthening individual and organisation capacity, while important, may not alone result in sustainable changes in the long term. The development and strengthening of institutional capacity and the creation of formal processes which support the generation and use of this information may be a requirement for long-term sustainability. This includes understanding and addressing the political environment and the rules which govern decision making, including the rules which dictate the use of evidence and the types of evidence used (519). Further, it has been suggested that in the absence of institutional capacity or without established structures in place to provide robust and independent scientific advice, there is the potential for amplification of selective use of evidence (520).

The development of institutional capacity will first require the identification of the institutional arrangements that facilitate “good” use of research information. In the UK, the National Institute for Health and Care Excellence (NICE) is a public body which exists to provide evidence-based guidance for health and public health practitioners. NICE produces guidelines for the UK’s national health system, provides access to reliable health information services and providing guidelines (521). In low and middle-income countries, the development of specialised agencies which house the capacity to access, analyse and interpret evidence and generate policy recommendations may be an appropriate, and necessary, long-term strategy to enhance the capacity to use research evidence to inform policy.

### **6.2.3 The role of modelling in the policy context**

In Chapter 5 it was further revealed that at the country level, there was no strong evidence of direct, instrumental use of models to inform HIV programme planning and decision making. Results from models were cited to provide further support for programme and policy decisions made on other grounds. Modelling analyses were also viewed as useful to cite when advocating for specific programmes, for example advocacy for programmes that address key populations such as sex workers. These examples were described as “cosmetic use” and align with what can

be described as conceptual and symbolic use of research information, which were the commonly described types of use of models reported by different stakeholders in both Malawi and Zambia.

Within the policy environment, results from mathematical models may not be viewed as “evidence” at present which may further limit their use and role in decision making. The similar concerns expressed in Armenia (Chapter 4) and Malawi and Zambia (Chapter 5) surrounding the lack of data available to inform robust modelling analyses, and the quality of the data that are used, may result in too many limitations for these analyses to be currently viewed as evidence. The concern and scepticism associated with model results as a result of the lack of availability of local data, and the quality of these data, is a finding which echoes the similar historical criticisms (described in Chapter 1) regarding the validity of model outputs.

While these case study investigations did not illustrate instrumental use of mathematical models occurring at the national level, the analysis does not capture utilisation which occurs at the global level, which may then filter down to lower levels. The development of antiretroviral treatment guidelines is one example. The normative guidance from WHO with respect to antiretroviral therapy will influence the development of regional and national treatment guidelines, thus there may be more inherent use of models than captured in the analysis in Chapter 5. In 2013, WHO included mathematical modelling analyses to inform the strategic guidance for the provision of ART (522-524). The role of modelling to inform the guidelines as part of this process was described as, “important but supplementary to the main evidence base” with the use of modelling integrated, “within a broad evidence review framework” (522). This description also aligns with conceptual use of mathematical models (and the enlightenment explanatory model) whereby mathematical models are just one of many sources of research information used to inform policy decision making. This suggests that moving forward the “supplementary” role of models at the national level could also be expected with use of model results in combination with other research information and evidence, and further complemented with considerations such as affordability, equity, and local health care delivery in support of a public health approach toward decision making. And given the potential limitations of models identified in Section 1.3.4 which were found to still be relevant today in data-limited settings, the supplementary role of modelling to inform policy may be the appropriate role in many settings.

### **6.3 Research approach**

The work in this thesis aimed to take a global health perspective by integrating different disciplines including epidemiology, political science and social science. Bridging across

disciplines exposed the author to different literature and new perspectives and theory, notably perspectives from social and political science. Recently, it is increasingly recognised that the large body of theoretical research from political and social science offers a breadth of insights and understanding relevant and applicable for global health (525, 526). The theoretical framework developed in Chapter 2 adopted the lens of the utilisation spectrum. This framework will be less novel to social scientists, but provides a perhaps more novel lens when applied in global health and may resonate with the research community where there is often an expectation that research information is (and should) be used instrumentally with less consideration given to other types of use. This type of framework has the potential advantage of broader application, particularly in LMIC settings, compared to more contemporary theory that has developed from specific HIC settings or health policy contexts. It may also be a particularly relevant framework in settings where routine mechanisms or platforms for research to policy are less established, or absent. The strong emphasis on evidence-informed decision making for HIV, and in health more generally, also makes the research utilisation spectrum a highly relevant analytic framework.

Different research methods were employed in this thesis with the use of both quantitative and qualitative methods. For HIV modelling, this work began with a purely academic application (conducted in Chapter 3), then takes modelling beyond the research environment and into the field (Chapter 4) and policy environment (Chapter 5). The work undertaken in the case study investigations in Chapter 5 built upon the analyses conducted in Chapters 3 and 4 which had identified that while the pace and scale of the development of mathematical models was increasing seemingly exponentially at the time, very little was known regarding how these models were actually used in the countries most affected. Chapter 5 further incorporates the country perspective bridging the gap identified between model developers and proponents of models, and the intended consumers of models. In this process, the PhD evolved from the technical application of modelling, to field application of modelling, to a contemporary investigation of model use in the contexts for which these models were explicitly designed.

The different viewpoints encapsulated through this process provide a unique perspective with access to countries, key stakeholders, high-level meetings, technical meetings and workshops enabled by working directly with UNAIDS, Imperial College London, the UNAIDS Reference Group on Estimates, Modelling and Projections, the HIV Modelling Consortium, and the Bill and Melinda Gates Foundation. This access provided opportunities to reflect on, and participate in, the discussions occurring at local, national, regional and global levels regarding the use of mathematical models to inform policy decision making. Also, to engage in these processes while

taking into account the perspectives offered not only by these different roles, but also the knowledge obtained from epidemiology, social and political science disciplines. One potential limitation of this approach is that work across disciplines may be more general compared to very detailed analyses specific to a single discipline, for example focussing entirely quantitatively on mathematical modelling, or entirely qualitatively on political science. However, a potential advantage is the ability to link research and practice and to investigate and try to understand both the research and policy perspectives.

## **6.4 The way forward**

The demand for the use of models in the settings under investigation came predominantly from international stakeholders. This is likely a result of relationships between researchers and international stakeholders, where there are specific mechanisms and relationships which support the access (and commissioning) of modelling analyses to inform programme and policy decisions. It is unrealistic at present to expect this same type of relationship to directly transfer into LMICs and into the policy environment of these countries where these relationships are less established or non-existent. Further, the same may also be said for evidence-informed decision making. This concept has emerged only fairly recently, but has very rapidly gained substantial traction. This rapid development has occurred predominantly in HIC settings and at the international level, but is now being directly transferred into LMICs where there is perhaps a less stable foundation for support, and without adequate consideration given to the policy environments of these countries, and the lack of established platforms to support policy making and to facilitate research utilisation.

An increased understanding, and consideration, of the needs of programme planners and policy makers is necessary in order to support the use of modelling and other strategic information to inform planning and decision making. This includes the understanding the key questions and gaps in information at more local levels and being responsive to those needs. For example, the essential (and acute) focus on health care delivery and the implementation of health programmes and policy. The need for not just epidemiological information but also cost effectiveness and resource allocation tools which can help inform these decisions. Importantly, the need for information at the levels at which planning and decision making occurs in order to inform decentralised decision making.

Finally, a more systematic engagement across disciplines is recommended. The integration of epidemiology, social and political science has the potential to enhance health gains by combining the available data, different methods and theoretical perspectives across disciplines.

This investigation makes an initial contribution to this process. Further case study investigations, which examine both the use of data and research information, are recommended particularly in LMIC where there are key gaps in knowledge and understanding of the role of strategic information to support programmes and policy decision making. In parallel, analyses of the policy process which investigate the process by which decisions are made in these same settings are needed.

It is possible that the use of different methods, for example the use of different analytic frameworks, may reveal new insights and understanding. The HIV stakeholder environment is particularly dense with a strong reliance on donor funding in many of the LMIC heavily affected. Analyses which incorporate actor-network theory as an analytic framework and focus on the relationships between and among stakeholders may reveal additional insights not captured in this thesis. This type of an analysis will likely require a strong insider perspective and may benefit from being conducted by researchers within the local context. A necessary initial step in the process is a better understanding of the landscape of donors and key stakeholders within the policy context. Taken together, these recommendations can further knowledge and understanding in order to better support and respond to the strategic information needs of programme planners and policy decision makers.

## References

1. Centers for Disease Control and Prevention. Pneumocystis Pneumonia -- Los Angeles. Morbidity and Mortality Weekly Report. 1981 Jun 5;30(21):250-2.
2. Masur H, Michelis MA, Greene JB, Onorato I, Vandestouwe RA, Holzman RS, et al. An Outbreak of Community-Acquired Pneumocystis-Carinii Pneumonia - Initial Manifestation of Cellular Immune Dysfunction. New Engl J Med. 1981;305(24):1431-8.
3. Centers for Disease Control and Prevention. Epidemiologic Notes and Reports Possible Transfusion-Associated Acquired Immune Deficiency Syndrome (AIDS) -- California. Morbidity and Mortality Weekly Report. 1982 Dec 10;31(48):652-4.
4. Centers for Disease Control and Prevention. Update on Acquired Immune Deficiency Syndrome (AIDS) among Patients with Hemophilia A. Morbidity and Mortality Weekly Report. 1982 Dec 10;31(48):644-6, 52.
5. Harris C, Small CB, Klein RS, Friedland GH, Moll B, Emeson EE, et al. Immunodeficiency in female sexual partners of men with the acquired immunodeficiency syndrome. N Engl J Med. 1983;308(20):1181-4. Epub 1983/05/19.
6. Oleske J, Minnefor A, Cooper R, Jr., Thomas K, dela Cruz A, Ahdieh H, et al. Immune deficiency syndrome in children. Jama. 1983;249(17):2345-9. Epub 1983/05/06.
7. Rosner F, Giron JA. Immune deficiency syndrome in children. Jama. 1983;250(22):3046. Epub 1983/12/09.
8. US Centers for Disease Control and Prevention. Current Trends Update: Acquired Immunodeficiency Syndrome -- United States. Morb Mortal Wkly Rep. 1986;35(2):17-21.
9. US Centers for Disease Control and Prevention. International Notes Update: Acquired Immunodeficiency Syndrome -- Europe. Morb Mortal Wkly Rep. 27 September 1985;34(38):583-9.
10. Centers for Disease Control and Prevention. Current Trends Update on Acquired Immune Deficiency Syndrome (AIDS) -- United States. Morbidity and Mortality Weekly Report. 1982;31(37):507-8,13-14.
11. Barre-Sinoussi F, Chermann JC, Rey F, Nugeyre MT, Chamaret S, Gruest J, et al. Isolation of a T-lymphotropic retrovirus from a patient at risk for acquired immune deficiency syndrome (AIDS). Science. 1983;220(4599):868-71. Epub 1983/05/20.
12. Gallo RC, Salahuddin SZ, Popovic M, Shearer GM, Kaplan M, Haynes BF, et al. Frequent detection and isolation of cytopathic retroviruses (HTLV-III) from patients with AIDS and at risk for AIDS. Science. 1984;224(4648):500-3. Epub 1984/05/04.
13. Piot P, Quinn TC, Taelman H, Feinsod FM, Minlangu KB, Wobin O, et al. Acquired immunodeficiency syndrome in a heterosexual population in Zaire. Lancet. 1984;2(8394):65-9. Epub 1984/07/14.
14. Van de Perre P, Rouvroy D, Lepage P, Bogaerts J, Kestelyn P, Kayihigi J, et al. Acquired immunodeficiency syndrome in Rwanda. Lancet. 1984;2(8394):62-5. Epub 1984/07/14.
15. Serwadda D, Mugerwa RD, Sewankambo NK, Lwegaba A, Carswell JW, Kirya GB, et al. Slim disease: a new disease in Uganda and its association with HTLV-III infection. Lancet. 1985;2(8460):849-52. Epub 1985/10/19.
16. Piot P, Plummer FA, Mhalu FS, Lamboray JL, Chin J, Mann JM. AIDS - An International Perspective. Science. 1988;239(4840):573-9.
17. Chin J, Mann JM. The Global Patterns and Prevalence of AIDS and HIV Infection. AIDS. 1988;2:S247-S52.

18. Chin J. Global estimates of AIDS cases and HIV infections: 1990. *AIDS*. 1990;4 Suppl 1:S277-83. Epub 1990/01/01.
19. WHO: Global Health Observatory - HIV/AIDS [database on the Internet]. World Health Organization. 2014 [cited 21 February 2014]. Available from: <http://www.who.int/gho/hiv/en/>.
20. UNAIDS. AIDS by the numbers. Geneva: Joint United Nations Programme on HIV/AIDS, 2013.
21. WHO. The top 10 causes of death. Geneva: World Health Organization; 2014 [cited 2015 August]; Available from: <http://www.who.int/mediacentre/factsheets/fs310/en/>.
22. UNAIDS. Fact Sheet 2015: Global Statistics 2015. Available from: [http://www.unaids.org/sites/default/files/media\\_asset/20150901\\_FactSheet\\_2015\\_en.pdf](http://www.unaids.org/sites/default/files/media_asset/20150901_FactSheet_2015_en.pdf).
23. Piot P, Kazatchkine M, Dybul M, Lob-Levyt J. AIDS: lessons learnt and myths dispelled. *Lancet*. 2009;374(9685):260-3. Epub 2009/03/24.
24. Piot P, editor. Why AIDS is exceptional. London School of Economics; 2005 February 8; London, UK.
25. Human Sciences Research Council. South African National HIV Prevalence, Incidence and Behaviour Survey, 2012/2014. Available from: <http://www.hsrc.ac.za/uploads/pageContent/4565/SABSSM%20IV%20LEO%20final.pdf>.
26. Ministry of Health. Swaziland HIV Incidence Measurement Survey (SHIMS): First findings report November 2012. Available from: [https://www.k4health.org/sites/default/files/SHIMS\\_Report.pdf](https://www.k4health.org/sites/default/files/SHIMS_Report.pdf).
27. Piot P, Bartos M, Ghys PD, Walker N, Schwartlander B. The global impact of HIV/AIDS. *Nature*. 2001;410(6831):968-73. Epub 2001/04/20.
28. Low-Beer D, Stoneburner RL, Mukulu A. Empirical evidence for the severe but localized impact of AIDS on population structure. *Nature medicine*. 1997;3(5):553-7. Epub 1997/05/01.
29. Farmer P. Social inequalities and emerging infectious diseases. *Emerg Infect Dis*. 1996;2(4):259-69. Epub 1996/10/01.
30. Foster C, Williamson J. A review of current literature on the impact of HIV/AIDS on children in sub-Saharan Africa. *AIDS*. 2000;14:S275-S84.
31. Dixon S, McDonald S, Roberts J. The impact of HIV and AIDS on Africa's economic development. *BMJ*. 2002;324(7331):232-4. Epub 2002/01/26.
32. Jamison DT, Sachs JD, Wang J. The Effect of the AIDS Epidemic on Economic Welfare in Sub-Saharan Africa 2001. Available from: <http://academiccommons.columbia.edu/item/ac:123830>.
33. Musgrove P, Zeramdini R, Carrin G. Basic patterns in national health expenditure. *Bull World Health Organ*. 2002;80(2):134-42. Epub 2002/04/16.
34. Lee RS, Kochman A, Sikkema KJ. Internalized stigma among people living with HIV-AIDS. *AIDS and Behaviour*. 2002;6(309-319).
35. Szekeres G. The next 5 years of global HIV/AIDS policy: Critical gaps and strategies for effective responses. UCLA Program in Global Health, AIDS Policy Development Center, 2008 January. Report No.
36. Rekart ML. Sex-work harm reduction. *Lancet*. 2005;366(9503):2123-34. Epub 2005/12/20.
37. Itaborahy LP, Zhu J. State-sponsored homophobia. A world survey of laws: Criminalisation, protection and recognition of same-sex love 2014. Available from: [http://old.ilga.org/Statehomophobia/ILGA\\_SSHR\\_2014\\_Eng.pdf](http://old.ilga.org/Statehomophobia/ILGA_SSHR_2014_Eng.pdf).

38. Buse K, Dickinson C, Sidibe M. HIV: know your epidemic, act on its politics. *J R Soc Med*. 2008;101(12):572-3. Epub 2008/12/19.
39. Piot P. AIDS: a global response. *Science*. 1996;272(5270):1855. Epub 1996/06/28.
40. Gulick RM, Mellors JW, Havlir D, Eron JJ, Gonzalez C, McMahon D, et al. Treatment with indinavir, zidovudine, and lamivudine in adults with human immunodeficiency virus infection and prior antiretroviral therapy. *New Engl J Med*. 1997;337(11):734-9.
41. Montaner JS, Reiss P, Cooper D, Vella S, Harris M, Conway B, et al. A randomized, double-blind trial comparing combinations of nevirapine, didanosine, and zidovudine for HIV-infected patients: the INCAS Trial. Italy, The Netherlands, Canada and Australia Study. *Jama*. 1998;279(12):930-7. Epub 1998/04/17.
42. Yazdanpanah Y. Costs associated with combination antiretroviral therapy in HIV-infected patients. *J Antimicrob Chemoth*. 2004;53(4):558-61.
43. Bloom DE, Ass RP. Something to be done: Treating HIV/AIDS. *Science*. 2000;288(5474):2171-3.
44. Piot P, Russell S, Larson H. Good politics, bad politics: the experience of AIDS. *Am J Public Health*. 2007;97(11):1934-6. Epub 2007/09/29.
45. Treatment Action Campaign. Fighting for our lives: The history of the treatment action campaign 2010. Available from: <http://www.tac.org.za/files/10yearbook/files/tac%2010%20year%20draft5.pdf>.
46. Nunn AS, da Fonseca EM, Bastos FI, Gruskin S. AIDS treatment in Brazil: impacts and challenges. *Health Aff (Millwood)*. 2009;28(4):1103-13. Epub 2009/07/15.
47. Smith RD, Correa C, Oh C. Trade, TRIPS, and pharmaceuticals. *Lancet*. 2009;373(9664):684-91. Epub 2009/01/27.
48. From ACT UP to the WTO: Urban protest and community building in an era of globalization. Shepard B, Hayduk R, editors. London, UK: Verso; 2002.
49. Individual Members of the Faculty of Harvard University. Consensus Statement on Antiretroviral Treatment for AIDS in Poor Countries 2001. Available from: [http://www.cid.harvard.edu/cidinthenews/pr/consensus\\_aids\\_therapy.pdf](http://www.cid.harvard.edu/cidinthenews/pr/consensus_aids_therapy.pdf).
50. Tassie JM, Szumilin E, Calmy A, Goemaere E. Highly active antiretroviral therapy in resource-poor settings: the experience of Medecins Sans Frontieres. *AIDS*. 2003;17(13):1995-7. Epub 2003/09/10.
51. Ivers LC, Kendrick D, Doucette K. Efficacy of antiretroviral therapy programs in resource-poor settings: a meta-analysis of the published literature. *Clin Infect Dis*. 2005;41(2):217-24. Epub 2005/06/29.
52. The Global Fund. About: History. 2015 [cited 2015 January 10]; Available from: <http://www.theglobalfund.org/en/about/history/>.
53. Crichton J, Theobald S. Strategies and tensions in communicating research on sexual and reproductive health, HIV and AIDS: a qualitative study of the experiences of researchers and communications staff. *Health Res Policy Syst*. 2011;9 Suppl 1:S4. Epub 2011/06/18.
54. The Henry J. Kaiser Family Foundation, UNAIDS. Financing the Response to HIV in Low- and Middle-Income Countries: International Assistance from Donor Governments in 2012 September 2013. Available from: [http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/document/2013/09/20130923\\_KFF\\_UNAIDS\\_Financing.pdf](http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/document/2013/09/20130923_KFF_UNAIDS_Financing.pdf).
55. Kaiser Family Foundation. Fact Sheet - The Global HIV/AIDS Epidemic 2009 1 February 2010. Available from: <http://www.kff.org/hivaids/upload/3030-14.pdf>.

56. Guyatt G. Evidence-Based Medicine - a New Approach to Teaching the Practice of Medicine. *Jama-J Am Med Assoc.* 1992;268(17):2420-5.
57. Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS. Evidence based medicine: What it is and what it isn't - It's about integrating individual clinical expertise and the best external evidence. *Brit Med J.* 1996;312(7023):71-2.
58. Brownson RC, Fielding JE, Maylahn CA. Evidence-Based Public Health: A Fundamental Concept for Public Health Practice. *Annu Rev Publ Health.* 2009;30:175-201.
59. Kohatsu ND, Robinson JG, Torner JC. Evidence-based public health - An evolving concept. *Am J Prev Med.* 2004;27(5):417-21.
60. Blanchard JF, Aral SO. Program Science: an initiative to improve the planning, implementation and evaluation of HIV/sexually transmitted infection prevention programmes. *Sex Transm Infect.* 2011;87(1):2-3. Epub 2010/12/04.
61. Aral SO, Blanchard JF. The Program Science initiative: improving the planning, implementation and evaluation of HIV/STI prevention programs. *Sex Transm Infect.* 2012;88(3):157-9. Epub 2012/03/01.
62. Piot P. Global AIDS epidemic: time to turn the tide. *Science.* 2000;288(5474):2176-8. Epub 2000/06/24.
63. Padian NS, McCoy SI, Karim SSA, Hasen N, Kim J, Bartos M, et al. HIV prevention transformed: the new prevention research agenda. *Lancet.* 2011;378(9787):269-78.
64. Donnell D, Baeten JM, Kiarie J, Thomas KK, Stevens W, Cohen CR, et al. Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: a prospective cohort analysis. *Lancet.* 2010;375(9731):2092-8.
65. Quinn TC, Wawer MJ, Sewankambo N, Serwadda D, Li CJ, Wabwire-Mangen F, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1. *New Engl J Med.* 2000;342(13):921-9.
66. Castilla J, del Romero J, Hernando V, Marinovich B, Garcia S, Rodriguez C. Effectiveness of highly active antiretroviral therapy in reducing heterosexual transmission of HIV. *J aids.* 2005;40(1):96-101.
67. Porco TC, Martin JN, Page-Shafer KA, Cheng A, Charlebois E, Grant RM, et al. Decline in HIV infectivity following the introduction of highly active antiretroviral therapy. *AIDS.* 2004;18(1):81-8.
68. Connor EM, Sperling RS, Gelber R, Kiselev P, Scott G, Osullivan MJ, et al. Reduction of Maternal-Infant Transmission of Human-Immunodeficiency-Virus Type-1 with Zidovudine Treatment. *New Engl J Med.* 1994;331(18):1173-80.
69. Saba J, Haverkamp G, Gray G, McIntyre J, Mmiro F, Ndugwa C, et al. Efficacy of three short-course regimens of zidovudine and lamivudine in preventing early and late transmission of HIV-1 from mother to child in Tanzania, South Africa, and Uganda (Petra study): a randomised, double-blind, placebo-controlled trial. *Lancet.* 2002;359(9313):1178-86.
70. Shaffer N, Chuachoowong R, Mock PA, Bhadrakom C, Siriwasin W, Young NL, et al. Short-course zidovudine for perinatal HIV-1 transmission in Bangkok, Thailand: a randomised controlled trial. *Lancet.* 1999;353(9155):773-80.
71. Wiktor SZ, Ekpini E, Karon JM, Nkengasong J, Maurice C, Severin ST, et al. Short-course oral zidovudine for prevention of mother-to-child transmission of HIV-1 in Abidjan, Cote d'Ivoire: a randomised trial. *Lancet.* 1999;353(9155):781-5.
72. Dabis F, Msellati P, Meda N, Welffens-Ekra C, You B, Manigart O, et al. 6-month efficacy, tolerance, and acceptability of a short regimen of oral zidovudine to reduce vertical transmission

of HIV in breastfed children in Cote d'Ivoire and Burkina Faso: a double-blind placebo-controlled multicentre trial. *Lancet*. 1999;353(9155):786-92.

73. Guay LA, Musoke P, Fleming T, Bagenda D, Allen M, Nakabiito C, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: HIVMET 012 randomised trial. *Lancet*. 1999;354(9181):795-802.

74. Moodley D, Moodley J, Coovadia H, Gray G, McIntyre J, Hofmyer J, et al. A multicenter randomized controlled trial of nevirapine versus a combination of zidovudine and lamivudine to reduce intrapartum and early postpartum mother-to-child transmission of human immunodeficiency virus type 1. *J Infect Dis*. 2003;187(5):725-35.

75. Dabis F, Bequet L, Ekouevi DK, Viho I, Rouet F, Horo A, et al. Field efficacy of zidovudine, lamivudine and single-dose nevirapine to prevent peripartum HIV transmission. *AIDS*. 2005;19(3):309-18.

76. WHO/ILO. Post-exposure prophylaxis to prevent HIV infection: Joint WHO/ILO guidelines on post-exposure prophylaxis (PEP) to prevent HIV infection. Geneva: World Health Organisation, 2008.

77. Smith DK, Grohskopf LA, Black RJ, Auerbach JD, Veronese F, Struble KA, et al. Antiretroviral postexposure prophylaxis after sexual, injection-drug use, or other nonoccupational exposure to HIV in the United States: recommendations from the U.S. Department of Health and Human Services. *MMWR Recomm Rep*. 2005;54(RR-2):1-20. Epub 2005/01/22.

78. Grant RM, Lama JR, Anderson PL, McMahan V, Liu AY, Vargas L, et al. Preexposure Chemoprophylaxis for HIV Prevention in Men Who Have Sex with Men. *New Engl J Med*. 2010;363(27):2587-99.

79. Karim QA, Karim SSA, Frohlich JA, Grobler AC, Baxter C, Mansoor LE, et al. Effectiveness and Safety of Tenofovir Gel, an Antiretroviral Microbicide, for the Prevention of HIV Infection in Women. *Science*. 2010;329(5996):1168-74.

80. Weiss HA, Quigley MA, Hayes RJ. Male circumcision and risk of HIV infection in sub-Saharan Africa: a systematic review and meta-analysis. *AIDS*. 2000;14(15):2361-70.

81. Westercamp N, Bailey RC. Acceptability of male circumcision for prevention of HIV/AIDS in sub-Saharan Africa: A review. *Aids and Behavior*. 2007;11(3):341-55.

82. Kahn JG, Marseille E, Auvert B. Cost-effectiveness of male circumcision for HIV prevention in a South African setting. *PLoS Med*. 2006;3(12):e517. Epub 2006/12/30.

83. Palmateer N, Kimber J, Hickman M, Hutchinson S, Rhodes T, Goldberg D. Evidence for the effectiveness of sterile injecting equipment provision in preventing hepatitis C and human immunodeficiency virus transmission among injecting drug users: a review of reviews. *Addiction*. 2010;105(5):844-59.

84. Mattick RP, Breen C, Kimber J, Davoli M. Methadone maintenance therapy versus no opioid replacement therapy for opioid dependence. *Cochrane Db Syst Rev*. 2009(3):-.

85. Gibson DR, Flynn NM, McCarthy JJ. Effectiveness of methadone treatment in reducing HIV risk behavior and HIV seroconversion among injecting drug users. *AIDS*. 1999;13(14):1807-18. Epub 1999/10/08.

86. Zaric GS, Barnett PG, Brandeau ML. HIV transmission and the cost-effectiveness of methadone maintenance. *Am J Public Health*. 2000;90(7):1100-11. Epub 2000/07/18.

87. Long EF, Brandeau ML, Galvin CM, Vinichenko T, Tole SP, Schwartz A, et al. Effectiveness and cost-effectiveness of strategies to expand antiretroviral therapy in St. Petersburg, Russia. *AIDS*. 2006;20(17):2207-15. Epub 2006/11/07.

88. Wolfe D, Carrieri MP, Shepard D. Treatment and care for injecting drug users with HIV infection: a review of barriers and ways forward. *Lancet*. 2010;376(9738):355-66. Epub 2010/07/24.
89. Gibson DR, Flynn NM, Perales D. Effectiveness of syringe exchange programs in reducing HIV risk behavior and HIV seroconversion among injecting drug users. *AIDS*. 2001;15(11):1329-41.
90. Wodak A, Cooney A. Do needle syringe programs reduce HIV infection among injecting drug users: A comprehensive review of the international evidence. *Subst Use Misuse*. 2006;41(6-7):777-813.
91. Piot P. The science of AIDS: a tale of two worlds. *Science*. 1998;280(5371):1844-5. Epub 1998/07/21.
92. Buse K, Martin-Hilber A, Widyantoro N, Hawkes SJ. Management of the politics of evidence-based sexual and reproductive health policy. *Lancet*. 2006;368(9552):2101-3.
93. Stall R, Mills TC. A quarter century of AIDS. *Am J Public Health*. 2006;96(6):959-61. Epub 2006/05/04.
94. Buse K, Lalji N, Mayhew SH, Imran M, Hawkes SJ. Political feasibility of scaling-up five evidence-informed HIV interventions in Pakistan: a policy analysis. *Sexually Transmitted Infections*. 2009;85:37-42.
95. Moss K. International HIV/AIDS, Tuberculosis, and Malaria: Key Changes to U.S. Programs and Funding. August 25 ed. Congressional Research Service: CRS Report for Congress; 2008.
96. Underhill K, Montgomery P, Operario D. Sexual abstinence only programmes to prevent HIV infection in high income countries: systematic review. *Brit Med J*. 2007;335(7613):248-52.
97. Dietrich JW. The Politics of PEPFAR: The President's Emergency Plan for AIDS Relief. *Ethics and International Affairs*. 2007;21(3):277-92.
98. Hulse C. Surge in Cases of H.I.V. Tests U.S. Policy on Needle Exchanges. *The New York Times*. 2015 May 16;Sect. U.S.
99. Strathdee SA, Beyrer C. Threading the Needle - How to Stop the HIV Outbreak in Rural Indiana. *New Engl J Med*. 2015;373(5):397-9.
100. Bridge J, Lazarus JV, Atun R. HIV epidemics and prevention responses in Asia and Eastern Europe: lessons to be learned? *AIDS*. 2010;24:S86-S94.
101. Smith AD, Tapsoba P, Peshu N, Sanders EJ, Jaffe HW. Men who have sex with men and HIV/AIDS in sub-Saharan Africa. *Lancet*. 2009;374(9687):416-22. Epub 2009/07/21.
102. Bertozzi SM, Laga M, Bautista-Arredondo S, Coutinho A. Making HIV prevention programmes work. *Lancet*. 2008;372(9641):831-44. Epub 2008/08/09.
103. Garnett GP. An introduction to mathematical models in sexually transmitted disease epidemiology. *Sex Transm Infect*. 2002;78(1):7-12. Epub 2002/03/02.
104. Schichl H. Models and the History of Modelling. In: Kallrath J, editor. *Modeling Languages in Mathematical Optimization*. Netherlands: Kluwer Academic Publishers Group; 2004.
105. Kalnay E, Kanamitsu M, Baker WE. Global Numerical Weather Prediction at the National-Meteorological-Center. *B Am Meteorol Soc*. 1990;71(10):1410-28.
106. Lorenc AC. Analysis-Methods for Numerical Weather Prediction. *Q J Roy Meteor Soc*. 1986;112(474):1177-94.
107. Briggs AH, Claxton K, Sculpher MJ. *Decision modelling for health economic evaluation*. Oxford: Oxford University Press; 2006. x, 237 p. p.

108. Dabbagh V. What is Mathematical Modelling. Canada: Simon Fraser University; [cited 2015 August]; Available from: <http://www.sfu.ca/~vdabbagh/Chap1-modeling.pdf>.
109. Mishra S, Fisman DN, Boily MC. The ABC of terms used in mathematical models of infectious diseases. *J Epidemiol Commun H.* 2011;65(1):87-94.
110. Garnett GP, Cousens S, Hallett TB, Steketee R, Walker N. Mathematical models in the evaluation of health programmes. *Lancet.* 2011;378(9790):515-25.
111. Anderson RM, May RM. *Infectious Diseases of Humans.* Oxford: Oxford University Press; 1991.
112. Heesterbeek H, Anderson RM, Andreasen V, Bansal S, De Angelis D, Dye C, et al. Modeling infectious disease dynamics in the complex landscape of global health. *Science.* 2015;347(6227):aaa4339. Epub 2015/03/15.
113. Rivers CM, Lofgren ET, Marathe M, Eubank S, Lewis BL. Modeling the impact of interventions on an epidemic of ebola in sierra leone and liberia. *PLoS currents.* 2014;6. Epub 2014/01/01.
114. Ebola virus disease in West Africa--the first 9 months of the epidemic and forward projections. *N Engl J Med.* 2014;371(16):1481-95. Epub 2014/09/23.
115. Whitty CJ, Farrar J, Ferguson N, Edmunds WJ, Piot P, Leach M, et al. Infectious disease: tough choices to reduce Ebola transmission. *Nature.* 2014;515(7526):192-4. Epub 2014/11/14.
116. Camacho A, Kucharski AJ, Funk S, Breman J, Piot P, Edmunds WJ. Potential for large outbreaks of Ebola virus disease. *Epidemics-Neth.* 2014;9:70-8. Epub 2014/12/07.
117. Pandey A, Atkins KE, Medlock J, Wenzel N, Townsend JP, Childs JE, et al. Strategies for containing Ebola in West Africa. *Science.* 2014;346(6212):991-5. Epub 2014/11/22.
118. Anderson RM, Medley GF, May RM, Johnson AM. A preliminary study of the transmission dynamics of the human immunodeficiency virus (HIV), the causative agent of AIDS. *IMA J Math Appl Med Biol.* 1986;3(4):229-63. Epub 1986/01/01.
119. Blythe SP, Anderson RM. Distributed incubation and infectious periods in models of the transmission dynamics of the human immunodeficiency virus (HIV). *IMA J Math Appl Med Biol.* 1988;5(1):1-19. Epub 1988/01/01.
120. Yorke JA, Hethcote HW, Nold A. Dynamics and Control of Transmission of Gonorrhea. *Sexually Transmitted Diseases.* 1978;5(2):51-6.
121. Dietz K, Haderl KP. Epidemiological Models for Sexually-Transmitted Diseases. *Journal of mathematical biology.* 1988;26(1):1-25.
122. Bailey NTJ. Introduction to the Modeling of Venereal-Disease. *Journal of mathematical biology.* 1979;8(3):301-22.
123. Anderson RM. *Population Dynamics of Infectious Diseases.* London: Chapman and Hall; 1982.
124. Isham V. Mathematical-Modeling of the Transmission Dynamics of Hiv Infection and Aids - a Review. *J Roy Stat Soc a Sta.* 1988;151:5-30.
125. Perelson AS, Nelson PW. Mathematical analysis of HIV-1 dynamics in vivo. *Siam Rev.* 1999;41(1):3-44.
126. Baggaley RF, Ferguson NM, Garnett GP. The epidemiological impact of antiretroviral use predicted by mathematical models: a review. *Emerging themes in epidemiology.* 2005;2:9. Epub 2005/09/13.
127. Anderson RM. Mathematical and statistical studies of the epidemiology of HIV. *AIDS.* 1989;3(6):333-46. Epub 1989/06/01.

128. Johnson LF, White PJ. A review of mathematical models of HIV/AIDS interventions and their implications for policy. *Sex Transm Infect.* 2011;87(7):629-34. Epub 2011/06/21.
129. Wodarz D, Nowak MA. Mathematical models of HIV pathogenesis and treatment. *Bioessays.* 2002;24(12):1178-87.
130. UNAIDS. Report on the Global HIV Epidemic, June 1998. Geneva: UNAIDS, 1998.
131. UNAIDS. Report on the Global HIV Epidemic, June 2000. Geneva: UNAIDS, 2000.
132. UNAIDS. Report on the Global HIV Epidemic, 2002. Geneva: UNAIDS, 2002.
133. UNAIDS. Methodology - Understanding the HIV Estimates. Geneva: Joint United Nations Programme on HIV/AIDS; 2013.
134. UNAIDS. How AIDS changed everything — MDG6: 15 years, 15 lessons of hope from the AIDS response. Geneva: Joint United Nations Programme on HIV/AIDS, 2015.
135. WHO/UNAIDS Working Group on Global HIV/AIDS and STI Surveillance, WHO. Guidelines for second generation HIV surveillance. An update: know your epidemic 2013 August 2015. Available from: [http://apps.who.int/iris/bitstream/10665/85511/1/9789241505826\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/85511/1/9789241505826_eng.pdf?ua=1).
136. Mertens TE, Belsey E, Stoneburner RL, Beer DL, Sato P, Burton A, et al. Global estimates and epidemiology of HIV-1 infections and AIDS: further heterogeneity in spread and impact. *AIDS.* 1995;9 Suppl A:S259-72. Epub 1995/01/01.
137. Salomon J, Gakidou E, Murray CJ. Methods for modelling the HIV/AIDS epidemic in sub-Saharan Africa. GPE Discussion Paper Series: No3 [Internet]. Available from: <http://www.who.int/healthinfo/paper03.pdf>.
138. UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance. Guidelines for second generation surveillance. 2000 26 February 2014. Available from: [http://www.who.int/hiv/pub/surveillance/en/cds\\_edc\\_2000\\_5.pdf](http://www.who.int/hiv/pub/surveillance/en/cds_edc_2000_5.pdf).
139. Avenir Health. Spectrum. 2015 [cited 2015 February]; Available from: <http://www.avenirhealth.org/software-spectrum.php>.
140. East-West Center. About EWC. Honolulu, HI [cited 2015 August]; Available from: <http://www.eastwestcenter.org/about-ewc/mission-and-organization>.
141. Avenir Health. Avenir Health: About Us. Glastonbury, CT [cited 2015 August]; Available from: <http://www.avenirhealth.org/about.php>.
142. Imperial College London. UNAIDS Reference Group on Estimates, Modelling and Projections. London, United Kingdom: Manta Ray Media; [cited 2015 May]; Available from: [www.epidem.org](http://www.epidem.org).
143. Brown T, Bao L, Eaton JW, Hogan DR, Mahy M, Marsh K, et al. Improvements in prevalence trend fitting and incidence estimation in EPP 2013. *AIDS.* 2014;28:S415-S25.
144. Marsh K, Mahy M, Salomon JA, Hogan DR. Assessing and adjusting for differences between HIV prevalence estimates derived from national population-based surveys and antenatal care surveillance, with applications for Spectrum 2013. *AIDS.* 2014;28:S497-S505.
145. Pisani E, Garnett GP, Brown T, Stover J, Grassly NC, Hankins C, et al. Back to basics in HIV prevention: focus on exposure. *Brit Med J.* 2003;326(7403):1384-7.
146. Mishra S, Sgaier SK, Thompson LH, Moses S, Ramesh BM, Alary M, et al. HIV epidemic appraisals for assisting in the design of effective prevention programmes: shifting the paradigm back to basics. *Plos One.* 2012;7(3):e32324. Epub 2012/03/08.
147. Hallett TB, White PJ, Garnett GP. Appropriate evaluation of HIV prevention interventions: from experiment to full-scale implementation. *Sex Transm Infect.* 2007;83 Suppl 1:i55-60. Epub 2007/01/12.

148. Hallett TB. Estimating the HIV incidence rate: recent and future developments. *Current Opinion in Hiv and Aids*. 2011;6(2):102-7.
149. Ahmed S, Lutalo T, Wawer M, Serwadda D, Sewankambo NK, Nalugoda F, et al. HIV incidence and sexually transmitted disease prevalence associated with condom use: a population study in Rakai, Uganda. *AIDS*. 2001;15(16):2171-9. Epub 2001/10/31.
150. Aulagnier M, Janssens W, De Beer I, van Rooy G, Gaeb E, Hesp C, et al. Incidence of HIV in Windhoek, Namibia: demographic and socio-economic associations. *Plos One*. 2011;6(10):e25860. Epub 2011/10/13.
151. Barnighausen T, Tanser F, Gqwede Z, Mbizana C, Herbst K, Newell ML. High HIV incidence in a community with high HIV prevalence in rural South Africa: findings from a prospective population-based study. *AIDS*. 2008;22(1):139-44. Epub 2007/12/20.
152. Feldblum PJ, Latka MH, Lombaard J, Chetty C, Chen PL, Sexton C, et al. HIV incidence and prevalence among cohorts of women with higher risk behaviour in Bloemfontein and Rustenburg, South Africa: a prospective study. *BMJ open*. 2012;2(1):e000626. Epub 2012/02/15.
153. Geis S, Maboko L, Saathoff E, Hoffmann O, Geldmacher C, Mmbando D, et al. Risk factors for HIV-1 infection in a longitudinal, prospective cohort of adults from the Mbeya Region, Tanzania. *J Acquir Immune Defic Syndr*. 2011;56(5):453-9. Epub 2011/02/08.
154. Kamali A, Carpenter LM, Whitworth JA, Pool R, Ruberantwari A, Ojwiya A. Seven-year trends in HIV-1 infection rates, and changes in sexual behaviour, among adults in rural Uganda. *AIDS*. 2000;14(4):427-34. Epub 2000/04/19.
155. Kumwenda N, Hoffman I, Chirenje M, Kelly C, Coletti A, Ristow A, et al. HIV incidence among women of reproductive age in Malawi and Zimbabwe. *Sex Transm Dis*. 2006;33(11):646-51. Epub 2006/06/15.
156. Lopman B, Nyamukapa C, Mushati P, Mupambireyi Z, Mason P, Garnett GP, et al. HIV incidence in 3 years of follow-up of a Zimbabwe cohort--1998-2000 to 2001-03: contributions of proximate and underlying determinants to transmission. *Int J Epidemiol*. 2008;37(1):88-105. Epub 2008/01/22.
157. Mmbaga EJ, Hussain A, Leyna GH, Klouman E, Masenga E, Sam N, et al. Incidence of HIV-1 infection and changes in prevalence of reproductive tract infections and sexual risk behaviours: a population-based longitudinal study in rural Tanzania. *African journal of AIDS research : AJAR*. 2006;5(3):281-8. Epub 2006/11/01.
158. Wambura M, Urassa M, Isingo R, Ndege M, Marston M, Slaymaker E, et al. HIV prevalence and incidence in rural Tanzania: results from 10 years of follow-up in an open-cohort study. *J Acquir Immune Defic Syndr*. 2007;46(5):616-23. Epub 2007/11/29.
159. Kassanjee R, Pilcher CD, Keating SM, Facente SN, McKinney E, Price MA, et al. Independent assessment of candidate HIV incidence assays on specimens in the CEPHIA repository. *AIDS*. 2014;28(16):2439-49.
160. Busch MP, Pilcher CD, Mastro TD, Kaldor J, Vercauteren G, Rodriguez W, et al. Beyond detuning: 10 years of progress and new challenges in the development and application of assays for HIV incidence estimation. *AIDS*. 2010;24(18):2763-71.
161. Mastro TD, Kim AA, Hallett T, Rehle T, Welte A, Laeyendecker O, et al. Estimating HIV Incidence in Populations Using Tests for Recent Infection: Issues, Challenges and the Way Forward. *Journal of HIV AIDS surveillance & epidemiology*. 2010;2(1):1-14. Epub 2010/01/01.
162. Incidence Assay Critical Path Working Group. More and Better Information to Tackle HIV Epidemics: Towards Improved HIV Incidence Assays. *Plos Medicine*. 2011;8(6).

163. Bao L, Ye J, Hallett TB. Incorporating incidence information within the UNAIDS Estimation and Projection Package framework: a study based on simulated incidence assay data. *AIDS*. 2014;28 Suppl 4:S515-22. Epub 2014/11/20.
164. UNAIDS. Epi Alert: UNAIDS quarterly update on HIV epidemiology /1Q 2010. Available from: [http://www.unaids.org/sites/default/files/media\\_asset/epi\\_alert\\_1stqtr2010\\_en\\_0.pdf](http://www.unaids.org/sites/default/files/media_asset/epi_alert_1stqtr2010_en_0.pdf).
165. Case KK, Ghys PD, Gouws E, Eaton JW, Borquez A, Stover J, et al. Understanding the modes of transmission model of new HIV infection and its use in prevention planning. *Bull World Health Organ*. 2012;90(11):831-8A. Epub 2012/12/12.
166. UNAIDS. Practical guidelines for intensifying HIV prevention: towards universal access. Available. [http://data.unaids.org/pub/Manual/2007/20070306\\_Prevention\\_Guidelines\\_Towards\\_Universal\\_Access\\_en.pdf](http://data.unaids.org/pub/Manual/2007/20070306_Prevention_Guidelines_Towards_Universal_Access_en.pdf), 2007.
167. World Bank. HIV/AIDS M&E - Getting Results. How GAMET helps countries to improve their HIV response through Epidemic, Response and Policy Syntheses: World Bank Global HIV/AIDS Program; December 2007.
168. Analysis of HIV prevention responses and modes of HIV transmission: the UNAIDS-GAMET- supported synthesis process [database on the Internet]. 2008. Available from: [http://www.unaidsrsta.org/sites/default/files/modesoftransmission/analysis\\_hiv\\_prevention\\_response\\_and\\_mot.pdf](http://www.unaidsrsta.org/sites/default/files/modesoftransmission/analysis_hiv_prevention_response_and_mot.pdf).
169. Alarcón Villaverde J. Modos de transmisión del VIH en América Latina: resultados de la aplicación del modelo. Peru: Organización Panamericana de la Salud, 2009.
170. UNAIDS. Uganda HIV prevention response and modes of transmission analysis. Uganda: Uganda National AIDS Commission, 2009.
171. UNAIDS. New HIV infections by mode of transmission in West Africa: A multi-country analysis. Dakar, Senegal: UNAIDS Regional Support Team for West and Central Africa, 2010.
172. Maleta K, Bowie C. Selecting HIV infection prevention interventions in the mature HIV epidemic in Malawi using the mode of transmission model. *BMC health services research*. 2010;10:243. Epub 2010/08/21.
173. Nasirian M. Modeling of new HIV infections based on exposure groups in Iran: Lambert Academic Publishing; 2012.
174. UNAIDS, The World Bank. Modes of HIV transmission in Nigeria: analysis of the distribution of new HIV infections in Nigeria and recommendations for prevention. Abuja, Nigeria: UNAIDS, 2009.
175. UNAIDS, National AIDS Secretariat, UNICEF. Sierra Leone HIV Modes of Transmission Study: Know your epidemic, know your response. Freetown, Sierra Leone: National AIDS Secretariat; 2010.
176. Zimbabwe National AIDS Council, The World Bank, UNAIDS. Zimbabwe Analysis of HIV Epidemic, Response and Modes of Transmission. Harare: Zimbabwe National AIDS Council; 2010.
177. Data Synthesis on Tendencies of the HIV epidemic in the Republic of Moldova 2011. Chisinau, Republic of Moldova 2012 [cited 2015 August]; Available from: <http://aids.md/aids/files/1248/raport%20EnglNEWWWW.pdf>.
178. UNAIDS. Short-term estimates of adult HIV incidence in the Philippines in 2010 by mode of transmission. Philippines: National Epidemiology Center, Department of Health; 2010 [cited 2015 August]; Available from: [http://www.unaids.org.ph/apanel/uploads/2011\\_MOT\\_Philippines\\_2009Report\\_%2025Feb2011\\_DOH.pdf](http://www.unaids.org.ph/apanel/uploads/2011_MOT_Philippines_2009Report_%2025Feb2011_DOH.pdf).

179. Ministerio de Salud. Modelo de Modos de Transmisión del VIH: Análisis de la distribución de nuevas infecciones por el VIH y recomendaciones para prevención Nicaragua: UNAIDS/USAID/PASCA; 2012 [cited 2015 August]; Available from: [file:///C:/Documents%20and%20Settings/kcase.DIDE/My%20Documents/Downloads/Modelos\\_de\\_modos\\_de\\_transmision\\_del\\_VIH\\_CONISIDA\\_USAID\\_PASCA\\_2012.pdf](file:///C:/Documents%20and%20Settings/kcase.DIDE/My%20Documents/Downloads/Modelos_de_modos_de_transmision_del_VIH_CONISIDA_USAID_PASCA_2012.pdf).
180. Samudio M, Vesga JF, Cohenca B, Jacobs M, Brezzo C. [Estimate of the incidence of HIV in the adult population of Paraguay using the MoT mathematical model]. *Revista panamericana de salud publica = Pan American journal of public health*. 2015;37(3):154-61. Epub 2015/05/20. Estimacion de la incidencia de VIH en poblacion adulta de Paraguay con el modelo matematico MoT.
181. Ministry of Public Health of Belize National Aids Program. "Modes of Transmission Model - MOT": New HIV infections expected in Belize for 2014. Belize: USAID/PASCA/Ministry of Health; 2014 [cited 2015 August]; Available from: [http://www.pasca.org/userfiles/MOT\\_Belize%20final%20report%207\\_March\\_2014.pdf](http://www.pasca.org/userfiles/MOT_Belize%20final%20report%207_March_2014.pdf).
182. UNAIDS, Jamaica National HIV/STI Programme. Modes of HIV transmission in Jamaica: distribution of new HIV infections in Jamaica for 2012: recommendations for efficient resource allocation and prevention strategies. Kingston, Jamaica: UNAIDS/National HIV/STI Programme, Ministry of Health 2012.
183. Organización Panamericana de la Salud. Modos de Transmisión del VIH en América Latina: Resultados de la aplicación del modelo Lima, Peru: Organización Panamericana de la Salud; 2009 [cited 2015 August]; Available from: [http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/countrypreport/2009/20090810\\_MOT\\_Peru\\_es.pdf](http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/countrypreport/2009/20090810_MOT_Peru_es.pdf).
184. Cassels S, Goodreau SM. Interaction of mathematical modeling and social and behavioral HIV/AIDS research. *Current Opinion in Hiv and Aids*. 2011;6(2):119-23.
185. Stover J, Walker N, Garnett GP, Salomon JA, Stanecki KA, Ghys PD, et al. Can we reverse the HIV/AIDS pandemic with an expanded response? *Lancet*. 2002;360(9326):73-7. Epub 2002/07/13.
186. Bollinger L, Cooper-Arnold K, Stover J. Where are the gaps? The effects of HIV-prevention interventions on behavioral change. *Studies in family planning*. 2004;35(1):27-38. Epub 2004/04/08.
187. Hallett TB, Garnett GP, Mupamberiyi Z, Gregson S. Measuring effectiveness in community randomized trials of HIV prevention. *International Journal of Epidemiology*. 2008;37(1):77-87.
188. Hallett TB, Singh K, Smith JA, White RG, Abu-Raddad LJ, Garnett GP. Understanding the Impact of Male Circumcision Interventions on the Spread of HIV in Southern Africa. *Plos One*. 2008;3(5).
189. Dushoff J, Patocs A, Shi CF. Modeling the population-level effects of male circumcision as an HIV-preventive measure: a gendered perspective. *Plos One*. 2011;6(12):e28608. Epub 2011/12/30.
190. Male circumcision for HIV prevention in high HIV prevalence settings: what can mathematical modelling contribute to informed decision making? *PLoS Med*. 2009;6(9):e1000109. Epub 2009/11/11.
191. Gray RH, Li XB, Kigozi G, Serwadda D, Nalugoda F, Watya S, et al. The impact of male circumcision on HIV incidence and cost per infection prevented: a stochastic simulation model from Rakai, Uganda. *AIDS*. 2007;21(7):845-50.

192. Williams BG, Lloyd-Smith JO, Gouws E, Hankins C, Getz WM, Hargrove J, et al. The potential impact of male circumcision on HIV in sub-Saharan Africa. *Plos Medicine*. 2006;3(7):1032-40.
193. Nagelkerke NJD, Moses S, de Vlas SJ, Bailey RC. Modelling the public health impact of male circumcision for HIV prevention in high prevalence areas in Africa. *Bmc Infect Dis*. 2007;7.
194. El-Sadr WM, Coburn BJ, Blower S. Modeling the impact on the HIV epidemic of treating discordant couples with antiretrovirals to prevent transmission. *AIDS*. 2011;25(18):2295-9.
195. Eaton JW, Johnson LF, Salomon JA, Barnighausen T, Bendavid E, Bershteyn A, et al. HIV Treatment as Prevention: Systematic Comparison of Mathematical Models of the Potential Impact of Antiretroviral Therapy on HIV Incidence in South Africa. *Plos Medicine*. 2012;9(7).
196. Granich RM, Gilks CF, Dye C, De Cock KM, Williams BG. Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. *Lancet*. 2009;373(9657):48-57.
197. Anderson RM, Gupta S, May RM. Potential of community-wide chemotherapy or immunotherapy to control the spread of HIV-1. *Nature*. 1991;350(6316):356-9. Epub 1991/03/28.
198. Blower SM, Gershengorn HB, Grant RM. A tale of two futures: HIV and antiretroviral therapy in San Francisco. *Science*. 2000;287(5453):650-4. Epub 2000/01/29.
199. Odone A, Amadasi S, White RG, Cohen T, Grant AD, Houben RM. The impact of antiretroviral therapy on mortality in HIV positive people during tuberculosis treatment: a systematic review and meta-analysis. *Plos One*. 2014;9(11):e112017. Epub 2014/11/13.
200. Martin NK, Devine A, Eaton JW, Miners A, Hallett TB, Foster GR, et al. Modeling the impact of early antiretroviral therapy for adults coinfecting with HIV and hepatitis B or C in South Africa. *AIDS*. 2014;28 Suppl 1:S35-46. Epub 2014/01/29.
201. Abbas UL, Anderson RM, Mellors JW. Potential impact of antiretroviral chemoprophylaxis on HIV-1 transmission in resource-limited settings. *Plos One*. 2007;2(9):e875. Epub 2007/09/20.
202. Desai K, Sansom SL, Ackers ML, Stewart SR, Hall HI, Hu DJ, et al. Modeling the impact of HIV chemoprophylaxis strategies among men who have sex with men in the United States: HIV infections prevented and cost-effectiveness. *AIDS*. 2008;22(14):1829-39. Epub 2008/08/30.
203. Hallett TB, Baeten JM, Heffron R, Barnabas R, de Bruyn G, Cremin I, et al. Optimal uses of antiretrovirals for prevention in HIV-1 serodiscordant heterosexual couples in South Africa: a modelling study. *PLoS Med*. 2011;8(11):e1001123. Epub 2011/11/24.
204. Pretorius C, Stover J, Bollinger L, Bacaer N, Williams B. Evaluating the cost-effectiveness of pre-exposure prophylaxis (PrEP) and its impact on HIV-1 transmission in South Africa. *Plos One*. 2010;5(11):e13646. Epub 2010/11/17.
205. Williams BG, Abdool Karim SS, Karim QA, Gouws E. Epidemiological impact of tenofovir gel on the HIV epidemic in South Africa. *J Acquir Immune Defic Syndr*. 2011;58(2):207-10. Epub 2011/06/10.
206. Cremin I, Alsallaq R, Dybul M, Piot P, Garnett G, Hallett TB. The new role of antiretrovirals in combination HIV prevention: a mathematical modelling analysis. *AIDS*. 2013;27(3):447-58.
207. Anderson RM, May RM, Boily MC, Garnett GP, Rowley JT. The spread of HIV-1 in Africa: sexual contact patterns and the predicted demographic impact of AIDS. *Nature*. 1991;352(6336):581-9. Epub 1991/08/15.
208. Murray CJL, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global burden of disease study. *Lancet*. 1997;349(9064):1498-504.

209. Mitchell KM, Lepine A, Terris-Prestholt F, Torpey K, Khamofu H, Folayan MO, et al. Modelling the impact and cost-effectiveness of combination prevention amongst HIV serodiscordant couples in Nigeria. *AIDS*. 2015;29(15):2035-44. Epub 2015/09/12.
210. Anderson SJ, Cherutich P, Kilonzo N, Cremin I, Fecht D, Kimanga D, et al. Maximising the effect of combination HIV prevention through prioritisation of the people and places in greatest need: a modelling study. *Lancet*. 2014;384(9939):249-56.
211. Nagelkerke NJ, Jha P, de Vlas SJ, Korenromp EL, Moses S, Blanchard JF, et al. Modelling HIV/AIDS epidemics in Botswana and India: impact of interventions to prevent transmission. *Bull World Health Organ*. 2002;80(2):89-96. Epub 2002/04/16.
212. Bradfield R, Wright G, Burt G, Cairns G, Van Der Heijden K. The origins and evolution of scenario techniques in long range business planning. *Futures*. 2005;37(8):795-812.
213. Cann A. Scenario-Based Strategic Planning in the U.S. Army Corps of Engineers Civil Works Program. IWR White Paper: Institute for Water Resources and US Army Corps of Engineers; 2010.
214. Malaska P, Malmivirta M, Meristo T, Hansen SO. Scenarios in Europe - Who Uses Them and Why. *Long Range Plann*. 1984;17(5):45-9.
215. Moss RH, Edmonds JA, Hibbard KA, Manning MR, Rose SK, van Vuuren DP, et al. The next generation of scenarios for climate change research and assessment. *Nature*. 2010;463(7282):747-56.
216. Brandt EN. Policy implications of modelling of the AIDS epidemic. *Stat Med*. 1989;8(1):137-9. Epub 1989/01/01.
217. Turner KM, Adams EJ, Lamontagne DS, Emmett L, Baster K, Edmunds WJ. Modelling the effectiveness of chlamydia screening in England. *Sex Transm Infect*. 2006;82(6):496-502. Epub 2006/12/08.
218. Turner K, Adams E, Grant A, Macleod J, Bell G, Clarke J, et al. Costs and cost effectiveness of different strategies for chlamydia screening and partner notification: an economic and mathematical modelling study. *BMJ*. 2011;342:c7250. Epub 2011/01/06.
219. Welte R, Kretzschmar M, Leidl R, van den Hoek A, Jager JC, Postma MJ. Cost-effectiveness of screening programs for Chlamydia trachomatis: a population-based dynamic approach. *Sex Transm Dis*. 2000;27(9):518-29. Epub 2000/10/18.
220. Regan DG, Wilson DP, Hocking JS. Coverage is the key for effective screening of Chlamydia trachomatis in Australia. *J Infect Dis*. 2008;198(3):349-58. Epub 2008/07/01.
221. Mandelblatt JS, Cronin KA, Berry DA, Chang Y, de Koning HJ, Lee SJ, et al. Modeling the impact of population screening on breast cancer mortality in the United States. *Breast*. 2011;20 Suppl 3:S75-81. Epub 2011/11/02.
222. Calonge N, Petitti DB, DeWitt TG, Dietrich AJ, Gregory KD, Grossman D, et al. Screening for Breast Cancer: US Preventive Services Task Force Recommendation Statement. *Ann Intern Med*. 2009;151(10):716-W236.
223. van Druten JA, de Boo T, Plantinga AD. Measles, mumps and rubella: control by vaccination. *Developments in biological standardization*. 1986;65:53-63. Epub 1986/01/01.
224. Gay NJ. Modeling measles, mumps, and rubella: implications for the design of vaccination programs. *Infect Control Hosp Epidemiol*. 1998;19(8):570-3. Epub 1998/10/03.
225. Kim JJ, Goldie SJ. Health and economic implications of HPV vaccination in the United States. *New Engl J Med*. 2008;359(8):821-32.
226. Barnabas RV, Laukkanen P, Koskela P, Kontula O, Lehtinen M, Garnett GP. Epidemiology of HPV 16 and cervical cancer in Finland and the potential impact of vaccination: Mathematical modelling analyses. *Plos Medicine*. 2006;3(5):624-32.

227. Boot HJ, Wallenburg I, de Melker HE, Mangen MJM, Gerritsen AAM, van der Maas NA, et al. Assessing the introduction of universal human papillomavirus vaccination for preadolescent girls in The Netherlands. *Vaccine*. 2007;25(33):6245-56.
228. Kulasingam S, Connelly L, Conway E, Flocking JS, Myers E, Regan DG, et al. A cost-effectiveness analysis of adding a human papillomavirus vaccine to the Australian National Cervical Cancer Screening Program. *Sex Health*. 2007;4(3):165-75.
229. Diaz M, Kim JJ, Albero G, de Sanjose S, Clifford G, Bosch FX, et al. Health and economic impact of HPV 16 and 18 vaccination and cervical cancer screening in India. *British journal of cancer*. 2008;99(2):230-8.
230. Goldie SJ, O'Shea M, Campos NG, Diaz M, Sweet S, Kim SY. Health and economic outcomes of HPV 16,18 vaccination in 72 GAVI-eligible countries. *Vaccine*. 2008;26(32):4080-93.
231. Brisson M, Van de Velde N, De Wals P, Boily MC. Estimating the number needed to vaccinate to prevent diseases and death related to human papillomavirus infection. *CMAJ*. 2007;177(5):464-8. Epub 2007/08/22.
232. Elbasha EH, Dasbach EJ, Insinga RP. Model for assessing human papillomavirus vaccination strategies. *Emerg Infect Dis*. 2007;13(1):28-41. Epub 2007/03/21.
233. Chesson HW, Ekwueme DU, Saraiya M, Markowitz LE. Cost-effectiveness of human papillomavirus vaccination in the United States. *Emerg Infect Dis*. 2008;14(2):244-51. Epub 2008/02/09.
234. Dasbach EJ, Insinga RP, Elbasha EH. The epidemiological and economic impact of a quadrivalent human papillomavirus vaccine (6/11/16/18) in the UK. *BJOG : an international journal of obstetrics and gynaecology*. 2008;115(8):947-56. Epub 2008/05/28.
235. Duintjer Tebbens RJ, Pallansch MA, Kew OM, Caceres VM, Sutter RW, Thompson KM. A dynamic model of poliomyelitis outbreaks: learning from the past to help inform the future. *Am J Epidemiol*. 2005;162(4):358-72. Epub 2005/07/15.
236. Thompson KM, Pallansch MA, Tebbens RJ, Wassilak SG, Cochi SL. Modeling population immunity to support efforts to end the transmission of live polioviruses. *Risk analysis : an official publication of the Society for Risk Analysis*. 2013;33(4):647-63. Epub 2012/09/19.
237. Salomon JA, Hogan DR, Stover J, Stanecki KA, Walker N, Ghys PD, et al. Integrating HIV prevention and treatment: from slogans to impact. *PLoS Med*. 2005;2(1):e16. Epub 2005/01/14.
238. Stover J. Influence of mathematical modeling of HIV and AIDS on policies and programs in the developing world. *Sex Transm Dis*. 2000;27(10):572-8. Epub 2000/12/01.
239. Rowley JT, Anderson RM, Ng TW. Reducing the Spread of Hiv-Infection in Sub-Saharan Africa - Some Demographic and Economic-Implications. *AIDS*. 1990;4(1):47-56.
240. Stover J, Bollinger L, Hecht R, Williams C, Roca E. The impact of an AIDS vaccine in developing countries: a new model and initial results. *Health Aff (Millwood)*. 2007;26(4):1147-58. Epub 2007/07/17.
241. Stover J, Bertozzi S, Gutierrez JP, Walker N, Stanecki KA, Greener R, et al. The global impact of scaling up HIV/AIDS prevention programs in low- and middle-income countries. *Science*. 2006;311(5766):1474-6. Epub 2006/02/04.
242. Schwartzlander B, Stover J, Hallett T, Atun R, Avila C, Gouws E, et al. Towards an improved investment approach for an effective response to HIV/AIDS. *Lancet*. 2011;377(9782):2031-41. Epub 2011/06/07.
243. Karon JM, Dondero TJ, Jr., Curran JW. The projected incidence of AIDS and estimated prevalence of HIV infection in the United States. *J Acquir Immune Defic Syndr*. 1988;1(6):542-50. Epub 1988/01/01.

244. Norman C. Aids Trends - Projections from Limited Data. *Science*. 1985;230(4729):1018-21.
245. Brookmeyer R. Reconstruction and future trends of the AIDS epidemic in the United States. *Science*. 1991;253(5015):37-42. Epub 1991/07/05.
246. Chin J, Lwanga SK. Estimation and projection of adult AIDS cases: a simple epidemiological model. *Bull World Health Organ*. 1991;69(4):399-406. Epub 1991/01/01.
247. United Nations/World Health Organization. The AIDS epidemic and its demographic consequences. Proceedings of the United Nations/World Health Organization on modelling the demographic impact of the AIDS epidemic in pattern II countries: Progress to date and policies for the future. December 13-15; New York 1989.
248. Chin J, Sato PA, Mann JM. Projections of HIV infections and AIDS cases to the year 2000. *Bull World Health Organ*. 1990;68(1):1-11. Epub 1990/01/01.
249. Spectrum v 3.33 [database on the Internet]. Available from: <http://www.futuresinstitute.org/pages/spectrum.aspx>. 2010 [cited 3 February 2010]. Available from: <http://www.futuresinstitute.org/pages/spectrum.aspx>.
250. Hecht R, Bollinger L, Stover J, McGreevey W, Muhib F, Madavo CE, et al. Critical choices in financing the response to the global HIV/AIDS pandemic. *Health Aff (Millwood)*. 2009;28(6):1591-605. Epub 2009/11/06.
251. Hecht R, Stover J, Bollinger L, Muhib F, Case K, de Ferranti D. Financing of HIV/AIDS programme scale-up in low-income and middle-income countries, 2009-31. *Lancet*. 2010;376(9748):1254-60. Epub 2010/10/12.
252. Guthrie T, Ndlovu N, Muhib F, Hecht R, Case KK. The Long-Term Costs and Financing of HIV/AIDS in South Africa. Washington DC: Results for Development Institute, 2010.
253. The Office of the Global AIDS Coordinator. PEPFAR Blueprint: Creating and AIDS-free generation 2012 [cited 2014 June]. Available from: <http://www.pepfar.gov/documents/organization/201386.pdf>.
254. The Global Fund. Global Fund Fourth Replenishment: Needs Assessment 2014-2016. Geneva: The Global Fund to Fight AIDS, Tuberculosis and Malaria; 2013.
255. Bollinger LA. How can we calculate the "E" in "CEA"? *AIDS*. 2008;22 Suppl 1:S51-7. Epub 2008/08/02.
256. Salomon JA, Murray CJ. Modelling HIV/AIDS epidemics in sub-Saharan Africa using seroprevalence data from antenatal clinics. *Bull World Health Organ*. 2001;79(7):596-607. Epub 2001/08/02.
257. Anderson R. Aids: trends, predictions, controversy. *Nature*. 1993;363(6428):393-4.
258. May RM, Anderson RM. The transmission dynamics of human immunodeficiency virus (HIV). *Philosophical transactions of the Royal Society of London Series B, Biological sciences*. 1988;321(1207):565-607. Epub 1988/10/31.
259. Garnett GP, Anderson RM. Factors controlling the spread of HIV in heterosexual communities in developing countries: patterns of mixing between different age and sexual activity classes. *Philosophical transactions of the Royal Society of London Series B, Biological sciences*. 1993;342(1300):137-59. Epub 1993/10/29.
260. Brookmeyer R, Gail MH. A Method for Obtaining Short-Term Projections and Lower Bounds on the Size of the Aids Epidemic. *J Am Stat Assoc*. 1988;83(402):301-8.
261. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med*. 2006;3(11):e442. Epub 2006/11/30.

262. WHO. The global burden of disease: 2004 update 2008 15 February 2010. Available from: [http://www.who.int/healthinfo/global\\_burden\\_disease/2004\\_report\\_update/en/index](http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index).
263. Department of Economic and Social Affairs Population Division UN. World population prospects: the 2008 revision. New York, NY, USA: United Nations, , 2009.
264. Merson MH, O'Malley J, Serwadda D, Apisuk C. The history and challenge of HIV prevention. *Lancet*. 2008;372(9637):475-88. Epub 2008/08/09.
265. Walker N, Grassly NC, Garnett GP, Stanecki KA, Ghys PD. Estimating the global burden of HIV/AIDS: what do we really know about the HIV pandemic? *Lancet*. 2004;363(9427):2180-5. Epub 2004/06/29.
266. WHO. World Malaria Report 2015. Geneva: World Health Organisation; 2015. Available from: <http://www.who.int/malaria/publications/world-malaria-report-2015/en/>.
267. WHO. Global tuberculosis report 2015. Geneva: World Health Organization; 2015. Available from: [http://www.who.int/tb/publications/global\\_report/en/](http://www.who.int/tb/publications/global_report/en/).
268. Case KK, Hallett TB, Gregson S, Porter K, Ghys PD. Development and future directions for the Joint United Nations Programme on HIV/AIDS estimates. *AIDS*. 2014;28:S411-S4.
269. UNAIDS. 2004 Report on the Global AIDS Epidemic. Geneva: UNAIDS, 2004.
270. Schwartlander B, Stanecki KA, Brown T, Way PO, Monasch R, Chin J, et al. Country-specific estimates and models of HIV and AIDS: methods and limitations. *AIDS*. 1999;13(17):2445-58. Epub 1999/12/22.
271. Walker N, Stanecki KA, Brown T, Stover J, Lazzari S, Garcia-Calleja JM, et al. Methods and procedures for estimating HIV/AIDS and its impact: the UNAIDS/WHO estimates for the end of 2001. *AIDS*. 2003;17(15):2215-25. Epub 2003/10/03.
272. The UNAIDS Reference Group on Estimates Modelling and Projections. Improved methods and assumptions for estimation of the HIV/AIDS epidemic and its impact: Recommendations of the UNAIDS Reference Group on Estimates, Modelling and Projections. *AIDS*. 2002;16(9):W1-14. Epub 2002/06/05.
273. Montana LS, Mishra V, Hong R. Comparison of HIV prevalence estimates from antenatal care surveillance and population-based surveys in sub-Saharan Africa. *Sexually Transmitted Infections*. 2008;84:I78-I84.
274. Gouws E, Mishra V, Fowler TB. Comparison of adult HIV prevalence from national population-based surveys and antenatal clinic surveillance in countries with generalised epidemics: implications for calibrating surveillance data. *Sexually Transmitted Infections*. 2008;84:I17-A23.
275. Ghys PD, Walker N, McFarland W, Miller R, Garnett GP. Improved data, methods and tools for the 2007 HIV and AIDS estimates and projections. *Sexually Transmitted Infections*. 2008;84:I1-I4.
276. WHO. World Health Statistics: 2008. Geneva: World Health Organization; 2008. Available from: [http://www.who.int/gho/publications/world\\_health\\_statistics/EN\\_WHS08\\_Full.pdf](http://www.who.int/gho/publications/world_health_statistics/EN_WHS08_Full.pdf).
277. International Institute for Population Sciences, Macro International. National Family Health Survey (NFHS-3) 2005-06: India. Deonar, Mumbai: International Institute for Population Sciences; 2007. Available from: <https://dhsprogram.com/pubs/pdf/FRIND3/FRIND3-Vol1AndVol2.pdf>.
278. Wang L, Wang N, Wang LY, Li DM, Jia MH, Gao X, et al. The 2007 Estimates for People at Risk for and Living With HIV in China: Progress and Challenges. *J aids*. 2009;50(4):414-8.
279. Murray CJ, Ortblad KF, Guinovart C, Lim SS, Wolock TM, Roberts DA, et al. Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990-

- 2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384(9947):1005-70. Epub 2014/07/26.
280. Gregson S, Hallett TB, Stover J, Ghys PD. Putting the burden of HIV in context. *AIDS*. 2013;27(13):2161-2. Epub 2014/01/05.
281. Hallett TB, Zaba B, Stover J, Brown T, Slaymaker E, Gregson S, et al. Embracing different approaches to estimating HIV incidence, prevalence and mortality. *AIDS*. 2014;28 Suppl 4:S523-32. Epub 2014/11/20.
282. Murray CJ. Towards good practice for health statistics: lessons from the Millennium Development Goal health indicators. *Lancet*. 2007;369(9564):862-73. Epub 2007/03/14.
283. Walker N, Bryce J, Black RE. Interpreting health statistics for policymaking: the story behind the headlines. *Lancet*. 2007;369(9565):956-63. Epub 2007/03/21.
284. AbouZahr C, Adjei S, Kanchanachitra C. From data to policy: good practices and cautionary tales. *Lancet*. 2007;369(9566):1039-46. Epub 2007/03/27.
285. Frenk J. Bridging the divide: global lessons from evidence-based health policy in Mexico. *Lancet*. 2006;368(9539):954-61. Epub 2006/09/12.
286. Kates J. Changes in donor financing over time: A global perspective. International AIDS Economics Network Pre-Conference Meeting; July 14: Kaiser Family Foundation; 2014.
287. Lagakos SW, Gable AR. Challenges to HIV prevention--seeking effective measures in the absence of a vaccine. *N Engl J Med*. 2008;358(15):1543-5. Epub 2008/04/12.
288. UNAIDS. The Gap Report. Geneva: Joint United Nations Programme on HIV/AIDS; 2014 [cited 2014 August 28]; Available from: [http://www.unaids.org/en/media/unaids/contentassets/documents/unaidspublication/2014/UNAIDS\\_Gap\\_report\\_en.pdf](http://www.unaids.org/en/media/unaids/contentassets/documents/unaidspublication/2014/UNAIDS_Gap_report_en.pdf).
289. Lozano R, Naghavi M, Foreman K, AlMazroa MA, Memish ZA. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010 (vol 380, pg 2095, 2012). *Lancet*. 2013;381(9867):628-.
290. Gouws E, White PJ, Stover J, Brown T. Short term estimates of adult HIV incidence by mode of transmission: Kenya and Thailand as examples. *Sex Transm Infect*. 2006;82 Suppl 3:iii51-5. Epub 2006/06/01.
291. Mumtaz G, Hilmi N, Zidouh A, El Rhilani H, Alami K, Bennani A, et al. HIV modes of transmission analysis in Morocco. Morocco: Kingdom of Morocco Ministry of Health and National STI/AIDS Programme, UNAIDS, and Weill Cornell Medical College - Qatar, 2010.
292. UNAIDS. Zambia HIV Prevention Response and Modes of Transmission Analysis. Lusaka: UNAIDS and World Bank Global HIV/AIDS Program, 2009.
293. Mngadi S, Fraser N, Mkhathshwa H, Lapidus T, Khumalo T, Tsela S, et al. Swaziland HIV prevention response and modes of transmission analysis. Mbabane, Swaziland: National Emergency Response Council on HIV and AIDS, 2009.
294. Khobotlo M, Tshehlo R, Nkonyana J, Ramoseme M, Khobotle M, Chitoshia A, et al. Lesotho: HIV prevention response and modes of transmission analysis. Maseru, Lesotho: National AIDS Commission.
295. Gelmon L, Kenya P, Oguya F, Cheluget B, Haile G. Kenya HIV Prevention Response and Modes of Transmission Analysis. Nairobi: Kenya: National AIDS Control Council.
296. HIV Modes of Transmission Model: Analysis of the distribution of new HIV infections in the Dominican Republic and recommendations for prevention. Santo Domingo, Dominican Republic: Consejo Presidencial del SIDA, Dirección General de Control de las Infecciones de Transmisión Sexual y Sida & Joint United Nations Programme on HIV/AIDS, 2010.

297. Gouws E, Cuchi P, I ICEH. Focusing the HIV response through estimating the major modes of HIV transmission: a multi-country analysis. *Sexually Transmitted Infections*. 2012;88:l76-l85.
298. The aids2031 Consortium. *AIDS: Taking a Long-Term View*. USA: Prentice Hall; 2010.
299. Byass P. The imperfect world of global health estimates. *PLoS Med*. 2010;7(11):e1006.
300. Charmaz K. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage Publications; 2006.
301. Corbin J, Strauss AL. *Basics of Qualitative Research*. 3rd ed. London: Sage Publications; 2008.
302. England KV. Getting personal: reflexivity, positionality and feminist research. *The Professional Geographer*. 1994;46(1):80-9.
303. Walt G, Shiffman J, Schneider H, Murray SF, Brugha R, Gilson L. 'Doing' health policy analysis: methodological and conceptual reflections and challenges. *Health Policy Plan*. 2008;23(5):308-17. Epub 2008/08/15.
304. Larson HJ, Bertozzi S, Piot P. Redesigning the AIDS response for long-term impact. *Bull World Health Organ*. 2011;89(11):846-52. Epub 2011/11/16.
305. HIV Modelling Consortium. Department of Infectious Disease Epidemiology, Imperial College London, UK2011 [cited 2015 December]; Available from: <http://www.hivmodelling.org/>.
306. Maxwell JA. Conceptual Framework: What do you think is going on? In: Bickman L, Rog DJ, editors. *Qualitative Research Design*. USA: SAGE Publications, Inc; 2013.
307. Ostrom E, editor. Beyond markets and states: Polycentric governance of complex economic systems. Nobel Prize Lecture; 2009 December 8; Stockholm Universtiy.
308. Sabatier PA. *Theories of the Policy Process*. 2nd ed. Boulder, Colorado: Westview; 2007.
309. Weiss CH. Knowledge Creep and Decision Accretion. *Sci Commun*. 1980;1(3):381-404.
310. de Leeuw E, McNess A, Crisp B, Stagnitti K. Theoretical reflections on the nexus between research, policy and practice. *Critical Public Health*. 2008;18(1):5-20.
311. Pelz DC. Some expanded perspectives on use of social science in public policy. In: Yinger JM, Cutler SJ, editors. *Major Social Issues: A Multidisciplinary View*. New York: Free Press; 1978. p. 346-57.
312. Caplan N, Morrison A, Stambaugh RJ. The use of social science knowledge in policy decisions at the national level: A report to respondents. Ann Arbor: Institute for Social Research, University of Michigan; 1975.
313. Rich RF. Uses of social science information by federal bureaucrats: Knowledge for action versus knowledge for understanding. In: Weiss CH, editor. *Using Social Research in Public Policy Making*. Lexington, MA: Lexington Books; 1977. p. 199-211.
314. Patton MQ, Grimes PS, Guthrie KM, Brennan NJ, French BD, Blyth DA. In search of impact: An analysis of the utilization of federal health evaluation research. Minnesota University: Center for Social Research, 1975.
315. Nutley SM, Walter I, Davies H. *Using Evidence: How Research Can Inform Public Services*. University of Bristol, UK: The Policy Press; 2007.
316. Rich RF. Selective utilization of social science related information by federal policy-makers. *Inquiry : a journal of medical care organization, provision and financing*. 1975;12(3):239-45. Epub 1975/09/01.
317. Knorr KD. Policymaker's use of social sciences knowledge: Symbolic or instrumental? In: Weiss CH, editor. *Using social research in public policy making*. Lexington, MA: Lexington Books; 1977. p. 165-82.

318. Weiss C. The many meanings of research utilization. *Public Administration Review*. 1979;39:426-31.
319. Knorr KD. Policymaker's use of social sciences knowledge: Symbolic or instrumental? Vienna: Institute for Advanced Studies, <http://www.ihs.ac.at/publications/ihsfo/fo103.pdf>; 1976. Research Memorandum no 103.
320. Lavis JN, Ross SE, Hurley JE. Examining the role of health services research in public policymaking. *Milbank Q*. 2002;80(1):125-54.
321. Weiss CH. Where politics and evaluation research meet. *Evaluation*. 1973;1(3):37-45.
322. Weiss CH. Improving the linkage between social research and public policy. In: Lynn LE, editor. *Knowledge and Policy: The Uncertain Connection*. Washington, D.C.: National Academy of Sciences; 1978. p. 23-81.
323. Bowen S, Zwi AB. Pathways to "evidence-informed" policy and practice: A framework for action. *Plos Medicine*. 2005;2(7):600-5.
324. Koon AD, Rao KD, Tran NT, Ghaffar A. Embedding health policy and systems research into decision-making processes in low- and middle-income countries. *Health Res Policy Syst*. 2013;11:30. Epub 2013/08/09.
325. Walt G. How far does research influence policy? *European Journal of Public Health*. 1994;4:233-5.
326. Black N. Evidence based policy: proceed with care. *BMJ*. 2001;323(7307):275-9. Epub 2001/08/04.
327. Young K, Ashby D, Boaz A, Grayson L. Social science and the evidence-based policy movement. *Social Policy and Society*. 2002;1(3):215-24.
328. Simon HA. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. 1st ed. New York: Macmillan; 1947.
329. Hanney SR, Gonzalez-Block MA, Buxton MJ, Kogan M. The utilisation of health research in policy-making: concepts, examples and methods of assessment. *Health Res Policy Syst*. 2003;1(1):2. Epub 2003/03/21.
330. Buse K, Mays N, Walt G. *Making Health Policy*. Black N, Raine R, editors. Berkshire, England: Open University Press; 2005.
331. Lindblom CE. The Science of "Muddling Through". *Public Administration Review*. 1959;19(2):79-88.
332. Nutley S, Webb J. Evidence and the policy process. In: Davies HTO, Nutley S, Smith PC, editors. *What Works? Evidence-based policy and practice in public services*. Bristol, UK: Policy Press; 2000.
333. Weiss CH. Research for policy's sake: The enlightenment function of social research. *Policy Analysis*. USA: University of California Press; 1977. p. 531-45.
334. Kothari A, Birch S, Charles C. "Interaction" and research utilisation in health policies and programs: does it work? *Health Policy*. 2005;71(1):117-25. Epub 2004/11/27.
335. Walt G. *Health Policy: An Introduction to Process and Power*. London, UK: Zed Books Ltd; 1994.
336. de Goede J, Putters K, van der Grinten T, van Oers HA. Knowledge in process? Exploring barriers between epidemiological research and local health policy development. *Health Res Policy Syst*. 2010;8:26. Epub 2010/09/18.
337. Hennink M, Stephenson R. Using research to inform health policy: barriers and strategies in developing countries. *Journal of health communication*. 2005;10(2):163-80. Epub 2005/04/05.

338. Estabrooks CA, Wallin L, Milner M. Measuring knowledge utilization in health care. *International Journal of Policy Analysis and Evaluation*. 2003;1:3-36.
339. Evidence-based medicine. A new approach to teaching the practice of medicine. *Jama*. 1992;268(17):2420-5. Epub 1992/11/04.
340. WHO. Child health research: A foundation for improving child health. Geneva: World Health Organization, 2002.
341. Ad Hoc Committee on Health Research Relating to Future Intervention Options. Summary of: Investing in Health Research and Development 1996. Available from: [http://apps.who.int/iris/bitstream/10665/63139/1/TDR\\_GEN\\_96.2.pdf](http://apps.who.int/iris/bitstream/10665/63139/1/TDR_GEN_96.2.pdf).
342. Landry R, Amara N, Lamari M. Climbing the ladder of research utilization - Evidence from social science research. *Sci Commun*. 2001;22(4):396-422.
343. Strandberg E, Eldh AC, Forsman H, Rudman A, Gustavsson P, Wallin L. The Concept of Research Utilization as Understood by Swedish Nurses: Demarcations of Instrumental, Conceptual, and Persuasive Research Utilization. *Worldv Evid-Based Nu*. 2014;11(1):55-64.
344. Estabrooks CA, Squires JE, Strandberg E, Nilsson-Kajermo K, Scott SD, Profetto-McGrath J, et al. Towards better measures of research utilization: a collaborative study in Canada and Sweden. *Journal of advanced nursing*. 2011;67(8):1705-18. Epub 2011/04/12.
345. Tulloch O, Mayaud P, Adu-Sarkodie Y, Opoku BK, Lithur NO, Sickle E, et al. Using research to influence sexual and reproductive health practice and implementation in Sub-Saharan Africa: a case-study analysis. *Health Res Policy Syst*. 2011;9 Suppl 1:S10. Epub 2011/06/18.
346. de Goede J, Putters K, van Oers H. Utilization of epidemiological research for the development of local public health policy in The Netherlands: a case study approach. *Soc Sci Med*. 2012;74(5):707-14. Epub 2012/01/24.
347. Dahl RA. *Who Governs? Democracy and Power in an American City*. New Haven: Yale University Press; 1961.
348. Wright Mills C. *The Power Elite*. New York: Oxford University Press; 1956.
349. Gilson L, Raphaely N. The terrain of health policy analysis in low and middle income countries: a review of published literature 1994-2007. *Health Policy Plann*. 2008;23(5):294-307.
350. Lasswell HD. *The Decision Process: Seven categories of functional analysis*. University of Maryland: College Park, Bureau of Governmental Research, College of Business and Public Administration; 1956.
351. Brewer GD, deLeon P. *The Foundations of Policy Analysis*. Pacific Grove, CA, USA: Brooks/Cole; 1983.
352. Schlager E, Blomquist W. A comparison of three emerging theories of the policy process. *Polit Res Quart*. 1996;49(3):651-72.
353. Cerny P. From 'iron triangles' to 'golden pentangles'? Globalizing the policy process. *Global Governance*. 2001;7(4):397-410.
354. George AL, Bennett A. *Case Studies and Theory Development in the Social Sciences*. Cambridge, Massachusetts: MIT Press; 2005.
355. Mason J. Linking qualitative and quantitative data. In: Bryman A, Burgess RG, editors. *Analyzing Qualitative Data*. London: Routledge; 1994. p. 89-110.
356. UNAIDS/WHO. 2008 report on the global AIDS epidemic July 2008. Available from: <http://www.unaids.org/en/KnowledgeCentre/HIVData/Epidemiology/latestEpiData.asp>.
357. WHO, UNICEF, UNAIDS, USAID, and the Policy Project. Coverage of selected services for HIV/AIDS prevention, care and support in low and middle income countries in 2003. June 2004. Available from: [http://www.who.int/hiv/pub/prev\\_care/en/coveragereport\\_2003.pdf](http://www.who.int/hiv/pub/prev_care/en/coveragereport_2003.pdf).

358. Stover J, Fahnstock M. Coverage of selected services for HIV/AIDS prevention, care, and treatment in low- and middle-income countries in 2005. Washington, DC: Constella Futures, POLICY Project 2006.
359. WHO. Information package on male circumcision and HIV prevention. 2007.
360. Stover J, Johnson P, Zaba B, Zwahlen M, Dabis F, Ekpin RE. The Spectrum projection package: improvements in estimating mortality, ART needs, PMTCT impact and uncertainty bounds. *Sex Transm Infect.* 2008;84 Suppl 1:i24-i30. Epub 2008/07/25.
361. Lawn SD, Harries AD, Anglaret X, Myer L, Wood R. Early mortality among adults accessing antiretroviral treatment programmes in sub-Saharan Africa. *AIDS.* 2008;22(15):1897-908.
362. AsimweOkiror G, Opio AA, Musinguzi J, Madraa E, Tembo G, Carael M. Change in sexual behaviour and decline in HIV infection among young pregnant women in urban Uganda. *AIDS.* 1997;11(14):1757-63.
363. Hallett TB, Aberle-Grasse J, Boulos LM, Cayemittes MPA, Cheluget B, Chipeta J, et al. Declines in HIV prevalence can be associated with changing sexual behaviour in Uganda, urban Kenya, Zimbabwe, and urban Haiti. *Sexually Transmitted Infections.* 2006;82:11-18.
364. Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, et al. Grading quality of evidence and strength of recommendations. *Brit Med J.* 2004;328(7454):1490-4.
365. WHO. Antiretroviral Therapy for HIV Infection in Adults and Adolescents: recommendations for a Public Health Approach - 2010 revision. Geneva: World Health Organisation, 2010. Available: [http://whqlibdoc.who.int/publications/2010/9789241599764\\_eng.pdf](http://whqlibdoc.who.int/publications/2010/9789241599764_eng.pdf). Report No.
366. Ferradini L, Jeannin A, Pinoges L, Izopet J, Odhiambo D, Mankhambo L, et al. Scaling up of highly active antiretroviral therapy in a rural district of Malawi: an effectiveness assessment. *Lancet.* 2006;367(9519):1335-42.
367. Lawn SD, Myer L, Orrell C, Bekker LG, Wood R. Early mortality among adults accessing a community-based antiretroviral service in South Africa: implications for programme design. *AIDS.* 2005;19(18):2141-8.
368. Cornell M, Grimsrud A, Fairall L, Fox MP, van Cutsem G, Giddy J, et al. Temporal changes in programme outcomes among adult patients initiating antiretroviral therapy across South Africa, 2002-2007. *AIDS.* 2010;24(14):2263-70.
369. Althoff KN, Gange SJ, Klein MB, Brooks JT, Hogg RS, Bosch RJ, et al. Late presentation for human immunodeficiency virus care in the United States and Canada. *Clin Infect Dis.* 2010;50(11):1512-20. Epub 2010/04/27.
370. Brown T, Peerapatanapokin W. The Asian Epidemic Model: a process model for exploring HIV policy and programme alternatives in Asia. *Sex Transm Infect.* 2004;80 Suppl 1:i19-24. Epub 2004/07/14.
371. Actuarial Society of South Africa. Aids Committee: Models. Cape Town, South Africa: Actuarial Society of South Africa; 2012 [cited 2011 July 9]; Available from: <http://www.actuarialsociety.org.za/Societyactivities/CommitteeActivities/AidsCommittee/Models.aspx>.
372. Brown T, Bao L, Raftery AE, Salomon JA, Baggaley RF, Stover J, et al. Modelling HIV epidemics in the antiretroviral era: the UNAIDS Estimation and Projection package 2009. *Sexually Transmitted Infections.* 2010;86:13-110.
373. Futures Institute. Spectrum. Glastonbury: Futures Institute; 2012 [cited 2012 July 9]; Available from: <http://futuresinstitute.org/Pages/spectrum.aspx>.

374. Republic of Armenia. UNGASS Country Progress Report. 2012; Available from: [http://www.unaids.org/sites/default/files/en/dataanalysis/knownyourresponse/countryprogressreports/2012countries/ce\\_ARM\\_Narrative\\_Report.pdf](http://www.unaids.org/sites/default/files/en/dataanalysis/knownyourresponse/countryprogressreports/2012countries/ce_ARM_Narrative_Report.pdf).
375. Foss A, Prudden H, Mehl A, Zimmerman C, Ashburn K, Trasi R, et al. The UNAIDS Modes of Transmission model: A useful tool for decision making? International Society for Sexually Transmitted Diseases Research; July 10-13; Quebec City, Canada: Sexually Transmitted Infections; 2011. p. A167.
376. Fleming DT, Wasserheit JN. From epidemiological synergy to public health policy and practice: the contribution of other sexually transmitted diseases to sexual transmission of HIV infection. *Sex Transm Infect.* 1999;75(1):3-17. Epub 1999/08/17.
377. Gray RH, Wawer MJ, Brookmeyer R, Sewankambo NK, Serwadda D, Wabwire-Mangen F, et al. Probability of HIV-1 transmission per coital act in monogamous, heterosexual, HIV-1-discordant couples in Rakai, Uganda. *Lancet.* 2001;357(9263):1149-53. Epub 2001/04/27.
378. Boily MC, Baggaley RF, Wang L, Masse B, White RG, Hayes RJ, et al. Heterosexual risk of HIV-1 infection per sexual act: systematic review and meta-analysis of observational studies. *Lancet Infect Dis.* 2009;9(2):118-29. Epub 2009/01/31.
379. Powers KA, Poole C, Pettifor AE, Cohen MS. Rethinking the heterosexual infectivity of HIV-1: a systematic review and meta-analysis. *Lancet Infect Dis.* 2008;8(9):553-63. Epub 2008/08/08.
380. Abu-Raddad L, Akala FA, Semini I, Riedner G, Wilson D, Tawil O. Characterizing the HIV/AIDS epidemic in the Middle East and North Africa: Time for Strategic Action. Washington DC: The World Bank Press, 2010.
381. Abu-Raddad LJ, Hilmi N, Mumtaz G, Benkirane M, Akala FA, Riedner G, et al. Epidemiology of HIV infection in the Middle East and North Africa. *AIDS.* 2010;24 Suppl 2:S5-23. Epub 2010/07/17.
382. Republic of Armenia. UNGASS Country Progress Report. 2014 [cited 2014 December 1]; Available from: [http://www.unaids.org/sites/default/files/en/dataanalysis/knownyourresponse/countryprogressreports/2014countries/ARM\\_narrative\\_report\\_2014.pdf](http://www.unaids.org/sites/default/files/en/dataanalysis/knownyourresponse/countryprogressreports/2014countries/ARM_narrative_report_2014.pdf).
383. Mishra S, Sgaier SK, Thompson L, Moses S, Ramesh BM, Alary M, et al. Revisiting HIV epidemic appraisals for assisting in the design of effective HIV prevention programs. International Society for Sexually Transmitted Diseases Research; July 10-13; Quebec City, Canada: Sexually Transmitted Infections; 2011. p. A 166-7.
384. UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance. Guidelines on Estimating the Size of Populations Most at Risk to HIV. Geneva, Switzerland: World Health Organization and UNAIDS, 2010.
385. Caceres C, Konda K, Pecheny M, Chatterjee A, Lyerla R. Estimating the number of men who have sex with men in low and middle income countries. *Sex Transm Infect.* 2006;82 Suppl 3:iii3-9. Epub 2006/06/01.
386. Lowndes CM, Jayachandran AA, Banandur P, Ramesh BM, Washington R, Sangameshwar BM, et al. Polling Booth Surveys: A Novel Approach for Reducing Social Desirability Bias in HIV-Related Behavioural Surveys in Resource-Poor Settings. *Aids and Behavior.* 2012;16(4):1054-62.
387. Fenton KA, Johnson AM, McManus S, Erens B. Measuring sexual behaviour: methodological challenges in survey research. *Sexually Transmitted Infections.* 2001;77(2):84-92.

388. Phillips AE, Gomez GB, Boily MC, Garnett GP. A systematic review and meta-analysis of quantitative interviewing tools to investigate self-reported HIV and STI associated behaviours in low- and middle-income countries. *International Journal of Epidemiology*. 2010;39(6):1541-55.
389. Mishra S, Vickerman P, Pickles M, Ramesh BM, Washington R, Isaac S, et al. HIV prevention based on the static Modes of Transmission synthesis for two indian districts: Insights from dynamical modelling. *International Society for Sexually Transmitted Diseases Research*; July 10-13; Quebec City, Canada: Sexually Transmitted Infections; 2011. p. A337.
390. Parker F. Education in the Federation of Rhodesia and Nyasaland. *The Journal of Negro Education*. 1961;30(3):286-93.
391. AIDSinfo [database on the Internet]. UNAIDS. 2015 [cited August 2015]. Available from: <http://aidsinfo.unaids.org/#>.
392. UNAIDS. Smart Investments. Geneva: The Joint United Nations Programme on HIV/AIDS; 2013 [cited 2015 August]; Available from: [http://www.unaids.org/sites/default/files/media\\_asset/20131130\\_smart-investments\\_en\\_1.pdf](http://www.unaids.org/sites/default/files/media_asset/20131130_smart-investments_en_1.pdf).
393. The World Bank. Data: Zambia 2014. The World Bank Group; 2015 [cited 2015 July]; Available from: <http://data.worldbank.org/country/zambia>.
394. Republic of Zambia. Zambia Country Report. National AIDS Council; 2012 [cited 2014 September]; Available from: [http://www.unaids.org/en/dataanalysis/knownyourresponse/countryprogressreports/2012countries/ce\\_ZM\\_Narrative\\_Report.pdf](http://www.unaids.org/en/dataanalysis/knownyourresponse/countryprogressreports/2012countries/ce_ZM_Narrative_Report.pdf).
395. UNAIDS. Zambia: HIV and AIDS estimates (2014). 2015 [cited 2015 August]; Available from: <http://www.unaids.org/en/regionscountries/countries/zambia/>.
396. The World Bank. Data: Malawi 2014. The World Bank Group; 2015 [cited 2015 July]; Available from: <http://data.worldbank.org/country/malawi>.
397. Malawi 'cashgate' scandal: Civil servant Sithole jailed. BBC News. 2014 <http://www.bbc.co.uk/news/world-africa-29897716> Sect. World: Africa.
398. UNAIDS. HIV and AIDS Estimates: Malawi (2013). Geneva: UNAIDS; 2014 [cited 2015 July 28]; Available from: <http://www.unaids.org/sites/default/files/epidocuments/MWI.pdf>.
399. UNAIDS. Malawi: HIV and AIDS estimates (2014). 2015 [cited 2015 August]; Available from: <http://www.unaids.org/en/regionscountries/countries/malawi/>.
400. Government of Malawi. Global AIDS Response Progress Report: Malawi Progress Report for 2013. 2014 [cited 2015 February 18]. Available from: [http://www.unaids.org/sites/default/files/country/documents/MWI\\_narrative\\_report\\_2014.pdf](http://www.unaids.org/sites/default/files/country/documents/MWI_narrative_report_2014.pdf).
401. U.S. Agency for International Development. USAID Malawi Health Systems Strengthening Fact Sheet. USAID; 2015 [cited 2015 July 28]; Available from: <http://www.usaid.gov/malawi/fact-sheets/usaids-malawi-health-systems-strengthening-fact-sheet-2012-13>.
402. Central Intelligence Agency. The World Factbook: Country comparison to the world - Area. 2015 [cited 2015 October]; Available from: <https://www.cia.gov/library/publications/the-world-factbook/fields/2147.html>.
403. The World Bank. Data: GDP per capita (current US\$). 2015 [cited 2015 August]; Available from: <http://data.worldbank.org/indicator/NY.GDP.PCAP.CD>.
404. World Bank list of economies [database on the Internet]. July 2015 [cited August 2015]. Available from: <http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS>.

405. Bank TW. Data: Health Expenditure per capita (current US\$). The World Bank Group; 2016 [cited 2016 January]; Available from: <http://data.worldbank.org/indicator/SH.XPD.PCAP>.
406. The World Bank. Data: Nurses and midwives (per 1,000 people). The World Bank Group; 2016 [cited 2015 January]; Available from: <http://data.worldbank.org/indicator/SH.MED.NUMW.P3?page=1>.
407. Yin R. Case Study Research: Design and Methods. Fourth ed. Thousand Oaks, CA: Sage Publications; 2009.
408. Case KK, editor. Participant interviews on the use of Spectrum and EPP. UNAIDS Reference Group on Estimates, Modelling and Projections; 2011 20 October 2011; Seattle, WA.
409. Varvasovszky Z, Brugha R. How to do (or not to do)... A stakeholder analysis. Health Policy Plan. 2000;15(3):338-45. Epub 2000/09/30.
410. Mendizabal E. The alignment, interest and influence matrix (AIIM) 2007. Available from: <http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/6509.pdf>.
411. Participant ZR2\_05\_1, Participant ZR2\_05\_2, Participant ZR2\_05\_3, Participant ZR2\_05\_4, Participant ZR2\_05\_5, Participant ZR2\_05\_6, et al. Interstakeholder meeting - government, international organisations. Lusaka, Zambia: 4 November 2013.
412. Participant ZR1\_08\_1, Participant ZR1\_08\_2, Participant ZR1\_08\_3. Personal interview - intergovernmental organisation. Lusaka, Zambia: 16 April 2013.
413. Participant ZR1\_17\_1. Personal interview - international organisation. Lusaka, Zambia: 18 April 2013.
414. Participant ZR2\_08\_1. Personal interview - intergovernmental organisation. Lusaka, Zambia: 5 November 2013.
415. Participant ZR1\_07\_1, Participant ZR1\_07\_2, Participant ZR1\_07\_3, Participant ZR1\_07\_4. Personal interview - international organisation. Lusaka, Zambia: 16 April 2013.
416. Participant MR1\_06\_1, Participant MR1\_06\_2, Participant MR1\_05\_3, Participant MR1\_05\_6. Personal interview - government. Lilongwe, Malawi: 25 July 2013.
417. Participant MR2\_03\_1, Participant MR2\_03\_2. Personal interview - international. Lilongwe, Malawi: 8 November 2013.
418. Participant MR1\_12\_1. Personal interview - international organisation. Lilongwe, Malawi: 28 July 2013.
419. Participant ZR1\_01\_1. Personal interview - government. Lusaka, Zambia: 18 April 2013.
420. Participant MR1\_16\_1, Participant MR1\_16\_2. Personal interview - international Lilongwe, Malawi: 29 July 2013.
421. Participant MR1\_14\_1, Participant MR1\_14\_2. Personal interview - government Lilongwe, Malawi: 29 July 2013.
422. Participant MR1\_20\_1, Participant MR1\_20\_1, Participant MR1\_20\_1, Participant MR1\_20\_1. Personal interview - international organisation Lilongwe, Malawi: 30 July 2013.
423. Participant ZR1\_07\_3. Personal interview - international organisation. Lusaka, Zambia: 18 April 2013.
424. Participant ZR2\_11\_1, Participant ZR2\_11\_2. Personal interview - academic. Lusaka, Zambia: 6 November; 2013.
425. Participant ZR2\_03\_1, Participant ZR2\_03\_2, Participant ZR2\_03\_3. Personal Interview - international and intergovernmental organisation. Lusaka, Zambia: 1 November 2013.

426. Tagar E, Sundaram M, Condliffe K, Matatiyo B, Chimbwandira F, Chilima B, et al. Multi-Country Analysis of Treatment Costs for HIV/AIDS (MATCH): Facility-Level ART Unit Cost Analysis in Ethiopia, Malawi, Rwanda, South Africa and Zambia. *Plos One*. 2014;9(11).
427. Hanlon M, Achan J, Burstein R, Chatterjee A, Conner R, Dansereau E, et al. The production and costs of health service across four African countries: Ghana, Kenya, Uganda, and Zambia. *Lancet*. 2013;381:56-.
428. Participant MR1\_21\_1. Personal interview - civil society. Lilongwe, Malawi: 30 July 2013.
429. Participant MR1\_13\_1. Personal interview - civil society. Lilongwe, Malawi: 29 July 2013.
430. Participant ZR2\_10\_1, Participant ZR2\_10\_2. Personal interview - civil society. Lilongwe, Malawi: 6 November 2013.
431. U.S. State Department. PEPFAR Dashboards: Zambia Planned Funding, FY 2013. [cited 2015 August]; Available from: <http://data.pepfar.net/country/funding?country=Zambia&year=2013>.
432. Participant ZR1\_09\_1, Participant ZR1\_09\_2, Participant ZR1\_09\_3, Participant ZR1\_09\_4, Participant ZR1\_09\_5, Participant ZR1\_09\_6, et al. Group interview - international. Lusaka, Zambia: 16 April 2013.
433. Participant ZR1\_03\_1, Participant ZR1\_03\_2. Personal interview - government. Lusaka, Zambia: 15 April 2013.
434. The Global Fund. Zambia: Grant Portfolio. The Global Fund to Fight AIDS, Tuberculosis and Malaria; 2015 [cited 2015 August]; Available from: <http://portfolio.theglobalfund.org/en/Country/Index/ZMB>.
435. PEPFAR. Malawi Operational Plan Report FY 2013. Accessed August 2015. Available from: <http://www.pepfar.gov/documents/organization/222173.pdf>.
436. U.S. State Department. PEPFAR Dashboards: Malawi Planned Funding, FY 2013. [cited 2015 August]; Available from: <http://data.pepfar.net/country/funding?country=Malawi&year=2013>.
437. Participant ZR1\_13\_1, Participant ZR1\_13\_2. Personal interview - intergovernmental organisation. Lusaka, Zambia: 17 April 2013.
438. Participant ZR1\_05\_1, Participant ZR1\_05\_2. Personal interview - intergovernmental organisation. Lusaka, Zambia: 16 April 2013.
439. MR1\_05\_10 P. Personal interview - government. MR1\_08 ed. Lilongwe, Malawi: 25 July; 2013.
440. Participant MR1\_10\_1. Personal interview - Intergovernmental organisation. Lilongwe, Malawi: 26 July 2013.
441. Participant ZR2\_01\_1. Personal interview - international organisation. Lusaka, Zambia: 31 October 2013.
442. Sang N. Whodunnit : Kalambula bwalo. *Malawi Ace* [Internet]. 2013 September 29 November 2013. Available from: <http://malawiace.com/2013/09/29/whodunnit-kalambula-bwalo/>.
443. Malawi President Joyce Banda statement on 'cash-gate' scandal: 'I will not shield anyone'. *Nyasa Times* [Internet]. 2013 October 9 November 2013. Available from: <http://www.nyasatimes.com/2013/10/09/malawi-president-joyce-banda-statement-on-cash-gate-scandal-i-will-not-shield-anyone/>.
444. Sharra S. How A Shooting Exposed The Plunder Of Malawi's Treasury. 2013 October 15. Available from: <https://globalvoices.org/2013/10/15/how-a-shooting-exposed-plunder-of-malawis-treasury/>.

445. Arrest of key suspect is game changer on Malawi 'cashgate' scandal. Nyasa Times [Internet]. 2013 October 6 November 2013. Available from: <http://www.nyasatimes.com/2013/10/06/arrest-of-key-suspect-is-game-changer-on-malawi-cashgate-scandal/>.
446. Malawi prepares for \$100m 'cashgate' corruption trial. The Guardian [Internet]. 2014 January 14. Available from: <http://www.theguardian.com/world/2014/jan/14/malawi-prepares-cashgate-corruption-trial>.
447. Fortin J. Cashgate: Malawi Faces A Ticking Time Bomb As International Aid Dries Up Over Pervasive Corruption. International Business News [Internet]. 2013 November 19. Available from: <http://www.ibtimes.com/cashgate-malawi-faces-ticking-time-bomb-international-aid-dries-over-pervasive-corruption-1476658>.
448. Blas J. Malawi 'cash-gate' corruption scandal unfolds like a thriller. Financial Times [Internet]. 2013 November 19. Available from: <http://www.ft.com/cms/s/0/c17480e0-50fb-11e3-b499-00144feabdc0.html#axzz3mN3l1Ygg>.
449. Government of Malawi MoH. Malawi Integrated HIV Program Report. Malawi: Department for HIV and AIDS, MoH October - December 2014.
450. Participant MR1\_11\_1. Personal interview - international organisation. Lilongwe, Malawi: 26 July 2013.
451. Participant MR1\_05\_1, Participant MR1\_05\_2, Participant MR1\_05\_3, Participant MR1\_05\_4, Participant MR1\_05\_5, Participant MR1\_05\_6, et al. Interstakeholder meeting - government, international organisations. Lilongwe, Malawi: 25 July 2013.
452. I-TECH. Who We Are. Seattle: University of Washington; 2011 [cited 2015 August]; Available from: <http://www.go2itech.org/who-we-are>.
453. Participant MR1\_02\_1. Personal interview - academic. Lilongwe, Malawi: 25 July; 2013.
454. Participant MR2\_02\_1. Personal interview - Intergovernmental organisation. Lilongwe, Malawi: 7 November 2013.
455. Participant MR2\_05\_1, Participant MR2\_01\_6. Personal interview - government Lilongwe, Malawi: 11 November; 2013.
456. Participant ZR2\_07\_1. Personal interview - academic. Lusaka, Zambia: 4 November 2013.
457. Republic of Zambia and National AIDS Council. Zambia Country Report: Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access. Submitted to the United Nations General Assembly Special Session on HIV and AIDS, 2014 March 31. Report No.
458. Participant ZR1\_14\_1, Participant ZR1\_14\_2, Participant ZR1\_14\_3. Personal interview - intergovernmental organisation. Lusaka, Zambia: 17 April 2013.
459. Participant MR1\_09\_1. Personal interview - international organisation. Lilongwe, Malawi: 26 July 2013.
460. Participant ZR1\_02\_1, Participant ZR1\_02\_2. Personal interview - government. Lusaka, Zambia: 15 April 2013.
461. Participant MR1\_15\_1, Participant MR1\_15\_2. Personal interview - government. Lilongwe, Malawi: 29 July 2013.
462. Participant ZR1\_06\_1. Personal interview - academic organisation. Lusaka, Zambia: 16 April 2013.
463. Participant MR2\_01\_1, Participant MR2\_01\_2, Participant MR2\_01\_3, Participant MR2\_01\_4, Participant MR2\_01\_5, Participant MR2\_01\_6, et al. Personal communication - government, international organisations. Lilongwe, Malawi: 7 November 2013.

464. Participant ZR2\_04\_1. Personal interview - government. Lusaka, Zambia: 1 November 2013.
465. Participant ZR1\_15\_1. Personal interview - academic. Lusaka, Zambia: 17 April 2013.
466. Participant MR1\_07\_1. Personal interview - local NGO. Lilongwe, Malawi: 25 July 2013.
467. Participant MR1\_17\_1, Participant MR1\_17\_2. Personal interview - intergovernmental. Lilongwe, Malawi: 29 July; 2013.
468. Participant MR1\_18\_1. Personal interview - academic organisation. Lilongwe, Malawi: 30 July; 2013.
469. Participant ZR2\_02\_1. Personal interview - international organisation. Lusaka, Zambia: 1 November; 2013.
470. Participant ZR1\_20\_1. Personal interview - academic Lusaka, Zambia: 18 April; 2013.
471. Participant MR1\_05\_2, Participant MR1\_05\_4. Personal interview - government and international organisation. Lilongwe, Malawi: 30 July; 2013.
472. The Global Fund. Instructions: Single HIV and TB Concept Note. 2014 [updated 19 March; cited 2015 October]; Available from: [file:///C:/Documents%20and%20Settings/kcase.DIDE/My%20Documents/Downloads/Funding Model\\_TBAndHIVConceptNote\\_Instructions\\_en.pdf](file:///C:/Documents%20and%20Settings/kcase.DIDE/My%20Documents/Downloads/Funding Model_TBAndHIVConceptNote_Instructions_en.pdf).
473. Participant ZR1\_04\_1, Participant ZR1\_04\_2, Participant ZR1\_04\_3. Personal interview - international stakeholder. Lusaka, Zambia: 15 April; 2013.
474. Participant MR1\_05\_10. Personal Interview - government. Lilongwe, Malawi: 25 July; 2013.
475. Embassy of the United States. PEPFAR in Zambia. US Department of State; [cited 2015 October]; Available from: <http://zambia.usembassy.gov/pepfar/pepfar-in-zambia.html>.
476. Burris H, Parkhurst J, Adu-Sarkodie Y, Mayaud P. Getting research into policy - Herpes simplex virus type-2 (HSV-2) treatment and HIV infection: international guidelines formulation and the case of Ghana. *Health Res Policy Syst*. 2011;9 Suppl 1:S5. Epub 2011/06/18.
477. Behague D, Tawiah C, Rosato M, Some T, Morrison J. Evidence-based policy-making: the implications of globally-applicable research for context-specific problem-solving in developing countries. *Soc Sci Med*. 2009;69(10):1539-46. Epub 2009/09/29.
478. Johnson LF, Dorrington RE. Modelling the demographic impact of HIV/AIDS in South Africa and the likely impact of interventions. *Demogr Res*. 2006;14:541-73.
479. Johnson L. THEMBISA version 1.0:A model for evaluating the impact of HIV/AIDS in South Africa. University of Cape Town: Centre for Infectious Disease Epidemiology and Research, 2014.
480. Chaulagai CN, Moyo CM, Koot J, Moyo HB, Sambakunsi TC, Khunga FM, et al. Design and implementation of a health management information system in Malawi: issues, innovations and results. *Health Policy Plan*. 2005;20(6):375-84. Epub 2005/09/07.
481. Lomas J. Connecting Research and Policy. *Printemps*. 2000:140-4.
482. Lavis JN, Robertson D, Woodside JM, McLeod CB, Abelson J, Grp KTS. How can research organizations more effectively transfer research knowledge to decision makers? *Milbank Q*. 2003;81(2):221-+.
483. Kerner JF. Integrating research, practice, and policy: What we see depends on where we stand. *J Public Health Man*. 2008;14(2):193-8.
484. Nabyonga-Orem J, Mijumbi R. Evidence for informing health policy development in Low-income Countries (LICs): perspectives of policy actors in Uganda. *International Journal of Health Policy and Management*. 2015;4(5):285-93.

485. Schouten EJ, Jahn A, Midiani D, Makombe SD, Mnthambala A, Chirwa Z, et al. Prevention of mother-to-child transmission of HIV and the health-related Millennium Development Goals: time for a public health approach. *Lancet*. 2011;378(9787):282-4. Epub 2011/07/19.
486. Hutchinson E, Parkhurst J, Phiri S, Gibb DM, Chishinga N, Droti B, et al. National policy development for cotrimoxazole prophylaxis in Malawi, Uganda and Zambia: the relationship between Context, Evidence and Links. *Health Res Policy Syst*. 2011;9 Suppl 1:S6. Epub 2011/06/18.
487. Metcalf CJ, Edmunds WJ, Lessler J. Six challenges in modelling for public health policy. *Epidemics-Neth*. 2015;10:93-6. Epub 2015/04/07.
488. Kingdon JW. *Agendas, Alternatives and Public Policies* Boston: Little, Brown; 1984.
489. Lasry A, Richter A, Lutscher F. Recommendations for increasing the use of HIV/AIDS resource allocation models. *BMC Public Health*. 2009;9 Suppl 1:S8. Epub 2009/12/16.
490. Piot P. AIDS: from crisis management to sustained strategic response. *Lancet*. 2006;368(9534):526-30. Epub 2006/08/08.
491. Reniers G, Araya T, Davey G, Nagelkerke N, Berhane Y, Coutinho R, et al. Steep declines in population-level AIDS mortality following the introduction of antiretroviral therapy in Addis Ababa, Ethiopia. *AIDS*. 2009;23(4):511-8.
492. Herbst AJ, Cooke GS, Barnighausen T, KanyKany A, Tanser F, Newell ML. Adult mortality and antiretroviral treatment roll-out in rural KwaZulu-Natal, South Africa. *B World Health Organ*. 2009;87(10):754-62.
493. Mwagomba B, Zachariah R, Massaquoi M, Misindi D, Manzi M, Mandere BC, et al. Mortality Reduction Associated with HIV/AIDS Care and Antiretroviral Treatment in Rural Malawi: Evidence from Registers, Coffin Sales and Funerals. *Plos One*. 2010;5(5).
494. Floyd S, Molesworth A, Dube A, Banda E, Jahn A, Mwafulirwa C, et al. Population-Level Reduction in Adult Mortality after Extension of Free Anti-Retroviral Therapy Provision into Rural Areas in Northern Malawi. *Plos One*. 2010;5(10).
495. Tanser F, Barnighausen T, Grapsa E, Zaidi J, Newell ML. High Coverage of ART Associated with Decline in Risk of HIV Acquisition in Rural KwaZulu-Natal, South Africa. *Science*. 2013;339(6122):966-71.
496. Barnighausen T, Eyal N, Wikler D. HIV treatment-as-prevention research at a crossroads. *PLoS Med*. 2014;11(6):e1001654. Epub 2014/06/04.
497. Hayes R, Ayles H, Beyers N, Sabapathy K, Floyd S, Shanaube K, et al. HPTN 071 (PopART): rationale and design of a cluster-randomised trial of the population impact of an HIV combination prevention intervention including universal testing and treatment - a study protocol for a cluster randomised trial. *Trials*. 2014;15:57. Epub 2014/02/15.
498. WHO. Guideline on when to start antiretroviral therapy and on pre-exposure prophylaxis for HIV. Geneva: World Health Organization; 2015. Available from: <http://www.who.int/hiv/pub/guidelines/earlyrelease-arv/en/>.
499. WHO. Treat all people living with HIV, offer antiretrovirals as additional prevention choice for people at "substantial" risk. Geneva: World Health Organization; 2015; Available from: <http://www.who.int/mediacentre/news/releases/2015/hiv-treat-all-recommendation/en/>.
500. UNAIDS. On the Fast-Track to end AIDS by 2030: Focus on location and population 2015. Available from: [http://www.unaids.org/sites/default/files/media\\_asset/WAD2015\\_report\\_en\\_part01.pdf](http://www.unaids.org/sites/default/files/media_asset/WAD2015_report_en_part01.pdf).

501. The Global Fund. Investment Case for the Global Fund's 2017-2019 Replenishment: The right side of the tipping point for AIDS, tuberculosis and malaria December 2015. Available from: [http://www.theglobalfund.org/en/blog/2015-12-16\\_End\\_It\\_For\\_Good/](http://www.theglobalfund.org/en/blog/2015-12-16_End_It_For_Good/).
502. Coordinator OotUSGA. PEPFAR 3.0: Controlling the epidemic - Delivering on the promise of an AIDS-free generation 2014. Available from: <http://www.pepfar.gov/documents/organization/234744.pdf>.
503. The HIV Modelling Consortium. Sources of Infections and National Intervention Impact Projections. Imperial College London: HIV Modelling Consortium; 2011; Available from: <http://www.hivmodelling.org/sites/default/files/publications/Meeting%20Report%201%20-%20Montreux.pdf>.
504. UNAIDS. Guidelines: Epidemiological review related to the Modes of Transmission Analysis (EPI-MOT). Geneva: Joint United Nations Programme on HIV/AIDS; 2012. Available from: [http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/document/2012/guidelines/JC2428\\_Epireview\\_ModesofTransmissionAnalysis\\_en.pdf](http://www.unaids.org/sites/default/files/en/media/unaids/contentassets/documents/document/2012/guidelines/JC2428_Epireview_ModesofTransmissionAnalysis_en.pdf).
505. UNAIDS. Data Tools: Incidence by Modes of Transmission. Joint United Programme on HIV/AIDS; [cited 2015 December]; Available from: <http://www.unaids.org/en/dataanalysis/datatools/incidencebymodesoftransmission>.
506. Annick Borquez. Personal Communication. August 20, 2015.
507. Peter Vickerman. Personal Communication. London, UK: HIV Modelling Consortium Key Partners Meeting; 12 January 2015.
508. WHO. Antiretroviral drugs for treating pregnant women and preventing HIV infection in infants: Recommendations for a public health approach. Geneva: The World Health Organization; 2010; Available from: [http://apps.who.int/iris/bitstream/10665/75236/1/9789241599818\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/75236/1/9789241599818_eng.pdf).
509. WHO. Antiretroviral therapy for HIV infection in adults and adolescents: Recommendations for a public health approach. Geneva: The World Health Organization; 2010.
510. WHO. Antiretroviral therapy for HIV infection in infants and children: Recommendations for a public health approach. Geneva: The World Health Organization; 2010; Available from: <http://www.who.int/hiv/pub/paediatric/infants2010/en/>.
511. WHO. Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection: Recommendations for a public health approach. 2013; Available from: <http://www.who.int/hiv/pub/guidelines/arv2013/download/en/>.
512. Piot P, Karim SSA, Hecht R, Legido-Quigley H, Buse K, Stover J, et al. Defeating AIDS-advancing global health. *Lancet*. 2015;386(9989):171-218.
513. Jones A, Cremin I, Abdullah F, Idoko J, Cherutich P, Kilonzo N, et al. Transformation of HIV from pandemic to low-endemic levels: a public health approach to combination prevention. *Lancet*. 2014;384(9939):272-9.
514. Dybul M, Piot P, Frenk J. Reshaping Global Health. *Policy Rev*. 2012(173):3-18.
515. El-Sadr WM, Barker P, Rabkin M, Pillay Y, Birx D. Putting quality at the heart of HIV programs. *AIDS*. 2015;29 Suppl 2:S119-20. Epub 2015/06/24.
516. Beyrer C, Birx DL, Bekker LG, Barre-Sinoussi F, Cahn P, Dybul MR, et al. The Vancouver Consensus: antiretroviral medicines, medical evidence, and political will. *Lancet*. 2015;386(9993):505-7.
517. Sturm R. Evidence-based health policy versus evidence-based medicine. *Psychiatr Serv*. 2002;53(12):1499-.

518. Biesma RG, Brugha R, Harmer A, Walsh A, Spicer N, Walt G. The effects of global health initiatives on country health systems: a review of the evidence from HIV/AIDS control. *Health Policy Plan.* 2009;24(4):239-52. Epub 2009/06/06.
519. Hawkes S, B KA, Jadeja N, Jimenez M, Buse K, Anwar I, et al. Strengthening capacity to apply health research evidence in policy making: experience from four countries. *Health Policy Plan.* 2015. Epub 2015/04/23.
520. Liverani M, Hawkins B, Parkhurst JO. Political and Institutional Influences on the Use of Evidence in Public Health Policy. A Systematic Review. *Plos One.* 2013;8(10).
521. NICE: What we do. United Kingdom: National Institute for Health and Care Excellence; 2016 [cited 2016 March]; Available from: <https://www.nice.org.uk/about/what-we-do>.
522. Easterbrook PJ, Doherty MC, Perriens JH, Barcarolo JL, Hirschschall GO. The role of mathematical modelling in the development of recommendations in the 2013 WHO consolidated antiretroviral therapy guidelines. *AIDS.* 2014;28:S85-S92.
523. Eaton JW, Menzies NA, Stover J, Cambiano V, Chindelevitch L, Cori A, et al. Health benefits, costs, and cost-effectiveness of earlier eligibility for adult antiretroviral therapy and expanded treatment coverage: a combined analysis of 12 mathematical models. *Lancet Global Health.* 2014;2(1):E23-E34.
524. Keebler D, Revill P, Braithwaite S, Phillips A, Blaser N, Borquez A, et al. Cost-effectiveness of different strategies to monitor adults on antiretroviral treatment: a combined analysis of three mathematical models. *Lancet Global Health.* 2014;2(1):E35-E43.
525. Fafard P. Beyond the usual suspects: using political science to enhance public health policy making. *J Epidemiol Community Health.* 2015;69(11):1129-32. Epub 2015/02/27.
526. Bernier NF, Clavier C. Public health policy research: making the case for a political science approach. *Health Promot Int.* 2011;26(1):109-16.
527. Bollinger LA. How can we calculate the "E" in "CEA"? *AIDS.* 2008;22:S51-S7.

## Appendix Chapter 2

### Appendix 2-1: Additional theory and theoretical frameworks reviewed

#### Public policy and the policy process

**Public policy:** those public issues defined as problems and the courses of action (or inaction) that arise to address said problems (1)

**Analysis for the policy process:** use of analytic techniques and research to inform the various stages of the policy process. Uses past and present time dimension with a view of predicting and possibly influencing policy development (2).

**Analysis of the policy process:** Considers how policy problems are defined, agendas set, policy formulated, decisions made and policy is subsequently implemented and evaluated (Parsons 1995, p xvi in (1). Strong retrospective dimension(2)

#### Theoretical Frameworks

**Theory:** Set of interrelated propositions containing constructs that describe, explain, predict or control behaviour (3). Theories assume relationships among variables and make predictions about likely outcomes (4). Will vary in the degree to which they have been conceptually developed and tested empirically. There can be many theories within a single framework (5)

**Model:** Ostrom viewpoint is that a model is a representation of a specific situation, narrower in scope than underlying theory, more precise in its assumptions (5)

**Theoretical paradigm:** Normally used to refer to the broad world view that informs a research approach (6).

#### Political theories

**Key caveat:** Most of the ideas and concepts are from studies in high income countries and on policy in general as opposed to health policy (*Walt paper, Doing health policy analysis is an exception, focuses on LMIC and health policy*).

Health sector has specific characteristics that differentiate it from other sectors – the state may be both provider and purchaser of services, but is also involved in research, training, regulation, funding (7). Health issues often high profile, may demand public responses and health interests have traditionally been perceived to demand public responses (7).

**Triangle framework (Walt and Gilson(8): Commonly used overarching framework**

**'classical' political theories: pluralism, elitism** (novel = elite pluralism)

**All included in thesis**

#### Classical models of decision making (policy analysts/planners):

**Rationalism:** Rational models of decision making assume decision makers identify a problem, gather and review all the data and select the solution that best matches their goals (i.e. goal oriented, aka 'means-end rationality') (9, 10), **idealist**

**Incrementalism:** Theory that decisions are not made through a rational process but by small adjustments to the status quo in the light of political realities (11). Series of small steps over long period(12),allows for a greater role of interests. **conservative**

**Both rationalism and incrementalism included in thesis**

### Models of the public policy process

Theories often focus on specifics such as actors or on specific stages but do not attempt to address the **process (13)**. The below are well-developed frameworks which may turn into general political theories of the policy process.

*The case study investigation is not an analysis of the policy process. In addition, the frameworks below are not focused on health. These were all reviewed (in greater detail than the short descriptions below) for general knowledge and awareness.*

Most of the below use a model of **bounded rationality** to explain behaviour (4). Most theories are grounded within a model of the individual but policy change occurs as a result of **collective action** thus how individuals come together/organise/gather is important and belief systems will likely play a role(4). Potentially useful for prediction, but too limited in scope. Better suited if narrow and more closely tailored to the specific decision process/context.

### Models of the policy process for the problem identification and agenda setting stages

**Institutional rational choice framework:** Family of frameworks focusing on how institutional rules alter behaviour of intendedly rational individuals motivated by self-interest (5). Public policies as institutional arrangements; policy change occurs from actions of rational individuals trying to improve their circumstances by altering rules. Actors' strategy choice guided by perceptions of expected costs/benefits, actors operate within rules but may be able to establish/modify rules ((13) but Bromley 1989). **Bromley; Ostrom and colleagues** advance this framework.

**Punctuated equilibrium theory: Baumgartner and Jones (1993)** argues US policy making characterised by long periods of incremental change punctuated by brief periods of major policy change (5).

- Similar to **multiple streams theory** and also has assumption of bounded rational people interacting in institutional settings (14)
- When new actors and interests emerge, rapid bursts of change are possible → **Shiffman et al 2002** examined global attention to TB, malaria and polio using this theory (7)

**Policy/problem/political streams framework :** Pertains to agenda setting phase, advises the exploitation of policy windows which create opportunity to push policy alternatives (15).

- **Kingdon: Model of agenda setting (16), 3 Streams**
  - Several independent processes/streams make policy (3 streams: policy, politics problem). *Example of a problem brewing for some time, shift in leadership (politics) which creates window for opportunity (policy) (16)*
- '**Policy entrepreneurs**' may also induce these windows of opportunity as they can recognise the right opportunity/timing
- aka **multiple-streams framework** – focuses on agenda setting and decision making, attempts to explain why policymakers adopt some policies and not others(14).
- Assumption of 'bounded rational' people interacting in institutional settings with parallel and serial information processing (ie may be simplistic) (14)
- Health policy scholars have adapted this theory to explain how health issues have emerged on policy agendas (for example, **Reich 1995** who added additional elements, and **Ogden et al 2003** who drew on these ideas in their TB research citing emergence of HIV/AIDS epidemic as opening global policy windows which helped advocacy networks to promote DOTS ) (7)

**Hall Model: 'legitimacy, feasibility, support'** Agenda setting theory that stipulates only when an issue and likely response are high in terms of legitimacy, feasibility and support do they get on the government agenda (Hall, P; *Change, Choice and Conflict*, 1975)

**Moe's political theory of bureaucracy:** Formation of public policies arise from the interaction of interest groups, politics and bureaucrats, but preoccupation with political control (near paranoid concern for re-election) results in choices not achieved via processes and structures adopted and thus cannot assume direct links between institutions and decisions made (13). Groups as the main actors for change.

#### Models of the policy process for the implementation stage

It is important to consider that just because a policy is developed in a certain way, does not mean it will be implemented in that way, changes can occur in the implementation stage. Political scientists often view decision making and implementation determined by how power is structured and use different theories to differentiate how these decisions are made (2).

*I did not focus on the implementation stage in my thesis have not incorporated any of the implementation theories below.*

**Decision making as top-down or bottom-up (e.g. Sabatier):** Argument that in US democracy, policy is top-down – reflects values/interests of governing elite, decisions are monitored at implementation stage to make sure they are not significantly altered (Dye, 2001 in (7)).

**Street level bureaucrats (Lipsky):** SLBs can change policies significantly at implementation stage

**'garbage can' model:** Discarded solutions remain, untidy process

**Advocacy coalition framework :** Sabatier & Jenkins-Smith; Attempts to explain policy change within a policy subsystem over relatively long time periods, as opposed to attending to particular policy adoptions or patterns of decisions (14). Highlights multiple major actors and other variables at work. Firmly rooted in a pluralistic notion of politics, emphasises role of information and learning as motivating factors in process of policy change, iterative process of policy formulation. Tailored to explaining policy change over decades, with changes resulting from changing preference/beliefs of critical actors (as opposed to change as a result of new actors with different preferences). (13)

- Advocacy coalitions (who share same beliefs/values/assumptions) group the actors together within a policy sub-system, members act together based on their belief systems, compete for influence (13, 16). Beliefs hold the coalitions together, eg politicians, civil servants, journalists, academics (17).
- Policy change occurs within policy sub-systems/advocacy coalitions and is the result of large changes in the external environment (e.g. new govt)

**Top-Down Approaches:** Closely aligned with rational model of the entire policy process, linear, policy formulation separate from execution (gap here) (12)

**Bottom-Up Approaches:** Implementers play key role, power over what occurs in implementation, (street-level bureaucrats fall here)

**Principal-agent theory:** Sub-optimal implementation is a result of government having to delegate the responsibility of implementation. These *agents* may have their own ideas for how things should occur, primary concern might not be the wishes of the *principal* (doctors, for example). *Agents* have own view, opinion, ambition, loyalties, etc.

**Street level bureaucracy:** Michael Lipsky, Argument that implementers shape policy as a result of their understanding of it but also as it fits in with their values and interests (and thus have the ability to re-shape policy during implementation) (16). Often constrained by resources, continuous negotiation to meet targets (18)

### Frameworks for health policy analysis

**Health policy triangle:**Walt, Argues that health policy wrongly focuses attention on **content** of reform and neglects to focus on the **actors** involved, the **process** contingent on developing and implementing change and the **context** within which policy is developed (8). Simplified depiction of complicated inter-relationships, can be used retrospectively and prospectively.

*I focussed on research information is used, as opposed to an analysis of how policy is made*

'stages heuristic' (usually 4, sometimes 5) (7):

1. **identification/agenda setting:** issue sorting, when problems are raised to attention of decision makers
2. **formulation:** legislatures et al design and enact policies
3. **implementation:** how govts carry out the policies
4. **evaluation:** assess impact

*Stages heuristic included in thesis to define the scope of investigation*

**Grindle and Thomas** (1991), *Public Choices and policy change* focus is explicitly on the process of policy making. They provide an analytical framework which incorporates process to help understand how public policy is made and who influences it (from the approach of economic policy reform, focus on actors and role of elites) (8).

### Models for research/evidence to policy; research utilisation

*<Key focus of this thesis>*

**Use of research evidence: Conceptual, Instrumental, Symbolic →Pelz(19)**

One of the first to elaborate on how research evidence is used, goes against the early thinking that research evidence is not used but that there are different types of use and need an expanded view of "utilisation". *Instrumental vs conceptual* actually somewhat originated from Robert Rich(20) who found it necessary to differentiate between *knowledge for action* (instrumental) and *knowledge for understanding* (conceptual) (19).

*Included in thesis*

**Classic/purist/knowledge-driven model:** *Included in thesis*

**Problem-solving/engineering/policy-driven model:** *Included in thesis*

**Enlightenment/percolation/limestone/infiltration model:** *Included in thesis*

**Interactive/social interaction model:** *Included in thesis*

**Tactical model:** *Included in thesis*

**Political model:** *Included in thesis*

**Diffusion models:** Early model was based on assumption that dispersion of research findings was sufficient for uptake, that policy makers were information-seeking and both were interested in similar questions. Initial attempt to focus on characteristics that affected research uptake; emphasis on high quality research being more likely than poor quality for uptake (later recognised quality was only one of many factors). Fails to recognise incremental nature of policy making and programme development, along with additional contextual constraints (21).

*Limited description/Simplistic representation of process, limited relevance in case study investigations*

**Dissemination models:** Focus on need for distribution of research findings in order to be used by decision makers. Timing and type/form of findings and who delivered to key to the distribution. Cons: Limited focus on receptivity of decision makers to the research findings; simplistic in the assumption that the info is out there, just needs to be disseminated appropriately for use (21).

*Limited description/simplistic representation of process, limited relevance in case study investigations*

**Interfaces and receptor model:** Hanney et al (9), Lomas (22): Multi-direction interactions, emphasis on the importance of actions at interfaces and the role of receptors. Broad enough to be applied to many situations.

*I did not have enough interactions and time in-country to be able to get a strong understanding of the relationships and interactions between key stakeholders*

**Elective affinities model:** Assumes the extent of contact and timing of interactions between researchers and policymakers along with the fit with personal values and beliefs will improve a positive reception from the policy audience (23). **Short**

*Potential relevance here, not just researchers but different donors. Again not enough time on ground to get a strong sense of the interactions between researchers/donors and decision makers*

**Conduit models:** Person/agency is a link between research, policy, practice and informs different "communities" of research outcomes and developments via user-friendly language/presentations, novel methods of making information accessible (24)

*Too narrow and limited relevance in case study investigations*

**Utilitarian Evidence model:** Research should be useful in order to be applied in policy/practice. Research must be "pitched" so that it is clearly of use to policy/practice individuals/communities (24)

- **Utility-Driven Evidence (de Leeuw, citing own self),** knowledge needs to be made relevant to stakeholders

*Potentially relevant to case studies*

**Alternative Evidence model:** If the research is counter to current political agendas/views/paradigms, its immediate impact will be muted (24)

*Potentially relevant to case studies*

**Stages of prevention research utilization:** Cunningham-Sabo model (25), adapted from Rogers 2003 diffusion of innovation model and expanding upon Oldenburg et al. Describes how prevention research can be used across five different stages (dissemination, intent to adopt, implementation/adaptation, institutionalisation, diffusion)

*Focus too limited*

**'Two-worlds' view:** (Lomas 2007 (26)) (aka 'two communities', Caplan 1979 (27)): view focusing on the different needs and expectations of researchers and policy makers.(28)

- Researchers and policy makers come from two different worlds/communities, use different language and methods of communication and bridging this gap is viewed as increasing the sensitivities of each and may encourage greater use of research (21)
- Researchers: scientifically complex world, emphasis on purity of findings
- Policy makers: world that wants certainty, timeliness, simplicity
- Caplan solution is to frame research in suitable way for policymakers and to have them be involved with research agendas and design (23)
- This model often refers to "linkage networks", "sustained interactivity", "interaction models" and "interactive processes"

*Some overlap with interactive model, too simplistic in that it only includes two communities – role of donors, intergovernmental orgs, civil society, all important in the settings under investigation*

**Knowledge to action framework (29):** Model for the practice of knowledge translation – iterative, dynamic, complex – knowledge creation and application (action cycle), fluid boundaries between action and creation. Stages can occur sequentially or simultaneously. Adopted by the Canadian Institutes of Health Research as the accepted model for promoting the application of research and a framework for the process of knowledge translation. As knowledge is filtered through each stage in the creation process, the resulting knowledge becomes more refined and likely more useful to end users. Synthesis brings together incongruent findings to identify common patterns, disentangle. Tools represent the best quality knowledge synthesised into decision making tools including practice guidelines/decision aids.

*Very detailed, more relevant for very developed contexts*

### Network Frameworks

In 1990's, emergence of new paradigm of health policy analysis focusing less on the 'what' (technical content) of policy and more on the 'who' (actors), power, processes and contexts involved in developing and implementing policy and the decision-making process(16).

Network frameworks highlight role of different interests and how relationships between and among groups and decision makers can result in an incremental policy process (9). Network approaches can provide a useful framework for studying research utilisation highlight the role of stakeholders in research utilisation.

Many different ways of classifying network frameworks (7), may be a more generic term, may refer to analysis:

- **Network analysis:** Debate whether network analysis is merely descriptive, or if there is explanatory value, whether it is largely a Western concept (US & UK) or if it has legitimacy for developing countries; whether it is new analytic system or reflects a change in policy environment (7) (*but see Thatcher 1998*).
  - Focus is on the relationships that shape policy agenda and decision making process, networks can impact how evidence is gathered and presented (30).
  - Tool for describing systems of interactions and interconnectedness between groups of actors (*see Thatcher 1998*)

**'policy network'** = different types of state/interest group relationships including:

- **'policy communities'** = tight networks with few participants who share basic values and resources → cohesive, which restricts access. May be layers – i.e. dominant core surrounded by outer layer more peripheral )(9) (7)
  - **Advocacy coalition:** A type of policy community with a shared set of norms/beliefs/policy goals
  - **'Discourse coalition':** groups of actors sharing a social construct who seek to impose their discourse in different domains. Discourse dominates modes of perception (18)
- **global public policy network:** alliances of government agencies, international organisations, corporations, operating between and above the nation state (18)
  - **'epistemic community':** formal and informal groups of "experts" who gather, share info/ideas/knowledge, synthesise and disseminate info about a policy issues, advocate for knowledge translation (30)
  - **issue network:** Brings together many different groups/individuals for common purpose/cause, compared to policy network has more members, looser organizational form (17). Focuses on configurations and interactions of coalitions of

actors within a policy network, with much less attention devoted to policy adoptions/decisions (14)

#### **Actor network theory/frameworks with regards to research utilisation**

Relationships between researchers and decision makers will shape the influence they have over each other. Close links are hypothesised to result in more influence (18). Dynamic networks ("actants") constantly forming and reforming, allowing for permeation of knowledge, redefining boundaries. Translation effort aims to construct central network, that the actors build and defend (24).

**Keeley and Scoones:** Interactions between groups with different political interests, actors (networks) and discourse (18). Caveats of this framework: underscores the role played by wider civil society, and what can happen to policies when they are implemented; does not appropriately reflect on actions at the nexus between research policy and practice (24).

**Latour's** work on formation of professional networks which mediate expert knowledge and practices with research utilisation, a loosely interconnected network of actors, ideas, technologies (31) (32). Driven by common objectives, importance given to conflict-free coherence; however, new scientific practice/analyses, etc can result in differing viewpoints.

**Ideas** (policy narratives and discourses), **actors** (policy actors and networks) and **context** (and institutions)(33). Factors shaping research impact on policy, three dimensions interacting and driving policy change, all can interrelate or influence each other, but focus is on the process (34)

- *Ideas*: policy ideas/narratives, how evidence and health issue are conceptualised and the way in which their relevance is understood as pertains to policy agendas
- *Actors*: policy actors/networks, work emphasising key decision makers, or influential groups/actors in decision making process
- *Context*: institutions/political context incl that in which decisions are made (hard) and the socio-economic/political/cultural enviros (soft) which shape policy processes ("rules of the game")

*The use of actor-network theory as a conceptual theory was considered for the case study investigations but the limited time spent in each country was not sufficient to allow for analysis from this type of lens.*

## REFERENCES

1. Nutley S, Webb J. Evidence and the policy process. In: Davies HTO, Nutley S, Smith PC, editors. *What Works? Evidence-based policy and practice in public services*. Bristol, UK: Policy Press; 2000.
2. Brugha R, Varvasovszky Z. Stakeholder analysis: a review. *Health Policy Plan*. 2000;15(3):239-46. Epub 2000/09/30.
3. Gibney L, DiClemente RJ, Vermund SH. *Preventing HIV in developing countries : biomedical and behavioral approaches*. New York: Kluwer Academic/Plenum Press; 1999. xxiii, 400 p. p.
4. Schlager E. A comparison of frameworks, theories and models of the policy process. In: Sabatier PA, editor. *Theories of the Policy Process*. 2nd ed. Boulder, Colorado: Westview; 2007. p. 293-319.
5. Sabatier PA. *Theories of the Policy Process*. 2nd ed. Boulder, Colorado: Westview; 2007.
6. Oliver P. *Writing Your Thesis*. London: Sage Publications; 2004.
7. Walt G, Shiffman J, Schneider H, Murray SF, Brugha R, Gilson L. 'Doing' health policy analysis: methodological and conceptual reflections and challenges. *Health Policy Plan*. 2008;23(5):308-17. Epub 2008/08/15.
8. Walt G, Gilson L. Reforming the health sector in developing countries: the central role of policy analysis. *Health Policy Plan*. 1994;9(4):353-70. Epub 1994/11/04.
9. Hanney SR, Gonzalez-Block MA, Buxton MJ, Kogan M. The utilisation of health research in policy-making: concepts, examples and methods of assessment. *Health Res Policy Syst*. 2003;1(1):2. Epub 2003/03/21.
10. Simon HA. *Administrative Behavior*. 4th ed. New York: The Free Press; 1997.
11. Lindblom CE. The Science of "Muddling Through". *Public Administration Review*. 1959;19(2):79-88.
12. Buse K, Mays N, Walt G. *Making Health Policy*. Black N, Raine R, editors. Berkshire, England: Open University Press; 2005.
13. Schlager E, Blomquist W. A comparison of three emerging theories of the policy process. *Polit Res Quart*. 1996;49(3):651-72.
14. Schlager E. A comparison of frameworks, theories and models of the policy processes. In: Sabatier PA, editor. *Theories of the Policy Process*. Boulder, Colorado: Westview; 2007. p. 293-319.
15. Weimer DL. Theories of and in the Policy Process. *Policy Stud J*. 2008;36(4):489-95.
16. Buse K, Dickinson C, Gilson L, Murray SF. How can the analysis of power and process in policy-making improve health outcomes? ODI briefing note number 25. London: Overseas Development Institute; 2007.
17. Buse K. Addressing the theoretical, practical and ethical challenges inherent in prospective health policy analysis. *Health Policy Plan*. 2008;23(5):351-60. Epub 2008/07/31.
18. Crewe E, Young J. Bridging research and policy: Context, evidence and links. Working Paper 173. London: Overseas Development Institute; 2002.
19. Weiss C. The many meanings of research utilization. *Public Administration Review*. 1979;39:426-31.
20. Rich RF. Selective utilization of social science related information by federal policy-makers. *Inquiry : a journal of medical care organization, provision and financing*. 1975;12(3):239-45. Epub 1975/09/01.
21. Kothari A, Birch S, Charles C. "Interaction" and research utilisation in health policies and programs: does it work? *Health Policy*. 2005;71(1):117-25. Epub 2004/11/27.
22. Lomas J. *Connecting Research and Policy*. Printemps. 2000:140-4.
23. de Goede J, Putters K, van der Grinten T, van Oers HA. Knowledge in process? Exploring barriers between epidemiological research and local health policy development. *Health Res Policy Syst*. 2010;8:26. Epub 2010/09/18.
24. de Leeuw E, McNess A, Crisp B, Stagnitti K. Theoretical reflections on the nexus between research, policy and practice. *Critical Public Health*. 2008;18(1):5-20.

25. Cunningham-Sabo L, Carpenter WR, Peterson JC, Anderson LA, Helfrich CD, Davis SM. Utilization of prevention research: searching for evidence. *Am J Prev Med.* 2007;33(1 Suppl):S9-S20. Epub 2007/08/19.
26. Lomas J. The in-between world of knowledge brokering. *Brit Med J.* 2007;334(7585):129-32.
27. Caplan N. The two-communities theory and knowledge utilization. *Am Behav Sci.* 1979;22(3):459-70.
28. Burris H, Parkhurst J, Adu-Sarkodie Y, Mayaud P. Getting research into policy - Herpes simplex virus type-2 (HSV-2) treatment and HIV infection: international guidelines formulation and the case of Ghana. *Health Res Policy Syst.* 2011;9 Suppl 1:S5. Epub 2011/06/18.
29. Straus SE, Tetroe JM, Graham ID. Knowledge translation is the use of knowledge in health care decision making. *J Clin Epidemiol.* 2011;64(1):6-10. Epub 2009/11/21.
30. Bowen S, Zwi AB. Pathways to "evidence-informed" policy and practice: A framework for action. *Plos Medicine.* 2005;2(7):600-5.
31. Behague D, Tawiah C, Rosato M, Some T, Morrison J. Evidence-based policy-making: the implications of globally-applicable research for context-specific problem-solving in developing countries. *Soc Sci Med.* 2009;69(10):1539-46. Epub 2009/09/29.
32. Latour B. *Reassembling the Social: An introduction to actor-network-theory.* Oxford: Oxford University Press; 2005.
33. Sumner A, Crichton J, Theobald S, Zulu E, Parkhurst J. What shapes research impact on policy? Understanding research uptake in sexual and reproductive health policy processes in resource poor contexts. *Health Res Policy Syst.* 2011;9 Suppl 1:S3. Epub 2011/06/18.
34. Tulloch O, Mayaud P, Adu-Sarkodie Y, Opoku BK, Lithur NO, Sickle E, et al. Using research to influence sexual and reproductive health practice and implementation in Sub-Saharan Africa: a case-study analysis. *Health Res Policy Syst.* 2011;9 Suppl 1:S10. Epub 2011/06/18.

## Appendix Chapter 3

### Appendix 3-1: Impact Matrix

| Intervention                              | Reduction in condom non-use (%) |        |       | Reduction in number of partners (%) |        |     | Increase in age at first sex (years) | Reduction in needle-sharing (%) |
|-------------------------------------------|---------------------------------|--------|-------|-------------------------------------|--------|-----|--------------------------------------|---------------------------------|
|                                           | High                            | Medium | Low   | High                                | Medium | Low | Medium                               | IDU                             |
| Community mobilisation                    | ...                             | -10.0  | -2.5  | ...                                 | ...    | ... | -0.3                                 | ...                             |
| Mass media                                | ...                             | -11.6  | -17.0 | ...                                 | -4.2   | ... | 0.0                                  | ...                             |
| Counselling and testing                   | -44.2                           | -23.4  | -16.1 | ...                                 | -13.1  | 0.0 | ...                                  | ...                             |
| Condom promotion                          | -85.1                           | -55.1  | -5.3  | ...                                 | -13.0  | ... | ...                                  | ...                             |
| Youth education in-school                 | ...                             | -15.7  | ...   | ...                                 | -18.3  | ... | 0.075                                | ...                             |
| Youth education outreach out-of-school    | ...                             | -16.6  | ...   | ...                                 | -18.3  | ... | 0.075                                | ...                             |
| Workplace education programmes            | -39.0                           | -17.1  | -1.0  | -93.0                               | -35.5  | ... | ...                                  | ...                             |
| Outreach & harm reduction for sex workers | -42.5                           | ...    | ...   | -11.2                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for MSM         | -36.3                           | ...    | ...   | -10.1                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for IDU         | -17.9                           | ...    | ...   | -1.2                                | ...    | ... | ...                                  | -49.5                           |
| Needle & syringe exchange for IDU         | -41.5                           | ...    | ...   | ...                                 | ...    | ... | ...                                  | -50.7                           |
| Drug substitution programmes for IDU      | ...                             | ...    | ...   | -46.0                               | ...    | ... | ...                                  | -65.0                           |

Effectiveness coefficients of the Goals model, originally describe by Bollinger et al<sup>23</sup>(186, 527)(186, 526)(186, 527)(186, 527)(186, 525)(186, 526)(186, 525)(186, 526)(186, 525)(185, 524)(184, 523)(184, 523)(184, 523) which quantify the impact of exposure to prevention interventions on the reduction in condom non-use, the reduction in number of partners, the increase in age at first sex, and for IDU, the reduction in unsafe injecting behaviour as a result of exposure to an effective prevention intervention. The coefficients are specific for the level of risk behaviour (high, medium or low).

<sup>2</sup> Bollinger L, Cooper-Arnold K, Stover J. Where are the gaps? The effects of HIV-prevention interventions on behavioral change. Studies in family planning. 2004;35(1):27-38.

<sup>3</sup> Bollinger LA. How can we calculate the "E" in "CEA"? AIDS. 2008;22:S51-S7.

## Appendix 3-2: Assumptions for coverage of prevention and treatment by scenario

|                                                                                                    | SOUTH AFRICA               |                                   | CHINA                      |                                   |
|----------------------------------------------------------------------------------------------------|----------------------------|-----------------------------------|----------------------------|-----------------------------------|
|                                                                                                    | 2007                       | 2015                              | 2007                       | 2015                              |
|                                                                                                    | <i>status quo coverage</i> | <i>expanded response coverage</i> | <i>status quo coverage</i> | <i>expanded response coverage</i> |
| <b>Community mobilisation</b>                                                                      | 25%                        | 70%                               | 5%                         | 10%                               |
| <i>Percentage of adults reached by community mobilisation</i>                                      |                            |                                   |                            |                                   |
| <b>Mass media</b>                                                                                  | 75%                        | 80%                               | 40%                        | 60%                               |
| <i>Percentage reached with HIV/AIDS communication programmes</i>                                   |                            |                                   |                            |                                   |
| <b>Counselling &amp; testing</b>                                                                   | 24.7%                      | 80%                               | 3%                         | 10%                               |
| <i>Of those engaging in risky behaviour, percentage testing and receiving results in past year</i> |                            |                                   |                            |                                   |
| <b>Condom promotion</b>                                                                            | 55%                        | 60%                               | 50%                        | 60%                               |
| <i>Social marketing and distribution of condoms</i>                                                |                            |                                   |                            |                                   |
| <b>Youth education in-school</b>                                                                   | 95%                        | 100%                              | 40%                        | 40%*                              |
| <i>Percentage of school youth reached per year</i>                                                 |                            |                                   |                            |                                   |
| <b>Youth education outreach out-of-school</b>                                                      | 35%                        | 50%                               | 3%                         | 5%                                |
| <i>Percentage aged 12-17 years reached per year</i>                                                |                            |                                   |                            |                                   |
| <b>Outreach &amp; harm reduction for sex workers</b>                                               | 20%                        | 60%                               | 38%                        | 60%                               |
| <i>Percentage reached by HIV interventions per year</i>                                            |                            |                                   |                            |                                   |
| <b>Outreach &amp; harm reduction for MSM</b>                                                       | 10%                        | 60%                               | 8%                         | 60%                               |
| <i>Percentage reached by HIV interventions per year</i>                                            |                            |                                   |                            |                                   |
| <b>Outreach &amp; harm reduction for IDU</b>                                                       | 10%                        | 60%                               | 24%                        | 60%                               |
| <i>Percentage reached by HIV interventions per year</i>                                            |                            |                                   |                            |                                   |
| <b>Needle exchange programmes for IDU</b>                                                          | 5%                         | 40%                               | 2%                         | 40%                               |
| <i>Percentage of IDU participating</i>                                                             |                            |                                   |                            |                                   |
| <b>Drug substitution programmes for IDU</b>                                                        | 0%                         | 20%                               | 4%                         | 20%                               |
| <i>Percentage of IDU participating</i>                                                             |                            |                                   |                            |                                   |
| <b>Male circumcision</b>                                                                           | 35%                        | 60%                               | 5%                         | 5%*                               |
| <i>Prevalence of male circumcision</i>                                                             |                            |                                   |                            |                                   |
| <b>ART</b>                                                                                         | 28%                        | 80%                               | 19%                        | 80%                               |
| <i>Of all those eligible, the proportion receiving treatment</i>                                   |                            |                                   |                            |                                   |

\*No increase in coverage

Coverage of interventions for South Africa and China. The status quo values correspond to coverage levels achieved in 2007 maintained through 2031 without increase. The expanded response values correspond to the assumption of the scaled-up coverage target achieved by 2015, maintained through 2031. Coverage is defined as the proportion of the population in-need of a service, who use the service.

### Appendix 3-3: Impact matrix with upper and lower quartile ranges for effectiveness coefficients used for sensitivity analyses

|                                           | Reduction in condom non-use (%) |        |       | Reduction in number of partners (%) |        |     | Increase in age at first sex (years) | Reduction in needle-sharing (%) |
|-------------------------------------------|---------------------------------|--------|-------|-------------------------------------|--------|-----|--------------------------------------|---------------------------------|
|                                           | High                            | Medium | Low   | High                                | Medium | Low | Medium                               | IDU                             |
| <b>AVERAGE IMPACT</b>                     |                                 |        |       |                                     |        |     |                                      |                                 |
| Community mobilisation                    | ...                             | -10.0  | -2.5  | ...                                 | ...    | ... | -0.3                                 | ...                             |
| Mass media                                | ...                             | -11.6  | -17.0 | ...                                 | -4.2   | ... | 0.0                                  | ...                             |
| Counselling and testing                   | -44.2                           | -23.4  | -16.1 | ...                                 | -13.1  | 0.0 | ...                                  | ...                             |
| Condom promotion                          | -85.1                           | -55.1  | -5.3  | ...                                 | -13.0  | ... | ...                                  | ...                             |
| Youth education in-school                 | ...                             | -15.7  | ...   | ...                                 | -18.3  | ... | 0.075                                | ...                             |
| Youth education outreach out-of-school    | ...                             | -16.6  | ...   | ...                                 | -18.3  | ... | 0.075                                | ...                             |
| Workplace education programmes            | -39.0                           | -17.1  | -1.0  | -93.0                               | -35.5  | ... | ...                                  | ...                             |
| Outreach & harm reduction for sex workers | -42.5                           | ...    | ...   | -11.2                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for MSM         | -36.3                           | ...    | ...   | -10.1                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for IDU         | -17.9                           | ...    | ...   | -1.2                                | ...    | ... | ...                                  | -49.5                           |
| Needle & syringe exchange for IDU         | -41.5                           | ...    | ...   | ...                                 | ...    | ... | ...                                  | -50.7                           |
| Drug substitution programmes for IDU      | ...                             | ...    | ...   | -46.0                               | ...    | ... | ...                                  | -65.0                           |
| <b>LOW IMPACT</b>                         |                                 |        |       |                                     |        |     |                                      |                                 |
| Community mobilisation                    | ...                             | -8.6   | -2.2  | ...                                 | ...    | ... | -0.3                                 | ...                             |
| Mass media                                | ...                             | -4.6   | -17.0 | ...                                 | 0.0    | ... | 0.0                                  | ...                             |
| Counselling and testing                   | -19.8                           | -5.5   | -2.3  | ...                                 | -2.0   | 0.0 | ...                                  | ...                             |
| Condom promotion                          | -79.6                           | -48.3  | -4.0  | ...                                 | -13.0  | ... | ...                                  | ...                             |
| Youth education in-school                 | ...                             | -5.6   | ...   | ...                                 | -5.25  | ... | 0.075                                | ...                             |
| Youth education outreach out-of-school    | ...                             | -9.4   | ...   | ...                                 | -5.25  | ... | 0.075                                | ...                             |
| Workplace education programmes            | -39.0                           | -12.3  | -0.5  | -93.0                               | -29.3  | ... | ...                                  | ...                             |
| Outreach & harm reduction for sex workers | -24.0                           | ...    | ...   | 5.2                                 | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for MSM         | -17.8                           | ...    | ...   | 3.4                                 | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for IDU         | -17.9                           | ...    | ...   | -1.2                                | ...    | ... | ...                                  | -30.8                           |
| Needle & syringe exchange for IDU         | -34.5                           | ...    | ...   | ...                                 | ...    | ... | ...                                  | -43.6                           |
| Drug substitution programmes for IDU      | ...                             | ...    | ...   | -46.0                               | ...    | ... | ...                                  | -49.3                           |
| <b>HIGH IMPACT</b>                        |                                 |        |       |                                     |        |     |                                      |                                 |
| Community mobilisation                    | ...                             | -13.2  | -2.7  | ...                                 | ...    | ... | -0.3                                 | ...                             |
| Mass media                                | ...                             | -18.6  | -17.0 | ...                                 | -6.3   | ... | 0.0                                  | ...                             |
| Counselling and testing                   | -63.5                           | -42.3  | -25.0 | ...                                 | -20.0  | 0.0 | ...                                  | ...                             |
| Condom promotion                          | -91.3                           | -62.0  | -6.7  | ...                                 | -13.0  | ... | ...                                  | ...                             |
| Youth education in-school                 | ...                             | -20.2  | ...   | ...                                 | -31.5  | ... | 0.000                                | ...                             |
| Youth education outreach out-of-school    | ...                             | -22.0  | ...   | ...                                 | -31.5  | ... | 0.000                                | ...                             |
| Workplace education programmes            | -39.0                           | -19.8  | -1.5  | -93.0                               | -41.8  | ... | ...                                  | ...                             |
| Outreach & harm reduction for sex workers | -57.7                           | ...    | ...   | -35.3                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for MSM         | -46.1                           | ...    | ...   | -23.5                               | ...    | ... | ...                                  | ...                             |
| Outreach & harm reduction for IDU         | -17.9                           | ...    | ...   | -1.2                                | ...    | ... | ...                                  | -68.3                           |
| Needle & syringe exchange for IDU         | -41.5                           | ...    | ...   | ...                                 | ...    | ... | ...                                  | -57.5                           |
| Drug substitution programmes for IDU      | ...                             | ...    | ...   | -46.0                               | ...    | ... | ...                                  | -80.8                           |

## Appendix Chapter 4

### Appendix 4-1: The Modes of Transmission Model: Model Assumptions\*

The risk of infection in a susceptible individual is assumed to be a simple binomial function of the number of partners and number of sex acts with each partner. Risk per susceptible individual is derived based upon the current prevalence of infection within their contacts and transmission probabilities which differ depending on whether additional sexually transmitted infections are present. Incidence for the next year at the population level is then derived by multiplying by the number susceptible using the following equation:

$$I = S \left[ 1 - \underbrace{pB[1-\beta']^{\alpha(1-v)}}_{\text{HIV/STI+ partner}} + \underbrace{p(1-B)[1-\beta]^{\alpha(1-v)}}_{\text{HIV+ partner}} + \underbrace{(1-p)}_{\text{HIV- partner}} \right]^n$$

$I$  = Incidence of HIV in the target population

$p$  = HIV prevalence among partners

$B$  = STI prevalence among partners

$v$  = Proportion of acts protected through condom use

$\alpha$  = Number of sex acts per partner per year

$n$  = Number of partners per year

$\beta$  = HIV transmission probability with no STIs (and with STIs  $\beta'$ )

$S$  = Number susceptible

The incidence of HIV in a population depends on the number susceptible ( $S$ ) and the HIV prevalence in the partner population ( $p$ ). The variable  $B$  is prevalence of STIs in the target or partner population (whichever is higher),  $\beta'$  and  $\beta$  represent the probability of transmission of HIV during a single contact in the presence or absence of an STI (in the case of transmission by needle-sharing  $\beta' = \beta$ ),  $v$  is the proportion of acts currently protected by effective condom use or the use of sterile needles,  $a$  is the number of contacts per partner and  $n$  is the number of partners.

The risk of becoming infected from having sex with these  $n$  partners will depend on their HIV prevalence, their STI prevalence, the number of sex acts they have with each partner and the proportion of times these acts are protected. The sex acts with non-infected partners are not obviously represented in the equation because they represent no risk of infection ( $\beta=0$ ), the probability of NOT getting infected after the  $\alpha$  acts with these partners is 1:  $(1-0)\alpha(1-v)=1$ .

**Male circumcision:** The effect of male circumcision on the probability of transmission is taken into account by a decrease the female to male probability of transmission (60% reduction multiplied by the proportion of men circumcised). This modified female to male transmission probability is applied to all sex acts between men and women, thus assuming that the proportion of circumcised men is the same in all male groups represented in the model.

**Stage of infection:** Variance in probability of transmission by stage of infection is not included.

**ART:** The effect of antiretroviral treatment on the probability of transmission was not included in the model when this analysis occurred.

*\*Adapted from<sup>4</sup> and resource documentation provided by Annick Borquez*

<sup>4</sup> UNAIDS. Modelling the expected short-term distribution of incidence of HIV infections by exposure group: User Manual. Geneva: The Joint United Nations Programme on HIV/AIDS, 2007

## **Appendix 4-2: Sources for data inputs for the MoT analysis in Armenia**

| Risk group*                                                                   | Estimate                   | Year         | Data sources / comments                                                                                                                  | Default estimate        |
|-------------------------------------------------------------------------------|----------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Total number of adults (15-49 years)</b>                                   | 1, 805, 800<br>1, 816, 800 | 2010<br>2009 | Armenia, statistical service/official data                                                                                               |                         |
| <b>Estimated Adult HIV prevalence</b>                                         | 0.1%                       | 2009         | EPP/Spectrum adults 15-49                                                                                                                |                         |
| <b>Injecting Drug Use (IDU)</b>                                               |                            |              |                                                                                                                                          |                         |
| Number of IDU in the adult population:                                        | 12,700                     | 2010         | NCAP/UNAIDS IDU pop size estimation                                                                                                      |                         |
|                                                                               | (4000-6000)                | 2008         | Expert opinion, previous national estimate                                                                                               |                         |
| Male                                                                          | 12,243                     | 2010         | BBS 2010 (96.4% M, N=270)                                                                                                                |                         |
| Female                                                                        | 457                        | 2010         | BBS 2010 (3.6% F, N=270)                                                                                                                 |                         |
| Prevalence of HIV in this population                                          | 6.5%                       | 2010         | NCAP: national prevalence<br>BBS, Yerevan only: 10.7% (6-16.8%)                                                                          |                         |
| Prevalence of any STI in this population                                      | 4.2% (1.7%-7.2%)           | 2010         | 2010 BBS 2010 (Yerevan), syphilis                                                                                                        |                         |
| Average number of injecting partners per year                                 | 2                          |              | No data available, estimates from Moldova used as proxy                                                                                  |                         |
| Average number of acts of needle sharing with each injecting partner per year | 17                         |              | No data available, estimates from Moldova used as proxy                                                                                  |                         |
| Percentage of times a clean needle is used when injecting drugs               | 91.3%                      | 2010         | BBS sterile needles at last injection                                                                                                    |                         |
| <b>Partners IDU</b>                                                           |                            |              |                                                                                                                                          |                         |
| Number/percent of IDU partners in the population:                             |                            |              |                                                                                                                                          | Half the number of IDUs |
| Male                                                                          | 207                        | 2010         | BBS 2010 45.2% married (33.1-54.4%) (N=270, Yerevan)<br>BBS 2007, 48.6% married (N=280), 4 regions + Yerevan (138.51 males)              |                         |
| Female                                                                        | 5533                       | 2010         | BBS 2010 45.2% married (33.1-54.4%) (N=270, Yerevan)<br>BBS 2007, 48.6% married (N=280), 4 regions + Yerevan (2291 females)              |                         |
| Prevalence of HIV in this population                                          | Assume ½ prev of IDU       |              | No data available - Assumption                                                                                                           |                         |
| Average number of sexual partners per year                                    | 1                          |              | Married/cohabitating                                                                                                                     |                         |
| Average number of sexual acts per partner per year                            | 120                        |              | 2008 & 2010, General Population Survey in Moldova, married and cohabitating within the range of the Durex Global Sex Survey 1993 & 2003. |                         |
| Percentage of times a condom is used during sex with IDU partner              | 39% *(0.8)                 | 2010         | BBS 2010, use at last sexual intercourse *effectiveness of condoms                                                                       |                         |
| <b>Sex workers</b>                                                            |                            |              |                                                                                                                                          |                         |

|                                                                      |                     |      |                                                                                                                                                                |  |
|----------------------------------------------------------------------|---------------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Number / percent of female sex workers in the population (FSW)       | 4000 (0.44%)        | 2008 | Report. Estimating the size of CSW and MSM 2008 (Yerevan 2100, Vanadzor 390, Gyumri 320, Kapan 115, multiplier 1.2)                                            |  |
| Prevalence of HIV in this population                                 | 1.2% (0-1.8%)       |      | 2010 BBS Yerevan only                                                                                                                                          |  |
|                                                                      | 0.8%                |      | 0.8%, 2007 BBS (Yerevan and 6 of 10 regions)                                                                                                                   |  |
| Prevalence of any STI in this population                             | 11.6%               | 2010 | BBS gonorrhea                                                                                                                                                  |  |
| Average number of sexual partners per year                           | 168                 | 2007 | BBS (8 per week and 23 per month), extrapolated for the year.                                                                                                  |  |
|                                                                      | 112                 | 2010 | (4.3 clients per week and 14.1 per month) extrapolated for the year                                                                                            |  |
| Average number of sexual acts per partner per year                   | 1                   |      |                                                                                                                                                                |  |
| Percentage of times a condom is used during sex                      | 91.6%               | 2007 | BBS (CSW use during last sex with a client)                                                                                                                    |  |
|                                                                      | 92.9%               | 2010 | BBS (CSW use during last sex with a client))                                                                                                                   |  |
| <b>Clients</b>                                                       |                     |      |                                                                                                                                                                |  |
| Number / percent of sex worker clients in the population             | 8%                  |      | 1.6% of M 15-49 visited sex worker in past year (DHS 2005), DHS underestimate by 5-10 fold (quantified by Lowndes et al). Conservative 5 fold adjustment used. |  |
| Prevalence of HIV in this population                                 | ½ prevalence of FSW |      | No data available – assumption. Rationale that these are the regular partners/clients of FSW                                                                   |  |
| Prevalence of any STI in this population                             | ½ prevalence of FSW |      | No data available – assumption.                                                                                                                                |  |
| Average number of sex worker partners per year                       | 6.2                 |      | 448,00 total sex acts by sex workers (112 *4000), need sex acts to balance thus divide total number of clients by number of sex acts                           |  |
| Average number of sexual acts per partner per year                   | 1                   |      |                                                                                                                                                                |  |
| Percentage of times a condom is used during sex with a sex worker    | 92.9%*(0.8)         | 2010 | BBS (CSW use during last sex with a client)                                                                                                                    |  |
| <b>Partners of Clients</b>                                           |                     |      |                                                                                                                                                                |  |
| Number / percent of partners of sex worker clients in the population | 4.92%               | 2005 | These are the regular partners.<br>DHS 2005, 61.5% of F married/leaving together                                                                               |  |
| Prevalence of HIV in this population                                 | 0.038%              | 2010 | No data available – assumption of double ANC prevalence. (Same value used for regular partners of those also having CHS)                                       |  |
| Average number of sexual partners per year                           | 1                   |      | These are the married/cohabitating partners                                                                                                                    |  |
| Average number of sexual acts per partner per year                   | 120                 |      | 2008 and 2010, General Population Survey in Moldova, married and cohabitating within the range of the Durex Global Sex Survey 1993 and 2003.                   |  |
| Percentage of times a condom is used during sex                      | 8% (0.8)            | 2005 | Prevalence of condom use for contraception (UNPOP 2005) * 80% (effectiveness of condom use)                                                                    |  |
| <b>Men who have sex with men (MSM)</b>                               |                     |      |                                                                                                                                                                |  |

|                                                                                                                               |                                                                                                                                           |                                  |                                                                                                                                              |  |
|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--|
| Number / percent of MSM in the population                                                                                     | 13,500 (~1.45%)                                                                                                                           | 2008                             | Report estimating the size of the CSWs and MSM in Armenia in 2008 (8000 MSM in Yerevan)                                                      |  |
| Prevalence of HIV in this population                                                                                          | 2.3% (0.2-5.2%)                                                                                                                           | 2010                             | BBS (270 MSM in Yerevan were tested for HIV) → <i>this value may be too high, may not be representative at national level</i>                |  |
| Prevalence of any STI in this population                                                                                      | 1.3%(0-3.8%)                                                                                                                              | 2010                             | BBS, syphilis (likely a lower bound for STI prev)<br>160 MSM tested in user-friendly clinic, ~30% had any STI                                |  |
| Average number of sexual partners per year                                                                                    | Average # of sexual partners in 1 month<br>10.35 (8.78-12.51)→<br><i>Arbitrarily assume 10% are anal sex partners *12 months</i><br><br>4 | BBS 2010                         | Note: 10.35 partners/month will include oral sex partners (possibly female partners too)<br><br>Data from Moldova – can be used as a proxy   |  |
| Average number of sexual acts per partner per year                                                                            | <i>Arbitrarily assume casual partners 3 acts/partner</i><br>17                                                                            |                                  | Data from Moldova – can be used as a proxy                                                                                                   |  |
| Percentage of times a condom is used during sex                                                                               | 64.5%<br>83.5%                                                                                                                            | 2010<br>2007                     | BBS 2010 condom use at last anal sex<br>BBS 2007                                                                                             |  |
| <b>Female partners of MSM</b>                                                                                                 |                                                                                                                                           |                                  |                                                                                                                                              |  |
| Number / percent of female partners of MSM in the population                                                                  | 36.9% of MSM have current F partner<br>3.1% are married<br>0.2% are divorced                                                              | 2010<br><br>2010 BBS<br>2010 BBS | BBS 2010<br>BBS 2007 (30% have current F partner)<br>(In 2007 9% were married, 14% were divorced)                                            |  |
| Prevalence of HIV in this population                                                                                          | 0.525%                                                                                                                                    |                                  | No data available - assumption. Have used midpoint value betw half the HIV prev in MSM and the value for partners of clients                 |  |
| Average number of sexual partners per year                                                                                    | 1                                                                                                                                         |                                  | These are the married/cohabitating partners                                                                                                  |  |
| Average number of sexual acts per partner per year                                                                            | 120                                                                                                                                       |                                  | 2008 and 2010, General Population Survey in Moldova, married and cohabitating within the range of the Durex Global Sex Survey 1993 and 2003. |  |
| Percentage of times a condom is used during sex                                                                               | 8% * (0.8)                                                                                                                                | 2005                             | Prevalence of condom use for contraception (UNPOP 2005) * 80% (effectiveness of condom use)                                                  |  |
| <b>Casual heterosexual sex</b>                                                                                                |                                                                                                                                           |                                  |                                                                                                                                              |  |
| Number/percent in the general population who engage in casual sex (multiple sex partners or non-regular, non-cohabiting sex): |                                                                                                                                           |                                  |                                                                                                                                              |  |

|                                                                                 |             |      |                                                                                                                                                                                                                                                                      |  |
|---------------------------------------------------------------------------------|-------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Male                                                                            | 21.2%       |      | Those reporting higher risk sex in DHS 2005, adjusted to the entire population (DHS value is for those who are sexually active) and subtracting clients, MSM and IDU<br>27.6 % (higher risk sex in last year) * 76.8% (sexually active males) – IDU – MSM - clients  |  |
| Female                                                                          | 0.5%        |      | Those reporting higher risk sex in DHS 2005, adjusted to the entire population (DHS value is for those who are sexually active) and subtracting sex workers and IDU<br>1.4% (higher risk sex in the past year) * 69.3% (sexually active females) – IDU – sex workers |  |
| Prevalence of HIV in this population                                            | 0.038%      | 2010 | No data available – assumption. Double ANC prevalence.                                                                                                                                                                                                               |  |
| Prevalence of any STI in this population                                        | 5.8%        |      | No data – assumption, same as clients                                                                                                                                                                                                                                |  |
| Average number of sexual partners per year                                      | 2           |      |                                                                                                                                                                                                                                                                      |  |
| Average number of sexual acts per partner per year                              | 60          |      | The same total numbers of sex acts per year as the married/cohabiting population                                                                                                                                                                                     |  |
| Percentage of times a condom is used during sex                                 | 76.4% (0.8) | 2005 | DHS 2005 condom use at last higher sex reported by males *(effectiveness of condom use)                                                                                                                                                                              |  |
|                                                                                 |             |      |                                                                                                                                                                                                                                                                      |  |
| <b>Partners CHS</b>                                                             |             |      |                                                                                                                                                                                                                                                                      |  |
| Number / percent in the general population whose partners engage in casual sex: |             |      |                                                                                                                                                                                                                                                                      |  |
| Male                                                                            | 0.42%       |      | Model assumption CHS F * 0.8                                                                                                                                                                                                                                         |  |
| Female                                                                          | 8.95%       |      | Model assumption CHS M * 0.8                                                                                                                                                                                                                                         |  |
| Prevalence of HIV in this population                                            | 0.019%      | 2010 | ANC prevalence 8/41,638 used as proxy                                                                                                                                                                                                                                |  |
| Average number of sexual partners per year                                      | 1           |      | These are the married/cohabitating partners                                                                                                                                                                                                                          |  |
| Average number of sexual acts per partner per year                              | 120         |      | 2008 and 2010, General Population Survey in Moldova, married and cohabitating within the range of the Durex Global Sex Survey 1993 and 2003.                                                                                                                         |  |
| Percentage of times a condom is used during sex                                 | 8% (0.8)    | 2005 | Condom use for contraception rate (UNPOP 2005) * 80% (efficacy of condom use)                                                                                                                                                                                        |  |
| <b>Low-risk heterosexual sex</b>                                                |             |      |                                                                                                                                                                                                                                                                      |  |
| #/% in stable relationships (married/in relationship with one stable partner):  |             |      |                                                                                                                                                                                                                                                                      |  |
| Male                                                                            |             |      | Residual: model assumption, but in agreement with marriage rates when added together with partners of higher risk are added together (56.3% of M are married/cohabitating DHS 2005)                                                                                  |  |
| Female                                                                          |             |      | Residual: model assumption, but in agreement with marriage rates when added together with partners of higher risk are added together (61.5% of F are married/cohabitating DHS 2005)                                                                                  |  |

|                                                                                                        |                        |      |                                                                                                                                              |                                   |
|--------------------------------------------------------------------------------------------------------|------------------------|------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Prevalence of HIV in this population                                                                   | 0.013%                 |      | Prevalence in blood donors                                                                                                                   |                                   |
| Prevalence of any STI in this population                                                               | 1.3%                   | 2005 | DHS 2005, self-report of genital/ulcer in last year by females 15-49 (ever had sex).                                                         |                                   |
| Average number of sexual partners per year                                                             | 1                      |      | These are the married/cohabitating partners                                                                                                  |                                   |
| Average number of sexual acts per partner per year                                                     | 120                    |      | 2008 and 2010, General Population Survey in Moldova, married and cohabitating within the range of the Durex Global Sex Survey 1993 and 2003. |                                   |
| Percentage of times a condom is used during sex                                                        | 8% (0.8)               | 2005 | Prevalence of condom use for contraception (UNPOP 2005) * 80% (effectiveness of condom use)                                                  |                                   |
| <b>No risk</b>                                                                                         |                        |      |                                                                                                                                              |                                   |
| Number/percent of people who are at NO risk of HIV infection                                           | M = 26.6%<br>F = 39.3% | 2005 | DHS 2005 not sexually active plus those who did not have sex in the past year                                                                |                                   |
| <b>Medical injections</b>                                                                              |                        |      |                                                                                                                                              |                                   |
| Number of people receiving medical injections per year                                                 |                        |      |                                                                                                                                              | Same as national adult prevalence |
| Prevalence of HIV in this population                                                                   | 0.013%                 |      | Prevalence in blood donors                                                                                                                   |                                   |
| Average number of medical injections received per person per year                                      | 1.85                   | 2005 | 1.8 for M, 1.9 F, midpoint used, DHS 2005                                                                                                    |                                   |
| Percentage of times sterile needles are used for medical injections                                    | 100%                   |      |                                                                                                                                              |                                   |
| <b>Blood transfusions</b>                                                                              |                        |      |                                                                                                                                              |                                   |
| Number of people receiving blood transfusions per year                                                 |                        |      |                                                                                                                                              |                                   |
| Prevalence of HIV in this population                                                                   | 0.013%                 |      | Prevalence in blood donors                                                                                                                   |                                   |
| Average number of blood transfusions per year (i.e. for those people who received a blood transfusion) |                        |      |                                                                                                                                              | Average of 1                      |
| Percentage of bloods that are effectively screened for HIV                                             | 100%                   |      | 100% of blood units screened in quality assured manner, UNGASS CPR 2008                                                                      |                                   |
| <b>Percent of adult males circumcised</b>                                                              |                        |      |                                                                                                                                              |                                   |
|                                                                                                        | 0%                     |      |                                                                                                                                              |                                   |

### Appendix 4-3: March 2011 Modes of Transmission workshop in Armenia

| <b>Agenda</b><br><b>Workshop: Modes of Transmission in Armenia</b><br>15-17 March 2011, Armenia |                                                                                                                                                                           |                              |
|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <b>Tuesday, 15 March 2011</b>                                                                   |                                                                                                                                                                           |                              |
|                                                                                                 |                                                                                                                                                                           |                              |
| 9.00                                                                                            | Opening statements and participant introduction                                                                                                                           | Armenia                      |
| 9.30                                                                                            | Workshop introduction and objectives                                                                                                                                      | Armenia                      |
| 10:00                                                                                           | <b>Session 1.</b> Update and overview on the HIV epidemic in Armenia                                                                                                      | Armenia                      |
| 10.45                                                                                           | <i>Break</i>                                                                                                                                                              |                              |
| 11:15                                                                                           | <b>Session 2.</b> Introduction to the model - HIV incidence by modes of transmission (MoT)                                                                                | Presenter: Ms. Kelsey Case   |
| 11:45                                                                                           | <i>Questions and discussion</i>                                                                                                                                           | Group                        |
| 12:00                                                                                           | <b>Session 3.</b> Presentation of data available in Armenia and discussion of data sources                                                                                | Armenia                      |
| 13.00                                                                                           | <i>Lunch</i>                                                                                                                                                              |                              |
| 14.00                                                                                           | <b>Session 3.</b> Introduction to the MoT project <ul style="list-style-type: none"> <li>– objectives</li> <li>– products</li> <li>– key steps for the project</li> </ul> | Presenter: Ms. Kelsey Case   |
| 14.30                                                                                           | <b>Session 4.</b> Discussion on populations to include in the MoT                                                                                                         | Group                        |
| 15.00                                                                                           | <i>Coffee Break</i>                                                                                                                                                       |                              |
| 15.30                                                                                           | <b>Session 5. Working Groups</b> Division into groups                                                                                                                     |                              |
| 15.45                                                                                           | Key points, introduction to software                                                                                                                                      | Presenter: Ms. Kelsey Case   |
| 16.00                                                                                           | Begin MoT software and data input into MoT worksheet                                                                                                                      |                              |
| 17.00                                                                                           | Discussion on issues that arose in working groups                                                                                                                         |                              |
| 17.15                                                                                           | Close                                                                                                                                                                     |                              |
| <b>Wednesday, 16 March 2011</b>                                                                 |                                                                                                                                                                           |                              |
| 09.00                                                                                           | Review of Day 1, discussion on issues encountered, overview of Day 2                                                                                                      | Facilitator: Ms. Kelsey Case |
| 09:30                                                                                           | <b>Session 6.</b> Discussion on data sources and quality of data; recommendations for the lack of data; uncertainty analysis.                                             | Presenter: Ms. Kelsey Case   |
| 10:15                                                                                           | Questions and discussion                                                                                                                                                  | Group                        |
| 10.30                                                                                           | <i>Break</i>                                                                                                                                                              |                              |
| 11.00                                                                                           | <b>Session 7.</b> Working groups continued – data input into MoT                                                                                                          | Facilitator: Ms. Kelsey Case |
| 12.30                                                                                           | <i>Lunch</i>                                                                                                                                                              |                              |
| 1.30                                                                                            | <b>Session 8.</b> Presentation of group work                                                                                                                              | Working Groups               |
| 15.00                                                                                           | <i>Break</i>                                                                                                                                                              |                              |
| 15.30                                                                                           | <b>Session 9.</b> Discussion on group work and inputs                                                                                                                     | Facilitator: Ms. Kelsey Case |
| 16.15                                                                                           | <b>Session 10.</b> Discussion on key questions, missing data                                                                                                              | Presenter: Ms. Kelsey Case   |
| 17.00                                                                                           | Review of the day and close                                                                                                                                               |                              |
| <b>Thursday, 17 March 2011</b>                                                                  |                                                                                                                                                                           |                              |
| 09.00                                                                                           | Review of previous day and overview of third day                                                                                                                          | Facilitator: Ms. Kelsey Case |
| 09.15                                                                                           | <b>Session 11.</b> Continue input into MoT                                                                                                                                |                              |

|       |                                                                                             |         |
|-------|---------------------------------------------------------------------------------------------|---------|
|       |                                                                                             |         |
| 10.30 | <i>Break</i>                                                                                |         |
| 11.00 | <b>Session 12.</b> Continue input into MoT                                                  |         |
| 12.00 | <b>Session 13.</b> Review of model, questions and discussion, identification of data needed | Group   |
| 12.30 | <i>Lunch</i>                                                                                |         |
| 14.00 | <b>Session 14.</b> Set up work plan and next steps for MoT                                  | Armenia |
| 15.15 | <i>Break</i>                                                                                |         |
| 15.45 | <b>Session 15.</b> Agreement of work plan, roles, responsibilities and deadlines            | Armenia |
| 16.45 | Review of workshop and closure                                                              |         |

## **Appendix 4-4: Armenia short report from MoT workshop**

### **Modes of Transmission**

#### **REPUBLIC OF ARMENIA**

**15-17 March 2011**

### **Short Report**

*Kelsey K Case*

## **Review of Workshop**

### **Day 1:**

- Discussion of the data sources available in Armenia
- Review of the current epidemiological situation
- Introduction of the Modes of Transmission (MoT) model and overview of the MoT project and process
- Discussion on populations to include in the MoT
- Working Groups and initiation of the MoT
- Discussion on missing data and other potential data sources available

It was discussed that migrants are an important population in Armenia and one where there is a need for more information in order to better understand the impact of migration on the epidemic in Armenia. However, it was agreed that there the data needed in order to include migrants as a separate risk group are not available and that additionally, migrants are captured in all of the risk categories (low-risk, casual heterosexual sex, IDU, MSM, FSW, clients) and that it was impossible to quantify the proportion of migrants in each risk group in order to include them as a separate category. Thus one limitation of the MoT for Armenia is that it does not include this important population. Additionally, the MoT is only able to calculate new infections as a result of prevalence in the current population in Armenia and thus does not include new infections as a result of behaviour when in other countries, for example new infections as a result of risk behaviour while in Russia or Ukraine where HIV prevalence is much greater. This is another limitation that needs to be kept in mind. And finally, the MoT only includes the adult population, 15-49 years of age, thus mother-to-child transmission of HIV is not included but this will remain an important mode of transmission that will not be identified in this exercise.

### **Day 2:**

- Completion of the MoT
- Data triangulation from available sources
- Discussion of all inputs
- Discussion of potential alternative data sources

It was discussed that there is no data available on clients of sex workers and only limited data on MSM. It was identified that the survey questions pertaining to behaviour of MSM do not differentiate between oral sex and anal sex in a way in which this information could be used to adequately inform on risk of HIV transmission and it was suggested that these could be modified to provide more precise information in the future.

A discussion on the epidemic in Armenia compared to other neighbouring countries highlighted that the situation in Armenia is different and may not be comparable, for example Iran and Azerbaijan have significant religious and cultural differences while Georgia has a much larger IDU population which is quite different (spread out) and Turkey does not have data. The HIV epidemics in Ukraine and Russia are also very different. It was agreed that Moldova might potentially be a comparable or similar epidemic.

**Day 3:**

- Completion of the MoT
- Review of preliminary results for completed populations
- Discussion on data sources and assumptions that may potentially be used in the absence of data
- Identification of follow-up activities
- Completion of an agreed work plan and timetable

It was agreed that we are unable to complete the entire MoT at this time without further consultation and research on key inputs identified in the follow-up and thus we reviewed and discussed the initial, preliminary outputs and agreed on a work plan and timetable for completion, review, consultation and consensus and dissemination.

**Workshop Outputs**

1. Draft MoT spreadsheet
2. Complete data sheet referencing sources for all inputs in MoT spreadsheet
3. Recommendation sheet for data and missing data
4. MoT work plan and timetable

**Workshop follow-up**

1. Armenia team to continue online/telephone consultation regarding MSM behaviour, specifically the proportion of all sexual partners in which oral sex is the only form of risk behaviour; the average number of anal sex partners; the average number of sex acts per anal sex partner; and STI prevalence in MSM.
2. Armenia team to continue online/telephone consultation regarding IDU behaviour, specifically the average number of needle sharing partners and the average number of injections per sharing partner.
3. Consultant to review published literature for regional information regarding MSM and IDU behaviour and the HIV prevalence in the partners of these two risk groups compared to HIV prevalence in these risk groups
4. Armenia team to update inputs with 2010 BBS results and 2010 DHS results (if possible).

#### Appendix 4-5: Modes of Transmission analysis: Republic of Armenia\*

| Adult Risk Behaviour     | Male   | Female | Male | Female | Total number with risk behaviour | Prevalence of HIV (%) | Number HIV+ | Prevalence of STI (%) | Number of partners per year                          | Number of acts of exposure per partner per year | Percentage of acts protected (%) | with STI        | No STI | Incidence | % of incidence | Incidence per 100,000 |
|--------------------------|--------|--------|------|--------|----------------------------------|-----------------------|-------------|-----------------------|------------------------------------------------------|-------------------------------------------------|----------------------------------|-----------------|--------|-----------|----------------|-----------------------|
| Injecting Drug Use (IDU) | 1.36%  | 0.05%  |      |        | 12,700                           | 6.5%                  | 826         | 4.2%                  | 2                                                    | 17                                              | 91%                              | NA              | 0.01   | 23        | 12.66          | 179                   |
| Partners IDU             | 0.02%  | 0.61%  |      |        | 5,740                            | 3.3%                  | 187         | NA                    | 1                                                    | 120                                             | 31%                              | 0.0044          | 0.0011 | 35        | 19.27          | 604                   |
| Sex workers              |        | 0.44%  |      |        | 4,000                            | 1.2%                  | 48          | 11.6%                 | 112                                                  | 1                                               | 74%                              | 0.0044          | 0.0011 | 1         | 0.49           | 22                    |
| Clients                  | 8.00%  |        |      |        | 72,232                           | 0.6%                  | 433         | 5.8%                  | 6                                                    | 1                                               | 74%                              | 0.0028          | 0.0007 | 1         | 0.72           | 2                     |
| Partners of Clients      |        | 4.92%  |      |        | 44,423                           | 0.0%                  | 17          | NA                    | 1                                                    | 120                                             | 6%                               | 0.0044          | 0.0011 | 35        | 19.57          | 79                    |
| MSM                      | 1.50%  |        |      |        | 13,500                           | 2.3%                  | 311         | 1.3%                  | 12                                                   | 3                                               | 52%                              | 0.0400          | 0.0100 | 55        | 30.39          | 405                   |
| Female partners of MSM   |        | 0.55%  |      |        | 4,998                            | 0.5%                  | 26          | NA                    | 1                                                    | 120                                             | 6%                               | 0.0044          | 0.0011 | 14        | 7.61           | 274                   |
| Casual heterosexual sex  | 11.20% | 0.50%  |      |        | 105,639                          | 0.0%                  | 40          | 5.8%                  | 2                                                    | 60                                              | 61%                              | 0.0029          | 0.0007 | 2         | 0.87           | 1                     |
| Partners CHS             | 0.42%  | 8.95%  |      |        | 84,602                           | 0.0%                  | 16          | NA                    | 1                                                    | 120                                             | 6%                               | 0.0043          | 0.0011 | 4         | 2.33           | 5                     |
| Low-risk heterosexual    | 50.90% | 44.67% |      |        | 862,956                          | 0.0%                  | 112         | 1.3%                  | 1                                                    | 120                                             | 6%                               | 0.0035          | 0.0009 | 11        | 6.10           | 1                     |
| No risk                  | 26.60% | 39.30% |      |        | 595,011                          | 0.0%                  | -           | 0.0%                  | 0                                                    | 0                                               | 0%                               |                 |        | 0         | 0.00           | 0                     |
| Medical injections       | 0.01%  | 0.01%  |      |        | 1,805,800                        | 0.0%                  |             | NA                    | 1                                                    | 1                                               | 100%                             | NA              | 0.004  | 0         | 0.00           | 0                     |
| Blood transfusions       | 0.01%  | 0.01%  |      |        | 99                               | 0.0%                  |             | NA                    | 1                                                    | 1                                               | 100%                             | NA              | 0.9    | 0         | 0.00           | 0                     |
| TOTAL ADULT POPULATION   | 100.00 | 100.00 |      |        | 1,805,800                        | 0.11                  | 2,015       |                       |                                                      |                                                 |                                  | Total incidence |        | 180       |                | 10                    |
|                          |        |        |      |        |                                  |                       |             |                       | Total incidence in partners of high-risk individuals |                                                 |                                  |                 |        | 88        | 48.774         | 63                    |

\*Note that the above model results reflect the author's work and have been produced by the author and do not represent official estimates from the Republic of Armenia

## Appendix Chapter 5

### Appendix 5-1: Ethics application in full and amendment to ethics application

Imperial College Research Ethics Committee

Imperial College London  
G02 Sir Alexander Fleming Building  
South Kensington Campus  
SW7 2AZ  
Tel: +44 (0)207 594 1770 Fax: +44 (0) 207 594 1792

[researchethicscommittee@imperial.ac.uk](mailto:researchethicscommittee@imperial.ac.uk)

14 March 2011

Professor Geoffrey Garnett,  
Dept. of Infectious Disease Epidemiology,  
St Mary's Campus,  
Norfolk Place,  
London,  
W2 1PG

Dear Professor Garnett,

**Study Title: Mathematical models to generate national estimates: User Experience Study**

**ICREC reference: ICREC\_11\_3\_2**

**CI: Professor Geoffrey Garnett**

The above study was approved by your HoD on 7<sup>th</sup> March 2011 and by the Joint Research Office on the 10th March 2011.

Under the Imperial College Research Ethics Committee process, a study that has been reviewed by the Joint Research Office and Head of Division/Department (or Principal), where no significant ethical issues have been identified in the protocol or ethics application, can be approved without requiring it to go to full committee.

#### Documents

The documents reviewed were:

- ICREC Application form
- Participant Information Sheet
- Participant Consent Form
- Semi-Structured Interview overview

Yours sincerely,



Gary Roper,  
Head of Regulatory Compliance,  
Imperial College London

Semi-structured interview

### 1. General

Background – where employed, how long, type of job  
Use of models – background and experience  
EPP and Spectrum – how long, what for, perceived level of capability

### 2. EPP/Spectrum

Issues – positive and negative  
User experience  
Difficulties  
Changing estimates  
*What is most difficult?*  
*What is most beneficial?*  
***What can be done better? How to improve?***

### 3. MoT? *(Same as above if they have done it)*

### 4. Stakeholders

Use of the models  
– By whom?  
– What for?  
– To what result?  
– Perceived importance?

### 5. Decision-making

How are the results used for decision-making and programme planning?

- Are they?
- To what degree?

Who makes the decisions in the local context?

- Who has the power of decision-making and non decision-making for HIV prevention?
- Who are the important stakeholders who had/could have considerable influence on AIDS policy?
- Interests, influence, power

How is evidence from models used to inform decision-making?

- Is it used?

Who else should I be talking to regarding these areas/issues? Why?

### 5. PrEP

- Views?
- Feasibility?
- In what context?

## Imperial College Research Ethics Committee [ICREC] Application Form

### Section One - Details of Principal Investigator

*If the application is a student project, please name the student's supervisor as the Principal Investigator. Please add the student's name and details of all other co-investigators or collaborators in Section Six.*

|                                                                                                                     |                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Name:                                                                                                               | Professor Geoffrey Garnett                                                                                                                    |
| Position:                                                                                                           | Professor of Microparasite Epidemiology                                                                                                       |
| Address:                                                                                                            | Dept of Infectious Disease Epidemiology, School of Public Health<br>St Mary's Campus, Norfolk Place, London W2 1PG                            |
| Telephone:                                                                                                          | +44 (0)207 594 3215                                                                                                                           |
| Email:                                                                                                              | g.garnett@imperial.ac.uk                                                                                                                      |
| Fax:                                                                                                                | +44 (0)207 594 8321                                                                                                                           |
| Summary of skills and experience relevant to this study:                                                            | PhD supervisor to over 22 students in the past 15 years<br>Secretariat Chair, UNAIDS Reference Group on Estimates Modelling and Projections   |
| Previous experience in any procedures to be used. (Including involvement with vulnerable participants if relevant): | Co-Investigator, Manicaland HIV Prevention Project,<br>Co-Investigator, PREVEN project focusin on sex workers, clients and general population |

### Section Two – Project Summary

|                                        |                                                                           |
|----------------------------------------|---------------------------------------------------------------------------|
| Full title of study:                   | Mathematical models to generate national estimates: User Experience Study |
| InfoEd proposal number (if applicable) | WPIA_F20224-1                                                             |
| Proposed Start Date:                   | January 1, 2011                                                           |
| Proposed End Date:                     | December 31, 2012                                                         |

*Does the study involve any of the following:*

|                                        |                          |   |                                                                                            |
|----------------------------------------|--------------------------|---|--------------------------------------------------------------------------------------------|
| Drugs/medication                       | <input type="checkbox"/> | N | <i>If yes, please attach the SmPc.</i>                                                     |
| Ionising radioactive substances/x-rays | <input type="checkbox"/> | N | <i>If yes, please also complete appendix one</i>                                           |
| Genetically modified materials         | <input type="checkbox"/> | N | <i>If yes, please also complete appendix two and attach the GM Safety Committee letter</i> |

### 2.a Project Summary

Please provide a summary of the project, including the expected outcomes, in LAY terms (max 350 words)

*Mathematical modelling provides an illustrative theoretical framework that can be used to inform programme planning and decision-making for HIV prevention. A greater understanding of how this evidence is generated, used and perceived by stakeholders can enhance its practicality. This study uses a qualitative approach drawing on principles in grounded theory to conduct semi-structured interviews with participants attending a UNAIDS technical training workshop in South Africa with the aim to gain a greater understanding of the user experience and the use of the results generated from the mathematical models developed with the support of the UNAIDS Reference Group on Estimates, Models and Projections. The expected outcomes of this inductive approach include the generation of common themes surrounding the user experience and the identification of key stakeholders in the local context who use the results from these tools to inform decision making. The results from this study will be used to advance the utility of mathematical models as evidence to inform programme planning and policy development for HIV prevention.*

### 2.b Ethical Summary

Please provide details of what you consider to be the ethical issues surrounding this project in LAY terms. (max 500 words)

*The ethical issues consist of participants volunteering their time to participate in an oral interview regarding their experiences using mathematical models during the training session and in the past and how these results are used to inform programme planning and decision-making and who uses these results. Participants may have had negative user-experiences using the tools in the past or may be reluctant to identify stakeholders who use the results generated and thus participants may not want their identity known. For these reasons, all interviewees will remain anonymous and any identifying details will be removed from the transcription. Each participant will be assigned a participant number which will be used in place of names. No identifying details will be stored on computer hard drives and paper copies of transcriptions will be kept in a locked cabinet.*

## Section Three- Project Details

### 3.a Protocol

Please provide details of the scientific justification for the study, and the research methodology to be used in LAY terms (max 750 words).

*Please attach the protocol and any questionnaires that will be used.*

*The UNAIDS Reference Group on Estimates, Modelling and Projections provides technical and methodological guidance for the tools used to generate national estimates of HIV; however, there is a gap between the technical experts who develop the methods and tools used, and the end users and stakeholders who implement the tools in practice and rely upon the estimates and projections generated. In order to improve the entire process, from the development of the tools to the use of these tools at the country level and the influence on policy decision making, this gap should be bridged. Qualitative research has the advantage that it gains the viewpoint and perspective of the participant with an emphasis is on their experience and understanding of events and processes. This research will be conducted within a grounded theory framework with simultaneous data collection and interpretation as part of an iterative process. I will use theoretical sampling, a form of purposive sampling, in which the concurrent collection, coding and analysis of data is used to inform further data collection to develop emerging theory in an ongoing process with continual refinement. Semi-structured interviews will be conducted with participants of a UNAIDS technical workshop. These participants are the users of the tools who generate national estimates of HIV in their counties.*

**3.b Value**

Please state the intended value of the project (in terms of the expected outcomes) in LAY terms (max 500 words).

*Mathematical modelling provides an illustrative theoretical framework that can be used to inform programme planning and decision-making for HIV prevention. A greater understanding of the user experience when employing these methods and of how these results are actually used and perceived in the local context can enhance their practicality. Qualitative research has the ability to expand our range of knowledge and understanding and can help to interpret and better understand the complex reality of a given situation. The insights gleaned from this study will be used to, 1) Inform the further development of these tools and, 2) To advance the utility of mathematical models as evidence to inform programme planning and policy development for HIV prevention.*

**3.c Location**

Please state where the study will take place.

*If part or all of the study will take place abroad, please state any steps that have been taken to ensure compliance with research and ethical rules in those countries.*

*The interviews will take place in Johannesburg, South Africa during a 3-day workshop conducted by UNAIDS. Agreement and support from UNAIDS has been given to conduct these interviews and local ethical approval is being sought in accordance with UNAIDS guidelines.*

**3.d Dissemination**

Please state how and to whom the results of this study will be disseminated, including the communication of results to the research participants.

*The results will be disseminated in a report to the funder (UNAIDS), in peer-review publication and in the PhD thesis which will be made electronically available and open access. Research participants will be made aware of these intentions and will be able to provide an email address to receive notifications regarding the publication of study results.*

**3.e Previous ethical approval**

|                                                                                |  |    |
|--------------------------------------------------------------------------------|--|----|
| Has any part of this proposal received prior ethical approval?                 |  | No |
| Has any part of this proposal previously been rejected by an ethics committee? |  | No |
| If yes to either of the above, please give details:                            |  |    |

*Please attach the relevant documentation*

|                                                                               |                                                                                                                          |  |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|--|
| <b>3.f Funding</b>                                                            |                                                                                                                          |  |
| Has this project received funding, or is in the process of receiving funding? | Yes                                                                                                                      |  |
| If yes, please provide details:                                               | This specific project has received £5,637.50 (as part of a larger grant) which has been approved by the funder (UNAIDS). |  |

**3. g Insurance and Indemnity Cover**

|                                               |  |  |
|-----------------------------------------------|--|--|
| Have you applied to the Joint Research Office |  |  |
|-----------------------------------------------|--|--|

|                                                     |                                                                                                                                                         |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| (JRO) for indemnity cover?                          | No                                                                                                                                                      |
| If no, please state when you intend to apply:       |                                                                                                                                                         |
| If you do not intend to apply, please give reasons: | I have Imperial College business travel insurance while travelling abroad; I have discussed this project with JRO and indemnity cover is not necessary. |

*If yes, please attach email from the Research Facilitator confirming insurance cover.*

#### Section Four – Participants

##### 4.a Study population

Please state the number of research participants to be recruited, including the inclusion and exclusion criteria for recruitment.

*Approximately 10 participants will be recruited from the UNAIDS southern African regional training workshop in Johannesburg, South Africa.*

*Inclusion criteria: Proficiency in English language, informed consent and prior use of EPP/Spectrum (mathematical models) or use of the results generated from these tools.*

*Exclusion criteria: No prior use of EPP/Spectrum or the results generated from these models.*

##### 4. b Vulnerable groups

Please give details of any vulnerable groups to be used in the study (eg those under 18, prisoners, those in a dependent relationship, the mentally ill), and give reasons for their inclusion.

*No vulnerable groups will be used in this study.*

##### 4.c Recruitment process

Please explain how you will recruit participants to the study. Please include any incentives (such as financial reimbursement).

If advertising is to be used, please attach a copy of the advert. If you are planning to recruit via email, please include a copy of the email.

*Recruitment will occur during a UNAIDS workshop training session. A convenience sample will be obtained with support from UNAIDS facilitators. Participants will be invited to participate in a short, semi-structured interview approximately 30 minutes in duration.*

*No incentives will be given for participation.*

##### 4.d Informed Consent

- i. Please detail your process for ensuring the informed consent of all research participants.
- ii. If vulnerable persons are to be used in the study, please give separate specific information on how you will ensure informed consent.
- iii. If participants whose first language is not English are to be recruited, please state how the details of the study will be explained and the informed consent process will be handled.

*Please attach a copy of the consent form and participant information sheet and any additional forms/information if appropriate.*

- i. *Informed consent (document attached) is a requisite for all study participants. All participants will receive a study information sheet (attached) detailing the study aims, how the results will be used and, providing contact information should they have further questions.*
- ii. *Not applicable*

- iii. All interviews will occur in English. If a participant is unable to understand the details of the study due to language barriers or an insufficient grasp of English, then they will not be enrolled in the study. The researcher will ensure that informed consent is obtained prior to enrolment, this will occur after providing the information sheet and discussing any further questions the participant may have.

#### 4.e Withdrawal

Please state procedures for the withdrawal of participants from the study.

*Participants may withdraw at any time during the study or afterwards and any information obtained will not contribute to study results or analysis. Participants will be withdrawn if they are unable to provide informed consent for any reason (including due to language barriers).*

#### 4.f Confidentiality

Please state the measures you have taken to ensure the confidentiality of the research participants and the data collected, including who will have access to the data. Please include information on any process to anonymise participants and their data and how the confidentiality of the research participants will be maintained both during and after the study.

*Each consenting participant will be assigned a participant identification number and no identifying details will be obtained. Additionally, any references to specific countries (by which the participant may be able to be identified) will not be disclosed without prior consent. Questionnaires, notes and recorded interviews will be securely stored and password protected both during and after the study.*

### Section Five – Risks And Benefits

#### 5.a Risks

Please state in LAY terms any potential risks/hazards, medical or non-medical, including mechanisms to minimise them.

|                                                      |                                                  |
|------------------------------------------------------|--------------------------------------------------|
| i. Research participants                             | <i>No potential risks or hazards identified.</i> |
| ii. Researchers                                      | <i>No potential risks or hazards identified.</i> |
| iii. Others (eg. Imperial College, industry funders) | <i>No potential risks or hazards identified.</i> |

#### 5.b Benefits

Please give, in LAY terms, details of any potential benefits to:

|                          |                                                                                                |
|--------------------------|------------------------------------------------------------------------------------------------|
| i. Research participants | <i>Future tools and resources (pertaining to mathematical models used to generate national</i> |
|--------------------------|------------------------------------------------------------------------------------------------|

|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      | <i>estimates of HIV) that address the user's current concerns and issues.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| ii. Researchers                                      | <i>An enhanced understanding of the user experience when utilising a fairly complex mathematical model and potential areas needing improvement or clarification; a greater understanding of the implications and ramifications at other levels as a result of estimates and projections generated by a specific mathematical model; insight into problems or potential errors in a specific mathematical model; and an enhanced understanding of how the estimates and projections from mathematical models are used to inform HIV prevention programme planning and implementation.</i> |
| iii. Others (eg. Imperial College, industry funders) | <i>For funders, donors and researchers, this project may provide insight into the user experience when generating estimates from mathematical models and how these estimates are used (or not used) to inform programme planning and may be beneficial to help bridge the gap between research and policy and will be able to inform other areas of research where mathematical models may be used to generate national estimates and may be used to inform policy development.</i>                                                                                                      |

#### Section 6 – Co-Investigators/Collaborators

*If there are more than 2 co-investigators, please use a separate sheet and follow the format below.*

|                                                                                                                     |                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Name:                                                                                                               | Kelsey Case                                                                                                                                                                      |
| Position:                                                                                                           | Research Assistant                                                                                                                                                               |
| Address:                                                                                                            | 15 Prince's Gardens, 3 <sup>rd</sup> Floor                                                                                                                                       |
|                                                                                                                     | London SW7 1NA                                                                                                                                                                   |
| Telephone:                                                                                                          | 020 7594 1524                                                                                                                                                                    |
| Email:                                                                                                              | k.case@imperial.ac.uk                                                                                                                                                            |
| Fax:                                                                                                                |                                                                                                                                                                                  |
| Summary of skills and experience relevant to this study:                                                            | BSc in Psychology (Honors); MSc in Sexually Transmitted Infections and HIV (Distinction); PhD candidate; Research Assistant in the Department of Infectious Disease Epidemiology |
| Previous experience in any procedures to be used. (Including involvement with vulnerable participants if relevant): | 2+ years qualitative research experience including clinical trial recruitment and interviewing.                                                                                  |

### PI Declaration

I declare that:

- I undertake to abide by the ethical principles underlying the Declaration of Helsinki (1964) and subsequent amendments and good practice guidelines on the proper conduct of research.
- I undertake to abide by the Data Protection Act 1998 and any applicable local laws.
- I undertake to abide by all local rules for non-UK research.
- I will report any adverse or unforeseen events which occur to ICREC within 7 days.
- I will provide an annual progress report of the project until the end of the study.
- I will provide notification of the end or early termination of the research project.
- I will inform the ICREC if there are any changes to the research protocol or personnel which affect the ethical aspects of the project.
- I will assist ICREC in any continuing review of the project deemed necessary by the Committee or Faculty members.
- I will re-apply for ethical approval after 5 years.
- All information on this form is correct.

|            |                    |
|------------|--------------------|
| Name:      | Geoffrey P Garnett |
| Signature: |                    |
| Date:      |                    |

Would you be willing to attend the ICREC meeting to answer any questions about your proposal?

Yes ☒  
No ☐

**Any attendance must be by the PI named in the section one of this application form. If this is a student application, the student may attend only if the supervisor is present. In addition, it is also possible for other relevant people to attend if necessary.**

|                                                                     |                          |
|---------------------------------------------------------------------|--------------------------|
| <b>Head of Department decision</b>                                  |                          |
| <i>Please indicate below your decision and the reasons for it -</i> |                          |
| Approval                                                            | <input type="checkbox"/> |
| Referral to ICREC                                                   | <input type="checkbox"/> |
| Reasons:                                                            |                          |
| Signed:                                                             |                          |
| Printed Name:                                                       |                          |
| Date:                                                               |                          |

|                                                                     |                          |
|---------------------------------------------------------------------|--------------------------|
| <b>Joint Research Office, or other relevant body, decision</b>      |                          |
| <i>Please indicate below your decision and the reasons for it -</i> |                          |
| Approval                                                            | <input type="checkbox"/> |
| Referral to ICREC                                                   | <input type="checkbox"/> |
| Reasons:                                                            |                          |
| Signed:                                                             |                          |
| Printed Name:                                                       |                          |
| Date:                                                               |                          |

**Kelsey K Case**  
Dept of Infectious Disease Epidemiology  
Imperial College London  
15 Prince's Gardens  
London, SW7 1NA  
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[k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk)  
Tel: +44 (0)20 7594 1524

March 2011

To participants of the southern Africa regional training workshop:

Dear Participant

**UNAIDS Reference Group on Estimates, Modelling and Projections informative study**

The UNAIDS Reference Group on Estimates, Modelling and Projections exists to provide impartial scientific advice to UNAIDS, the World Health Organization (WHO) and other United Nations and partner organisations on global estimates and projections of the prevalence, incidence and impact of HIV/AIDS. The group is co-ordinated by a secretariat based in the Department of Infectious Disease Epidemiology, Imperial College London ([www.epidem.org](http://www.epidem.org)) and provides technical and methodological guidance on the tools used to generate national estimates and the technical issues that arise from the use of these tools.

*What is the purpose of this study?*

We are seeking to improve the estimation process, specifically, to bridge the gap between the technical experts who develop the methods and the tools used and the country-level users and stakeholders who apply the tools in practice and rely upon the results generated. In order to do this, we are conducting an informative study to better understand the experience and perspective of those who use the models to generate national estimates and to identify how these estimates are used to inform programme planning and decision-making.

*What would you be asked to do if you agree to participate?*

If you agree to participate in this research, you would be asked to spend approximately 30 minutes discussing your past and current experience using EPP and Spectrum to generate national estimates. This will take place during the southern Africa UNAIDS training workshop.

*What would be the risks and benefits if you participate in the research?*

You are free to decide whether or not to take part in the research study. There are no risks in participating in this research, your views and experiences will remain anonymous and any identifying details will be removed. Your participation will help to provide an enhanced understanding of the estimation process and the use of these tools in the local context and this information will be used to inform and improve the development and use of these models and results.

You may keep this information sheet. If you have any further questions, please contact me at [k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk).

Kind Regards

Kelsey K Case  
Research Manager

P. No

**UNAIDS Reference Group on Estimates, Modelling & Projections**

**Mathematical models to generate national estimates:**

**User Experience Study**

- |                                                                                                               |     |                          |    |                          |
|---------------------------------------------------------------------------------------------------------------|-----|--------------------------|----|--------------------------|
| 1. Have you read the project information sheet?                                                               | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |
| 2. Have you had the opportunity to ask questions and discuss the study?                                       | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |
| 3. Do you understand that this is a research project and that your decision to consent is entirely voluntary? | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |
| 4. Do you agree to participate in this study?                                                                 | Yes | <input type="checkbox"/> | No | <input type="checkbox"/> |

**User Experience Study**

I confirm that the nature and demands of the research have been explained to me and I understand and accept them. I understand that my consent is entirely voluntary and that I may withdraw from the research project if I find that I am unable to continue for any reason.

**Signed (study participant):** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Investigator's Statement:**

I have explained the nature, demands and foreseeable risks of the above research to the respondent.

**Signed (interviewer):** \_\_\_\_\_

**Date:** \_\_\_\_\_

---

**YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP**

If you have any further questions about this study or the use of the results, please contact Kelsey Case at: +44 (0)20 7594 1524, or via email: [k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk).

---

**Imperial College Research Ethics Committee**

Imperial College London  
Room 5L10D, 5<sup>th</sup> Floor, Lab Block  
Charing Cross Hospital  
Fulham Palace Road  
London  
W6 8RF

Tel: +44 (0)203 331 0208 Fax: +44 (0) 203 311 0203

[researchethicscommittee@imperial.ac.uk](mailto:researchethicscommittee@imperial.ac.uk)

Professor Brian G. Spratt  
Wellcome Trust Principal Research Fellow  
Department of Infectious Disease Epidemiology  
Imperial College London  
LG35, Old Medical School Building  
St. Mary's Hospital,  
Norfolk Place  
London W2 1PG,

26<sup>th</sup> July 2013

Dear Professor Spratt,

**Study Title: Use of models and data to inform HIV programme planning and resources allocation.**

**ICREC reference: ICREC\_11\_3\_2**

The above study was approved by your HoD on 7<sup>th</sup> March 2011 and by the Joint Research Office on the 10<sup>th</sup> March 2011.

The Joint Research Compliance Office (JRCO) have reviewed your Notice of Amendment on 26<sup>th</sup> July 2013 and would like to grant full approval to this study on the basis described in the Notice of Amendment.

**Documents**

The documents reviewed were:

- Notice of Amendment
- Information letter v2 22/07/13
- Consent form v2 22/07/13
- Semi structured interview list v2 22/07/13

Yours sincerely,



**Gary Roper,**  
**Head of Regulatory Compliance,**  
**Imperial College London**

Imperial College of Science, Technology and Medicine

## NOTICE OF AMENDMENT

*For use in the case of all research previously approved by Imperial College Research Ethics Committee (ICREC)*

*Please complete in language comprehensible to a lay person and submit to the ICREC Coordinator at [researchethicscommittee@imperial.ac.uk](mailto:researchethicscommittee@imperial.ac.uk)*

|                                                |                                                                            |
|------------------------------------------------|----------------------------------------------------------------------------|
| <b>Details of Principal Investigator (PI):</b> |                                                                            |
| <i>Name:</i>                                   | Professor Geoffrey Garnett                                                 |
| <i>Address:</i>                                | Bill and Melinda Gates Foundation<br>500 Fifth Avenue<br>Seattle, WA 98102 |
| <i>Telephone:</i>                              | +1.206.770.1722                                                            |
| <i>Email:</i>                                  | <a href="mailto:g.garnett@imperial.ac.uk">g.garnett@imperial.ac.uk</a>     |
| <i>Fax:</i>                                    |                                                                            |

|                                   |                                                                                 |
|-----------------------------------|---------------------------------------------------------------------------------|
| <b>Full title of study:</b>       | Use of models and data to inform HIV programme planning and resource allocation |
| <b>ICREC reference number:</b>    | ICREC_11_3_2                                                                    |
| <b>Date study commenced:</b>      | 10 March 2011                                                                   |
| <b>Amendment number and date:</b> | Amendment 1, 18 July 2013                                                       |

| Reason for Submitting Amendment     |                                     |                                                                      |
|-------------------------------------|-------------------------------------|----------------------------------------------------------------------|
|                                     | Please tick                         |                                                                      |
| Change in Study Design or Documents | <input checked="" type="checkbox"/> | <i>Please complete section 1 on page 2 and declaration on page 4</i> |
| Request for Time Extension          | <input checked="" type="checkbox"/> | <i>Please complete section 2 on page 2 and declaration on page 4</i> |
| Change in Study Team                | <input type="checkbox"/>            | <i>Please complete section 3 on page 3 and declaration on page 4</i> |

### Section One – Change in Study Design or Study Documents

The below documents have been amended following the completion of the initial pilot project and before commencing the case studies in-country. The documents have undergone only very minor changes, reflecting their applicability to the current target audience which is a broader group of people – various stakeholders in HIV research and programme planning – as opposed to just users of mathematical models who were contacted in the initial phase. These changes have little significance for the actual study.

Here is a detailed explanation of the changes for each document:

Participant information sheet:

- Title and content altered to reflect that the focus is on both the use of mathematical models and data to inform HIV programme planning.
- Content altered to reflect that this is not part of a UNAIDS training workshop

Participant consent form:

- Title has been altered to reflect participant audience and UNAIDS removed from title

Semi-structured interview form:

- Interview structure has been altered to reflect that the focus is on both the use of mathematical models and data in regards to HIV programme planning and the decision making process as opposed to the specific use of mathematical models

| <i>Document Name</i>                     | <i>Version</i> | <i>Date</i>           |
|------------------------------------------|----------------|-----------------------|
| Information letter_e2_April2013          |                | Last amended 18/07/13 |
| Consent form_e2_April2013                |                | Last amended 11/04/13 |
| Semi-structured interview list_vJune2013 |                | Last amended 24/06/13 |
|                                          |                |                       |
|                                          |                |                       |

### Section Two - Request for Time Extension

When was the original ICREC approval granted? 10/March/2011

When would the PI require the ethical approval to be extended to? 31/May/2014  
( no greater than 5 years from amendment submission)

Please give justification for the time extension request.

**It has taken longer than anticipated for the logistical aspect of the in-country case studies to be organised.**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------------------------------------|
| <b>Section Three – Change in Study Team</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |                                    |
| <b>Please select from the following options:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   | please tick                        |
| A study team member is leaving (excluding PI)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   | <i>Please complete part A</i>      |
| There is a new study team member (excluding PI)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   | <i>Please complete part B</i>      |
| There is a new CI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |   | <i>Please complete part C</i>      |
| <b>Part A – A study team member is leaving</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |                                    |
| Name:<br>Title:<br>Position:<br>Location:<br>Email:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |   |                                    |
| Is this person being replaced?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | N | Y ( <i>please fill in part B</i> ) |
| <b>Part B – There is a new study team member</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   |                                    |
| Name:<br>Title:<br>Position:<br>Location:<br>Email:<br><br>Summary of skills and experience relevant to the area of this study:                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |                                    |
| <b>Part C – There is a New PI</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |   |                                    |
| Name:<br>Title:<br>Position:<br>Location:<br>Email:<br><br>Summary of skills and experience relevant to the area of this study:                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |                                    |
| <b>The New PI must also read the following statement and sign their agreement:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |   |                                    |
| I declare that: <ul style="list-style-type: none"> <li>• I undertake to abide by the ethical principles underlying the Declaration of Helsinki and good practice guidelines on the proper conduct of research.</li> <li>• I undertake to abide by the Data Protection Act 1998 and any applicable local laws.</li> <li>• I undertake to abide by all local rules for non-UK research.</li> <li>• I will report any adverse or unforeseen events which occur to ICREC within 7 days.</li> <li>• I will provide notification of the end or early termination of the research project.</li> </ul> |   |                                    |

- I will inform ICREC if there are any changes to the research protocol or personnel which affect the ethical aspects of the project.
- I will assist ICREC in any continuing review of the project deemed necessary by the Committee or Faculty members.
- I will re-apply for ethical approval after 5 years.
- All information on this form is correct.

Signed:

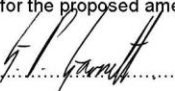
Date:

#### Any other relevant information

This amendment refers solely to a study interviewing participants about non-sensitive subject matter.

#### Declaration

- I confirm that the information in this form is accurate to the best of my knowledge and I take full responsibility for it.
- I consider that it would be reasonable for the proposed amendment to be implemented.

Signature of Principal Investigator: 

Print name: Geoffrey P Garnett.....

Date of submission: .....

#### FOR JRO/ICREC USE ONLY

##### ICREC Decision

- JRO approves the amendment ☐
- ICREC approves the amendment ☐
- ICREC requires further information before making a decision on the amendment (please specify) ☐
- ICREC rejects the amendment (please give reasons) ☐

**Attach JRO/Committee response letter to this document.**

Kelsey K Case  
Dept of Infectious Disease Epidemiology  
Imperial College London  
London, W2 1PG  
[k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk)  
Tel: +44 (0)20 7594 1524

July 2013

Dear Participant

**Re: Use of models and data to inform HIV programme planning and resource allocation**

*What is the purpose of this study?*

We are seeking to gain a better understanding of the decision making and the use of mathematical models and data to inform this process. We are also interested in understanding the barriers and facilitators to the use of data and models to inform decision making for HIV prevention and treatment. In order to do this, we are conducting an informative study to better understand the experience and perspective of those who involved with research, data collection and programme planning and decision-making for HIV.

*What would you be asked to do if you agree to participate?*

If you agree to participate in this research, you would be asked to spend approximately 60 providing your perspective on the data available and how these data are utilised in your country and provide your perspective on the decision making process for HIV programme planning.

*What would be the risks and benefits if you participate in the research?*

You are free to decide whether or not to take part in the research study. There are no risks in participating in this research, your views and experiences will remain anonymous and any identifying details will be removed. Your participation will help to provide an enhanced understanding of the estimation process and the use of these tools in the local context and this information will be used to inform and improve the development and use of these models and results.

You may keep this information sheet. If you have any further questions, please contact me at [k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk).

Kind Regards

Kelsey K Case  
Research Manager

Version 2, 22 July 2013

Deleted: 15 Prince's Gardens¶

Deleted: s

Deleted: 7

Deleted: NA

Deleted: [www.epidem.org](http://www.epidem.org)¶

Deleted: March

Deleted: 1

Deleted: To participants of the southern Africa regional training workshop:¶

Deleted: UNAIDS Reference Group on Estimates, Modelling and Projections Informative study

Deleted: The UNAIDS Reference Group on Estimates, Modelling and Projections exists to provide impartial scientific advice to UNAIDS, the World Health Organization (WHO) and other United Nations and partner organisations on global estimates and projections of the prevalence, incidence and impact of HIV/AIDS. The group is co-ordinated by a secretariat based in the Department of Infectious Disease Epidemiology, Imperial College London ([www.epidem.org](http://www.epidem.org)) and provides technical and methodological guidance on the tools used to generate national estimates and the technical issues that arise from the use of these tools.¶

Deleted: improve the estimation

Deleted: process, specifically, to bridge the gap between the technical experts who develop the methods and the tools used and the country-level users and stakeholders who apply the tools in practice and rely upon the results generated

Deleted: use the models to generate national estimates and to identify how these estimates are used to inform

Deleted: 30

Deleted: minutes discussing your past and current experience using EPP and Spectrum to generate national estimates. This will take place during the southern Africa UNAIDS training workshop.

P. No

Use of models and data to inform HIV programme planning and resource allocation

Deleted: UNAIDS Reference Group on Estimates, Modelling & Projections¶

Deleted: Mathematical

Deleted: generate national estimates

Deleted: :

Deleted: User Experience Study¶

1. Have you read the project information sheet? Yes ☐ No ☐
2. Have you had the opportunity to ask questions and discuss the study? Yes ☐ No ☐
3. Do you understand that this is a research project and that your decision to consent is entirely voluntary? Yes ☐ No ☐
4. Do you agree to participate in this study? Yes ☐ No ☐

Informative Study

Deleted: User Experience

I confirm that the nature and demands of the research have been explained to me and I understand and accept them. I understand that my consent is entirely voluntary and that I may withdraw from the research project if I find that I am unable to continue for any reason.

Signed (study participant): \_\_\_\_\_

Date: \_\_\_\_\_

**Investigator's Statement:**

I have explained the nature, demands and foreseeable risks of the above research to the respondent.

Signed (interviewer): \_\_\_\_\_

Date: \_\_\_\_\_

**YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP**

If you have any further questions about this study or the use of the results, please contact Kelsey Case at: +44 (0)20 7594 1524, or via email: [k.case@imperial.ac.uk](mailto:k.case@imperial.ac.uk).

Version 2, 22 July 2013

Semi-structured interview

## 1. General

Background – where employed, how long, type of job  
Use of models – background and experience  
EPP and Spectrum – how long, what for, perceived level of capability

## 2. Use of models/data

➤ Which models? What for? By whom? To what result? Perceived importance/weight of this information?

➤ Which data sources? Used for? By whom? To what result? Perceived importance/weight of this information?

Issues – positive and negative  
Difficulties

What is most difficult?

What is most beneficial?

What can be done better? How to improve?

## 3. Stakeholders

Use of the models  
– By whom?  
– What for?  
– To what result?  
– Perceived importance?

## 4. Decision-making

How are the results used for decision-making and programme planning?

- Are they?
- To what degree?

Who makes the decisions in the local context?

- Who has the power of decision-making and non decision-making for HIV prevention?
- Who are the important stakeholders who had/could have considerable influence on AIDS policy?
- Interests, influence, power

How is evidence from models used to inform decision-making?

- Is it used?

Who else should I be talking to regarding these areas/issues? Why?

Follow-up with email

Version 2, 22 July 2013

Deleted: EPP/Spectrum

Deleted: User experience¶

Deleted: Changing estimates¶

Deleted: 3. MoT? (Same as above if they have done it)¶

Deleted: 4

Deleted: 5

Deleted: 5. PrEP¶  
<#>Views?¶  
<#>Feasibility?¶  
<#>In what context?¶  
<#>Are there any other things that could be improved with EPP/Spectrum?¶  
¶

Deleted: Are there any other things that you have thought of that could be improved with EPP/Spectrum?¶

## Appendix 5-2: Interview schedules in Zambia and Malawi

### Zambia Itinerary

#### Round 1, Informational Interviews: Lusaka, Zambia

Geoff Garnett, Damian Walker, Kelsey Case

April 15 – 19 2013

| Date                      | Partner                                                                                                                                                                                                                                                                                                                 | Participant                                                                                                                                                                                  |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Monday April 15</b>    |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| 01                        | XX<br>(Local government)<br>(policy)                                                                                                                                                                                                                                                                                    | Participant: R1_01_1<br>Participant: R1_01_2                                                                                                                                                 |
| 02                        | XX<br>(Local government: policy)                                                                                                                                                                                                                                                                                        | Participant: R1_02_1<br>Participant: R1_02_2                                                                                                                                                 |
| 03                        | XX<br>(Local government: modelling, policy)                                                                                                                                                                                                                                                                             | Participant: R1_03_1<br>Participant: R1_03_2                                                                                                                                                 |
| 04                        | XX<br>(International organization: modelling, policy)                                                                                                                                                                                                                                                                   | Participant: R1_04_1<br>Participant: R1_04_2 (on phone)<br>Participant: R1_04_3 (on phone)                                                                                                   |
| <b>Tuesday April 16</b>   |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| 05                        | XX<br>(intergovernmental organization – UN: modelling, policy)                                                                                                                                                                                                                                                          | Participant: R1_05_1<br>Participant: R1_05_2                                                                                                                                                 |
| 06                        | XX<br>(Academic: research, policy, health service delivery)                                                                                                                                                                                                                                                             | Participant: R1_06_1                                                                                                                                                                         |
| 07                        | XX<br>(International organization – health: modelling, policy)                                                                                                                                                                                                                                                          | Participant: R1_07_1<br>Participant: R1_07_2<br>Participant: R1_07_3<br>Participant: R1_07_4                                                                                                 |
| 08                        | XX<br>(Intergovernmental organization, UN: modelling, policy)                                                                                                                                                                                                                                                           | Participant: R1_08_1<br>Participant: R1_08_2<br>Participant: R1_08_3                                                                                                                         |
| 09                        | XX<br>(International government: modelling, healthcare delivery)<br>XX<br>(International government)<br>XX<br>(International government: data collection, modelling, policy)<br>XX<br>(International government: implementing partner)<br>XX<br>(International government)<br>XX<br>(International government: finance) | Participant: R1_09_1<br>Participant: R1_09_2<br>Participant: R1_09_3<br>Participant: R1_09_4<br>Participant: R1_09_5<br>Participant: R1_09_6<br>Participant: R1_09_7<br>Participant: R1_09_8 |
| 10                        | XX<br>(Local NGO – healthcare provision, research)                                                                                                                                                                                                                                                                      | Participant: R1_10_1                                                                                                                                                                         |
| <b>Wednesday April 17</b> |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                              |
| 11                        | XX<br>(Local research institution: policy, health service delivery)                                                                                                                                                                                                                                                     | Participant: R1_06_2                                                                                                                                                                         |
| 12                        | XX                                                                                                                                                                                                                                                                                                                      | Participant: R1_12_1                                                                                                                                                                         |

|                          |                                                                              |                                                                             |
|--------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                          | <i>(Local NGO: healthcare provision)</i>                                     |                                                                             |
| 13                       | <b>XX</b><br><i>(Intergovernmental organization – UN: modelling, policy)</i> | Participant: R1_13_1<br>Participant: R1_13_2                                |
| 14                       | <b>XX</b><br><i>(intergovernmental organization - UN: policy)</i>            | Participant: R1_14_1<br>Participant: R1_14_2<br>Participant: R1_14_3        |
| 15                       | <b>XX</b><br><i>(Local university: research, education)</i>                  | Participant: R1_15_1                                                        |
| 16                       | <b>XX</b><br><i>(International organization: impact evaluation)</i>          | 2 participants, notes/memos only, no transcript, (not included in analysis) |
| <b>Thursday April 18</b> |                                                                              |                                                                             |
| 17                       | <b>XX</b><br><i>(International organization: development)</i>                | Participant: R1_17_1                                                        |
| 18                       | <b>XX</b><br><i>(Local government)</i>                                       | Participant: R1_01_1 (follow-up)                                            |
| 19                       | <b>XX</b><br><i>(International organization – health: modelling, policy)</i> | Participant: R1_07_3 (follow-up)                                            |
| 20                       | <b>XX</b><br><i>(Research and education)</i>                                 | Participant: R1_20_1                                                        |
| <b>Friday April 19</b>   |                                                                              |                                                                             |
| 21                       | <b>XX</b><br><i>(Local government)</i>                                       | Participant: R1_21_1<br>Participant: R1_21_2                                |
| 22                       | <b>XX</b><br><i>(Local government, research)</i>                             | Participant: R1_22_1<br>Participant: R1_22_2<br>Participant: R1_22_3        |

## Malawi Itinerary

### Round 1, Informational Interviews: Lilongwe, Malawi

Geoff Garnett, Martin Gross, Kelsey Case

July 24 – 30 2013

| Date                     | Partner                                                                                                                                                                                                                       | Participant                                                                                     |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| <b>Wed, 24 July 2013</b> |                                                                                                                                                                                                                               |                                                                                                 |
| 01                       | <b>XX</b><br><i>(Academic: research, education)</i>                                                                                                                                                                           | R1_01_1                                                                                         |
| <b>Thu, 25 July 2013</b> |                                                                                                                                                                                                                               |                                                                                                 |
| 02                       | <b>XX</b><br><i>(Academic: research, education, training)</i>                                                                                                                                                                 | R1_02_1                                                                                         |
| 03                       | <b>XX</b><br><i>(International organisation)</i>                                                                                                                                                                              | Second-hand recap only, no transcript                                                           |
| 04                       | <b>XX</b><br><i>(International organisation: research, modelling, policy)</i>                                                                                                                                                 | R1_04_1                                                                                         |
| 05                       | <b>XX</b><br><i>(Local government)</i><br><b>XX</b><br><i>(International government; service provision, modelling)</i><br><b>XX</b><br><i>(Local government: modelling, policy)</i><br><b>XX</b><br><i>(Local government)</i> | R1_05_1<br>R1_05_2<br>R1_05_3<br>R1_05_4<br>R1_05_5<br>R1_05_6<br>R1_05_7<br>R1_05_8<br>R1_05_9 |

|                          |                                                                                                                             |                                                                |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
|                          |                                                                                                                             | R1_05_10<br>( <i>observational meeting</i> )                   |
| 06                       | XX<br>( <i>Local government: technical/research</i> )<br>XX<br>( <i>Local government: modelling, policy</i> )               | R1_05_3<br>R1_05_6<br>R1_06_1<br>R1_06_2                       |
| 07                       | XX<br>( <i>Local NGO</i> )                                                                                                  | R1_07_1                                                        |
| 08                       | XX<br>( <i>Local government</i> )                                                                                           | R1_05_10                                                       |
| <b>Fri, 26 July 2013</b> |                                                                                                                             |                                                                |
| 09                       | XX<br>( <i>International organization: research and technical support, modelling, policy</i> )                              | R1_09_1                                                        |
| 10                       | XX<br>( <i>Intergovernmental organization: UN, modelling; policy</i> )                                                      | R1_10_1                                                        |
| 11                       | XX<br>( <i>International organization: health, modelling, policy</i> )                                                      | R1_11_1                                                        |
| <b>Sat, 27 July 2013</b> |                                                                                                                             |                                                                |
| <b>Sun, 28 July 2013</b> |                                                                                                                             |                                                                |
| 12                       | XX<br>( <i>International organization: development</i> )                                                                    | R1_12_1                                                        |
| <b>Mon, 29 July 2013</b> |                                                                                                                             |                                                                |
| 13                       | XX<br>( <i>Civil society</i> )                                                                                              | R1_13_1                                                        |
| 14                       | XX<br>( <i>Local government</i> )                                                                                           | R1_14_1<br>R1_14_2                                             |
| 15                       | XX<br>( <i>Local government</i> )                                                                                           | R1_15_1<br>R1_15_2                                             |
| 16                       | XX<br>( <i>International organization - government</i> )                                                                    | R1_16_1<br>R1_16_2                                             |
| 17                       | XX<br>( <i>Intergovernmental organization: UN</i> )                                                                         | R1_17_1<br>R1_17_2                                             |
| <b>Tue, 30 July 2013</b> |                                                                                                                             |                                                                |
| 18                       | XX<br>( <i>International organization: Education, training, technical support</i> )                                         | R1_18_1                                                        |
| 19                       | XX<br>( <i>Local government</i> )<br>XX<br>( <i>International organization – government: service provision, modelling</i> ) | R1_05_2<br>R1_05_4                                             |
| 20                       | XX<br>( <i>international organization – health: modelling; policy</i> )                                                     | R1_20_1<br>R1_20_2<br>R1_20_3<br>R1_20_4                       |
| 21                       | XX<br>( <i>civil society</i> )                                                                                              | R1_21_1                                                        |
| 22                       | XX<br>( <i>international organization - service</i> )                                                                       | R1_22_1<br>R1_22_2                                             |
| 23                       | XX<br>( <i>international organization – health: modelling; policy</i> )                                                     | R1_20_2<br>( <i>informal, no transcript memos/notes only</i> ) |

## Zambia Itinerary

### Round 2, In-depth interviews: Lusaka, Zambia

Kelsey Case, Oct 30<sup>th</sup> – Nov 6<sup>th</sup> 2013

| Date                    | Partner                                                                                                                                                                                                                                                                                                                                                                                           | Participant                                                                                                                                                                          |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Thursday, Oct 31</b> |                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                      |
| 01                      | <b>XX</b><br>(International organization:<br>modelling, policy, research)                                                                                                                                                                                                                                                                                                                         | R2_01_1                                                                                                                                                                              |
| <b>Friday, Nov 1</b>    |                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                      |
| 02                      | <b>XX</b><br>(international organization – health:<br>modelling, policy)                                                                                                                                                                                                                                                                                                                          | R2_02_1                                                                                                                                                                              |
| 03                      | <b>XX</b><br>(intergovernmental organization –<br>UN: modelling)<br><b>XX</b><br>(International government:<br>modelling; policy)                                                                                                                                                                                                                                                                 | R2_03_1<br>R2_03_2<br>R2_03_3                                                                                                                                                        |
| 04                      | <b>XX</b><br>(Local government: modelling; policy)                                                                                                                                                                                                                                                                                                                                                | R2_04_1                                                                                                                                                                              |
| <b>Monday, Nov 4</b>    |                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                      |
|                         | <b>XX</b><br>(International organization: private<br>foundation)                                                                                                                                                                                                                                                                                                                                  | (review & discussion of data<br>collected, not in-depth interview)                                                                                                                   |
| 05                      | <b>XX</b><br>(Local government)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(International government:<br>modelling, service delivery)<br><b>XX</b><br>(International government)<br><b>XX</b><br>(International government:<br>modelling, policy)<br><b>XX</b><br>(International government:<br>implementing partner)<br><b>XX</b><br>(International organization: private<br>foundation) | R2_05_1<br>R2_05_2<br>R2_05_3<br>R2_05_4<br>R2_05_5<br>R2_05_6<br>R2_05_7<br>R2_05_8<br>R2_05_9<br>R2_05_10<br>R2_05_11<br>R2_05_12<br>R2_05_13<br><br>(informational, not in-depth) |
| 06                      | <b>XX</b><br>(intergovernmental organization -<br>UN)                                                                                                                                                                                                                                                                                                                                             | R2_06_1<br>R2_06_2                                                                                                                                                                   |
| 07                      | <b>XX</b><br>(Academic: modelling, policy)                                                                                                                                                                                                                                                                                                                                                        | R2_07_1                                                                                                                                                                              |
| <b>Tuesday, Nov 5</b>   |                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                      |
| 08                      | <b>XX</b><br>(intergovernmental organization –<br>UN: modelling; policy)                                                                                                                                                                                                                                                                                                                          | R2_08_1                                                                                                                                                                              |
| 09                      | <b>XX</b><br>(Local government)                                                                                                                                                                                                                                                                                                                                                                   | R2_09_1                                                                                                                                                                              |
| <b>Wednesday, Nov 6</b> |                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                      |
| 10                      | <b>NZP+</b><br>(civil society)                                                                                                                                                                                                                                                                                                                                                                    | R2_10_1<br>R2_10_2                                                                                                                                                                   |

|    |                                                                                                           |                    |
|----|-----------------------------------------------------------------------------------------------------------|--------------------|
| 11 | <b>UNZA – Demography Dept</b><br>(research; education)                                                    | R2_11_1<br>R2_11_2 |
| 12 | <b>Centre for Infectious Disease Research in Zambia (CIDRZ)</b><br>(NGO – healthcare provision, research) | R2_12_1            |

## Malawi Itinerary

### Round 2, In-depth interviews: Lilongwe, Malawi

Kelsey Case, Nov 7-12 2013

| Date                   | Partner                                                                                                                                                                                                                                                                                                                             | Participant                                                                                                                                                         |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Thursday, Nov 7</b> |                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                     |
| 01                     | <b>XX</b><br>(Local government: modelling; policy)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(International organization: private foundation – funder)<br><b>XX</b><br>(International government: implementation)                                                                       | R2_01_1<br>R2_01_2<br>R2_01_3<br>R2_01_4<br>R2_01_5<br>R2_01_6<br>R2_01_7<br>R2_01_8<br>R2_01_9<br>R2_01_10<br>R2_01_11<br>(informational, not in-depth)            |
|                        | <b>XX</b><br>(International government: implementation)<br><b>XX</b><br>(International organization: private foundation – funder)<br><b>XX</b><br>(International government)                                                                                                                                                        | 5 participants<br>(informal meeting & discussion of data obtained, no transcript)                                                                                   |
| <b>Friday, Nov 8</b>   |                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                     |
| 02                     | <b>XX</b><br>(Intergovernmental organization – UN)                                                                                                                                                                                                                                                                                  | R2_02_1                                                                                                                                                             |
| 03                     | <b>XX</b><br>(International government)                                                                                                                                                                                                                                                                                             | R2_03_1<br>R2_03_2                                                                                                                                                  |
| <b>Saturday, Nov 9</b> |                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                     |
| 04                     | <b>XX</b><br>(Local government)<br><b>XX</b><br>(Local government: modelling, policy)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(Local government)<br><b>XX</b><br>(International government: implementation)<br><b>XX</b><br>(International organization: private foundation – funder) | R2_04_1<br>R2_04_2<br>R2_01_1<br>R2_01_2<br>R2_01_4<br>R2_01_3<br>R2_01_5<br>R2_01_6<br>R2_01_8<br>R2_01_9<br>R2_01_10<br>R2_01_11<br>(informational, not in-depth) |

|                           |                                                                        |                               |
|---------------------------|------------------------------------------------------------------------|-------------------------------|
| <b>Monday, Nov 11</b>     |                                                                        |                               |
| 05                        | <b>XX</b><br>(Local government: modelling, policy)                     | R2_05_1<br>R2_01_6            |
| 06                        | <b>XX</b><br>(International NGO)                                       | R2_06_1                       |
| <b>Tuesday, Nov 12</b>    | <b>Field visit: Adventist Health Centre</b>                            |                               |
| 07                        | <b>*XX</b><br>(Local NGO: service provision)                           | R2_07_1<br>R2_07_2<br>R2_07_3 |
| 08                        | <b>*XX</b><br>(Intergovernmental organization – UN: modelling, policy) | R2_08_1<br>R2_08_2            |
| 09                        | <b>*XX</b><br>(Local government: modelling, data collection)           | R2_09_1<br>R2_09_2            |
| 10                        | <b>*XX</b><br>(International organization – research)                  | R2_10_1<br>R2_10_2            |
| <b>Wednesday, Nov 13*</b> |                                                                        |                               |
|                           |                                                                        |                               |

\* Cancelled due to researcher illness

## Appendix 5-3: Stakeholder mapping

### Stakeholder mapping: Zambia

| Stakeholder       | Classification    | Role                                | Projects                                                                                                                                                                                                                                                                             | Influence                                                                                                                                                                          | Interest                                                                                                                                                                                                                                 |
|-------------------|-------------------|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Akros             | International NGO | NGO                                 | Water and sanitation, DHIS2 related work, malaria                                                                                                                                                                                                                                    | Low                                                                                                                                                                                | <b>Low</b>                                                                                                                                                                                                                               |
| BMGF              | International     | Funder                              | Planning grant to MoH<br>INSP<br>Match study (CHAI)<br>MC (PSI)                                                                                                                                                                                                                      | Med - considering grant directly to govt; funding partners/multi-lat orgs in Zambia through Gfund and USG                                                                          | <b>Medium</b> - funding HIV costing analyses that inform cost-effectiveness models; fund the organisations leading modelling work (e.g. UNAIDS). Interested in data-driven approaches, Global Fund Business Case, ?Investment Framework. |
| Boston University | Academic          | University (research)               | BUPIP                                                                                                                                                                                                                                                                                |                                                                                                                                                                                    | Unclear (in Zambia)                                                                                                                                                                                                                      |
| CDC               | International     | Funder, implementing agency         | SMARTCare<br><b>Strategic Information Initiative (SII)</b><br>Key populations study<br>Census; DHS; MDGs survey; HTC tool<br>SAVVY, maternal mortality<br>Funding training programmes/courses at UNZA, Dept of Population Studies                                                    | <b>Considerable</b><br>Substantial investments - funding an extensive range of projects, training, involved in most major data-oriented HIV projects. Strong clout with Ministry   | <b>Medium - funding related work</b>                                                                                                                                                                                                     |
| CHAI              | International     | International organisation (health) | NASA?<br>Option B+ business case (& costing)<br>Resource tracking<br>Health financing, resource allocation tool<br>Mobile data collection - malaria<br>PMTCT & district level programmes w/ MCDMCH (also mapping community volunteers?)<br>Commn-based health mngmnt mobile platform | <b>Considerable</b><br><b>Close link w govt, MoH, MCDMCH</b><br>CHAI works directly with governments - MOH for national level work, MCDMCH for PMTCT and district level programmes | <b>Medium: Array of modelling applications and models used in past decade; B+ business case</b>                                                                                                                                          |
| China             | International     | International government            | Hospitals, infrastructure                                                                                                                                                                                                                                                            | Considerable? for infrastructure                                                                                                                                                   | <b>Low</b> (in Zambia)                                                                                                                                                                                                                   |
| CHAZ              | Local NGO         | NGO - Healthcare provision          |                                                                                                                                                                                                                                                                                      | PR for Global Fund<br>Largest NGO health provider in Zambia                                                                                                                        | <b>Low</b>                                                                                                                                                                                                                               |

## Zambia (cntd)

| Stakeholder                      | Classification                      | Role                                                                  | Projects                                                                                                                                             | Influence                                                                                                                              | Interest                                                                                                                     |
|----------------------------------|-------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| CIDA (Canada)                    | International                       |                                                                       |                                                                                                                                                      | Pulling out in May 2013                                                                                                                | <b>Low</b> (in Zambia)                                                                                                       |
| CIDRZ                            | Local NGO                           | NGO - Healthcare provision, training, research                        | Service (2/3 of budget), majority is PEPFAR TB, child health, HPV vaccination, rotavirus, women's health (Fogarty/NIH), immunisation                 | Direct cooperating agreement w/CDC<br>Work closely with local govt                                                                     | <b>Low</b> (in Zambia)                                                                                                       |
| Civil Society Organisations      | Civil society                       | Human rights, advocacy                                                | NZP+, TALC, ZINGO, PPZ, Youth Vision Zambia, Southern Africa AIDS Trust                                                                              | Unclear                                                                                                                                | <b>Low</b>                                                                                                                   |
| Central Statistical Office (CSO) | Government                          | National statistics (social, ag, dem, econ); surveys                  | DHS; Sexual Behaviour Survey; Census Spectrum Estimates<br>SII (data warehouse)<br>VR (with National Registrars); VA w/ SAVVY                        | Empowered by Parliament to manage data, but cited as having "weak leadership at the top"                                               | <b>Low-med</b><br>Low - For own interest, manage the data. Do partake in modelling exercises to provide the demographic data |
| DFID                             | International                       | International organisation (development); cooperating partner; funder | Couples counselling & testing<br>Referrals tracking<br>Investment Framework (UNAIDS)<br>Basic Health Package; Nutrition<br>Funding malaria<br>Census | <b>Low-Med</b><br>Previously signif donor (LMIC status has reduced funding)<br>Direct support to NAC<br>Tech support to NAC via UNAIDS | <b>Low-med</b><br>Limited participation in Investment Framework                                                              |
| Dept of Defense                  | International                       | Implementing agency                                                   | SII - creating lecture hall & computer centre at UNZA                                                                                                | Low in itself, but USG                                                                                                                 | Low (in Zambia)                                                                                                              |
| EU                               | International                       | Intergovernmental organisation                                        | Data warehouse at MCDMCH (?)                                                                                                                         | Unclear                                                                                                                                | Unclear                                                                                                                      |
| Futures Institute                |                                     |                                                                       | Goals, MoT technical support, EPP/Spectrum sub-national estimates                                                                                    | Low-Med: Do work directly with country governments                                                                                     | <b>High</b>                                                                                                                  |
| FHI 360                          | International                       | International organisation (development)                              | PMTCT II, SMGL, K4Health, REMZ, TB CARE, Corridors of Hope                                                                                           | Unclear                                                                                                                                | Low-med?                                                                                                                     |
| Global Fund                      | International<br>?Intergovernmental | Funder                                                                | Funding HIV, TB, malaria                                                                                                                             | <b>High</b><br>~\$100M in 2012<br>Largest funder after PEPFAR                                                                          | <b>Medium (at time of visit)</b><br>GF Business Case still in development                                                    |
| ID Insight                       | Academic                            | Research - Impact evaluation                                          |                                                                                                                                                      | Low                                                                                                                                    | Unclear (limited projects)                                                                                                   |
| IHME                             | Academic                            | Research                                                              | <a href="http://ihea2013.abstractssubmit.org/sessions/1662/">http://ihea2013.abstractssubmit.org/sessions/1662/</a>                                  | Low                                                                                                                                    | <b>High - use of data for modelling processes</b>                                                                            |
| India                            | International                       | International government                                              | health posts (soft loan)                                                                                                                             | Low                                                                                                                                    | Low (in Zambia for HIV)                                                                                                      |
| JSI                              | International                       | International organisation - research                                 | Public health management consulting & research org. Funded by PEPFAR                                                                                 | Unclear                                                                                                                                | Unclear                                                                                                                      |

## Zambia (cntd)

| Stakeholder                                             | Classification | Role                                      | Projects                                                                                                                 | Influence                                                                                                                                                                        | Interest                                                                                                                                                                 |
|---------------------------------------------------------|----------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ministry of Finance                                     | Government     | Government (local)                        | ABCE project: Survey of 221 health facilities                                                                            | Med-High for planning resource allocation                                                                                                                                        | Unclear                                                                                                                                                                  |
| Ministry of Commun Development, Mother and Child Health | Government     | Government (local)                        | Focus will be on community level, vulnerable populations (orphans, <5 yrs, >65 yrs)                                      | <b>Medium:</b> Newly formed, stil some confusion re responsibilities (and structure), lack of clarity for roles, funding, but decision for this minstry came from the President. | <b>Low</b> (at time of study visit)                                                                                                                                      |
| Ministry of Health                                      | Government     | Government (local)                        | UNAIDS Investment Framework; national estimates (EPP/Spectrum)<br><i>SmartCare</i><br>Organising resource financing work | <b>Med-high</b><br>In position of power and influence, sombut confusion with recent ministry split                                                                               | <b>Medium-high:</b> Quoting of figures, citing of modelling reports, and involvement in modelling exercises (providing data from HMIS), interested in mapping            |
| NAC                                                     | Government     | Coordinating the HIV/AIDS response        | e-mapping, CDC Strategic Info Initiative; Spectrum estimates; UNAIDS Investment Case; MC; NASA                           | Low-med at time of study visit - important role but reorganisation has weakened influence, funding cut.                                                                          | <b>High:</b> Tasked with leading modelling processes - Investment Framework, EPP/Spectrum estimates, MoT, but externally driven processes and technical support required |
| NZP+                                                    | Civil society  | Civil society organisation                | NACmis; Stigma index<br>Patient surveys: reproductive health needs, adolescents, healthcare                              | Unclear; From org: 800,000+ memberships, all districts                                                                                                                           | Low                                                                                                                                                                      |
| Panos Institute Southern Africa                         | Regional NGO   | Regional nonprofit NGO                    | Key population study, access to services                                                                                 | Low                                                                                                                                                                              | Unclear                                                                                                                                                                  |
| PATH                                                    | International  | International nonprofit global health org | MACEPA                                                                                                                   | Low for HIV                                                                                                                                                                      | Medium (malaria)                                                                                                                                                         |
| PEPFAR                                                  | International  | US Government; funder; service provision  |                                                                                                                          | <b>HIGH</b><br><b>Over \$300M planned in funding for FY2013</b><br>Funding ~85% of treatment                                                                                     | <b>Med-High: Parallel modelling processes, PMTCT model</b>                                                                                                               |
| PMI                                                     | International  | Partner/Funder                            | Malaria                                                                                                                  | \$25 million - major funder for malaria                                                                                                                                          | Unclear                                                                                                                                                                  |
| SIDA (Sweden)                                           | International  | International government                  |                                                                                                                          | Unclear                                                                                                                                                                          | Low (in Zambia)                                                                                                                                                          |

## Zambia (cntd)

| Stakeholder                      | Classification    | Role                           | Projects                                                                                                                                      | Influence                                                                 | Interest                                                                                                                                            |
|----------------------------------|-------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| UNAIDS                           | Intergovernmental | Intergovernmental organisation | Investment Framework; Spectrum estimates; NASA; World Bank project (w Imperial, UNFPA);                                                       | Medium                                                                    | <b>High:</b> Initiate and fund modelling exercises (MoT, Investment Framework, EPP/Spectrum estimates) and are directly involved in these processes |
| UNICEF                           | Intergovernmental | Intergovernmental organisation |                                                                                                                                               | Unclear                                                                   | <b>Medium:</b> Use of model results, some involvement in modelling processes, PMTCT modelling                                                       |
| UNDP                             | Intergovernmental | Intergovernmental organisation | Currently supporting GF grants                                                                                                                | Temporary PR for Global Fund                                              | Unclear                                                                                                                                             |
| UNFPA                            | Intergovernmental | Intergovernmental organisation | World Bank Project (with Imperial, UNAIDS) Census                                                                                             | Unclear                                                                   | ?Medium: Involved in resource allocation projects                                                                                                   |
| UNZA, Dept of Population Studies | Academic          | University                     | SII activities (training & skills for strengthening analysis and use of data - EDU course, QEDU); HTC Tool; Measure course on survey analysis | Almost all activities are under SII, funded by CDC                        | Low: More survey and data analysis                                                                                                                  |
| UNZA, Dept of Economics          | Academic          | University                     | Investment Framework (lead for costing)                                                                                                       | Unclear                                                                   | <b>Medium:</b> Involved in costing component of modelling exercises leading the Investment Framework costing                                        |
| USAID                            | Intergovernmental | Implementing agency            | Funded CDC for mapping & size estimation of MSM, FSW with biobehavioural data for FSW Risk assessments (detailed)                             | Unclear                                                                   | <b>Medium:</b> Mapping                                                                                                                              |
| US Government                    | International     | Funder                         | PEPFAR, CDC, USAID, DoD, PMI                                                                                                                  | <b>High</b><br>Largest donor, estimated 85% of response is USG (from USG) | <b>High:</b> All groups together (CDC, PEPFAR, etc)                                                                                                 |
| WHO                              | Intergovernmental | Intergovernmental organisation | SHA 2011 maternal and child health costing (request from MCDMCH)                                                                              | Low                                                                       | <b>Low</b> (in Zambia), small team and limited capacity. ( <i>Medium in terms of global guidelines</i> )                                            |

## Zambia (cntd)

| Stakeholder                                                    | Classification    | Role                                                                                          | Projects                                                                                                                                                                                                                                                                                         | Influence                                                                                                                        | Interest                                                                                                                                                    |
|----------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The World Bank                                                 | Intergovernmental | Funder - funding goes direct to Ministries to carry out projects<br>Work with both NAC & govt | PETS; RBF (results-based financing)<br>2012 Programme Efficiency study (regional, focusing on prevention)<br>July 2014 - 5 year govt strengthening project (\$61M), research→policy, focus on MCH<br>Risk assessments<br>HPV vaccination<br>Census - living conditions<br>Analysing supply chain | <b>Med:</b> Funding directly to ministries for govt-led projects<br>Also oversees/manages parallel financing (from other donors) | <b>Med:</b> Funding resource allocation work, involved in Investment Framework (supposed to lead scenario analysis), modelling project with Imperial, UNFPA |
| ZAMBART                                                        |                   | Local NGO                                                                                     | TB - prevention/diagnostics<br>popART                                                                                                                                                                                                                                                            | Unclear                                                                                                                          | Unclear                                                                                                                                                     |
| ZCAHRD                                                         | Academic          | Research                                                                                      | BUPIP; rapid syphilis testing; integration of ART into ANC;<br>SMS for receiving test results;<br>Costs & outcomes of pt cohort;<br>Costing full PMTCT package (in Southern province only)                                                                                                       | Funded by CDC (among others)                                                                                                     | Unclear                                                                                                                                                     |
| <b>Interest scales</b>                                         |                   |                                                                                               |                                                                                                                                                                                                                                                                                                  |                                                                                                                                  |                                                                                                                                                             |
| <i>Low = Very low/no direct involvement with models</i>        |                   |                                                                                               |                                                                                                                                                                                                                                                                                                  |                                                                                                                                  |                                                                                                                                                             |
| <i>Med = some direct use of models/moderate use of results</i> |                   |                                                                                               |                                                                                                                                                                                                                                                                                                  |                                                                                                                                  |                                                                                                                                                             |
| <i>High = direct use of models/high use of results</i>         |                   |                                                                                               |                                                                                                                                                                                                                                                                                                  |                                                                                                                                  |                                                                                                                                                             |

## Stakeholder mapping: Malawi

| Stakeholder                           | Classification | Role                                              | Projects                                                                                                                                                                                                                                                                                                                                                              | Influence                                                                                                                                                                                | Interest                                                                                                                                                                                                  |
|---------------------------------------|----------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Baobab Health                         | Local NGO      | Local NGO                                         | Develops electronic data systems: partial coverage in Malawi (but district hospitals and fairly geo reprsntv)                                                                                                                                                                                                                                                         | Low<br>Work w/ govt for electronic data systems<br>Predom in central & south region ( <i>LIN in northern region</i> )                                                                    | Unclear - electronic HIV data                                                                                                                                                                             |
| BMGF                                  | International  | Funder                                            | MATCH study                                                                                                                                                                                                                                                                                                                                                           | <b>Med-high</b> - E10 considering grant directly to govt; funding partners/multi-lat orgs. President Banda met with BMGF study team re proposed planning grant (during Cashgate scandal) | analyses that inform cost-effectiveness models; fund the organisations leading modelling work (e.g. UNAIDS). Interested in data-driven approaches, e.g. Global Fund Business Case, ?Investment Framework. |
| US CDC                                | International  | US Government organisation                        | Funding UNC projects<br>Funding for Baobab electronic data systems (HIV)<br>Funding for EMR (national e-health)<br>Funding I-TECH Tech Assistants<br>Funding quarterly HIV data collection<br>Vital registration project (SI)<br>Funding clinical and operational research<br>BBSS<br>Funded NAC for translation, research → policy<br>recs (no outputs from NAC yet) | <b>HIGH</b> - direct involvement (lead in many cases) and funder of key HIV surveillance, survey and research applications/projects.                                                     | <b>Medium</b> - fund modelling-related work, geo-spatial analyses                                                                                                                                         |
| CHAI                                  | International  | International organisation (health)               | (nurses/midwives); Safe Motherhood; point-of-care diagnostics, Evidence-based planning/policy (NAC); financial management; UNAIDS Investment Case                                                                                                                                                                                                                     | <b>Fairly high</b> , work directly w/ gov, suggest analyses for gov, generate recs for gov, produce presentations for gov to deliver                                                     | <b>Medium</b> : Costing the Invstmnt Framework, PMTCT model                                                                                                                                               |
| CIDA                                  | International  | Donor                                             |                                                                                                                                                                                                                                                                                                                                                                       | Unclear                                                                                                                                                                                  | Unclear                                                                                                                                                                                                   |
| Medicine)                             | Academic       | Education, training, research                     | MSM study (UNDP)                                                                                                                                                                                                                                                                                                                                                      | Unclear                                                                                                                                                                                  | Unclear                                                                                                                                                                                                   |
| DFID                                  | International  | International organisation (development)          | Place (fund) tech support at NAC                                                                                                                                                                                                                                                                                                                                      | Unclear                                                                                                                                                                                  | Unclear                                                                                                                                                                                                   |
| Dignitas Intl                         | International  | International organisation (healthcare, research) |                                                                                                                                                                                                                                                                                                                                                                       | Unclear                                                                                                                                                                                  | Unclear                                                                                                                                                                                                   |
| DNHA<br>(Dept of Nutrition, HIV/AIDS) | Government     | Policy and high level advocacy for HIV/AIDS       |                                                                                                                                                                                                                                                                                                                                                                       | <b>Med-high</b> : In position of influence with mandate for HIV/AIDS policy. Some clash in roles with NAC re who should generate policy                                                  | Unclear                                                                                                                                                                                                   |

## Malawi (cntd)

| Stakeholder                         | Classification                      | Role                                                      | Projects                                                                                                        | Influence                                                                                                                                                                                                                                                                                                            | Interest                                                                                                                     |
|-------------------------------------|-------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| FHI360                              | International                       | International organisation                                | BBSS                                                                                                            | Unclear                                                                                                                                                                                                                                                                                                              | Unclear                                                                                                                      |
| Futures Institute                   | International                       | International organisation (research & technical support) | Goals, MoT technical support, EPP/Spectrum zonal estimates                                                      | Low-Med:Do work directly with country governments, but generally one-off applications                                                                                                                                                                                                                                | <b>High - technical consultants for MoT, Goals, EPP/Spectrum subnational estimates</b>                                       |
| Global Fund                         | International<br>?Intergovernmental | Funder                                                    | HIV, TB, malaria                                                                                                | <b>HIGH</b> - main source of funding                                                                                                                                                                                                                                                                                 | GF Business Case still in development                                                                                        |
| HIV TWG                             | Multi-stakeholder                   | Technical working group                                   | Discussion and review of research, clinical trial results, guidelines, generates recommendations for policy     | <b>HIGH</b> - provide policy recommendations to PS which go on to OPC                                                                                                                                                                                                                                                | Multi-stakeholder group so limited direct involvement of group as a whole                                                    |
| HIV Unit                            | Government                          | Local government                                          | Quarterly HIV data collection, quarterly reports                                                                | <b>HIGH</b> , "running the show", global electronic dissemination of quarterly reports                                                                                                                                                                                                                               | Provide the HIV data and key technical insight for modelling exercises, global electronic dissemination of quarterly reports |
| I-TECH                              | Academic                            | Tech systems support<br>HIV/AIDS is focal area            | TA in HIV Unit<br>TA in HIV Treatment and Care<br>TA in Supply Chain Mangmnt<br>TA in Health Informatics (CMED) | <b>HIGH</b> - (In terms of position). Technical assistant (TA) positions seconded to ministry (since 2003) are key for performance. HIV data collection system is one of the best reporting programmes in the region and is supported by key technical support person. Requires Ministry consent for placement of TA | <b>Med-high</b><br>Provide the HIV data and key technical insight for modelling exercises                                    |
| Johns Hopkins                       | Academic                            | University (research)                                     | Collaborate w NSO (data collection)                                                                             | Unclear                                                                                                                                                                                                                                                                                                              | Unclear                                                                                                                      |
| Johnson & Johnson                   | International                       | Private funder                                            | Funding UNC projects                                                                                            | Low                                                                                                                                                                                                                                                                                                                  | Low                                                                                                                          |
| Luke International (LIN)            | International                       | International NGO                                         | National e-health<br>Training, skill development @ Mizunu University<br>Community prevention                    | Low - Med (national e-health)<br>MoU with government (since 2009)<br>Working mainly in Northern region<br>(Baobab is central & south region)                                                                                                                                                                         | Low direct involvement                                                                                                       |
| MANERELA                            | Civil society                       | Civil Society org, advocacy                               | SAVE model                                                                                                      | Unclear, >500 members                                                                                                                                                                                                                                                                                                | Low                                                                                                                          |
| MANET+                              | Civil society                       | Civil Society org                                         |                                                                                                                 | Unclear, reportedly (self) strongest CSO in Malawi                                                                                                                                                                                                                                                                   | Low                                                                                                                          |
| MHEN (Malawi Health Equity Network) | Civil society                       | Group of civil society orgs                               | Working with health services delivery                                                                           | Unclear                                                                                                                                                                                                                                                                                                              | Low                                                                                                                          |
| MIAA (Malawi Interfaith AIDS Assn)  | Civil society                       | Civil society organisation                                | Coordinating the SAVE model campaign                                                                            | Unclear. Close govt links - Edith Mkawa, Rev Sembereka                                                                                                                                                                                                                                                               | Low                                                                                                                          |

## Malawi (cntd)

| Stakeholder                                  | Classification | Role                                                                                                                 | Projects                                                                                                                                                                                                                                                   | Influence                                                                                                                                                                                                                                                                                                                                                 | Interest                                                                                                                                                             |
|----------------------------------------------|----------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MoH                                          | Government     | Implementation of the health programme                                                                               | Health programme. Implementation                                                                                                                                                                                                                           | <b>High.</b> Primary sub-recipient of Global Fund HIV grants. Technically sits in OPC                                                                                                                                                                                                                                                                     | <b>Medium</b> - Good quality data to facilitate modelling, high technical competency in HIV Unit                                                                     |
| MSF                                          | International  | International NGO - healthcare provision                                                                             | Part of HIV unit data collection teams                                                                                                                                                                                                                     | Unclear                                                                                                                                                                                                                                                                                                                                                   | Low                                                                                                                                                                  |
| NAC<br>(National AIDS Commission)            | Government     | Coordinate the HIV Response<br>Global Fund Principal Recipient<br>Grant making institution<br>Technical coordination | BBSS (support role); UNAIDS Investment case, national estimates; mapping service providers                                                                                                                                                                 | <b>Low-med</b> (at time of study visit)<br>Limited capacity (HR), seemingly minimal engagement, weaker under current leadership than previously... But in a position of influence (mandate to coordinate the HIV response), Principal Recipient of Global Fund HIV grants. Sits across OPC, DNHA, Director appears to have good power relationships (OPC) | <b>High:</b> Investment Case (lead), MoT (direct liaison with Futures Institute), national estimates, but externally driven processes and technical support required |
| Norway                                       | International  | Funder - core support but also support partners                                                                      | Core support for College of Medicine<br>Core person seconded for Resource Mapping<br>Core support BLM, USAID<br>Support Luke Intl → electronic data systems<br>Working w CHAI investigating missing supplies<br>Funding Pub Health Institute Malawi (PHIM) | Medium<br><br>Involved in all health, but strong involvement in HIV-related issues. Highly cited (TA, funding, projects, electronic data collection)                                                                                                                                                                                                      | Low-Med<br>Low direct involvement, but do support Resource Mapping work                                                                                              |
| NSO<br>(National Statistics Office)          | Government     | Local government                                                                                                     | DHS (every 5 years)<br>Census (every 10 years)<br>BBSS<br>MICS implementation<br>MDGs Endline Survey<br>Vital registration project (SI)                                                                                                                    | Low<br>UNFPA & UNDP investing to strengthen                                                                                                                                                                                                                                                                                                               | <b>Low-Medium:</b> Provide demographic data for national estimates process (EPP/Spectrum), no HIV data.<br>Data only, no analysis                                    |
| OPC<br>(Office of the President and Cabinet) | Government     | Advise the President & Cabinet                                                                                       | Overall strategy and policy                                                                                                                                                                                                                                | <b>Medium-high</b> due to mandate to provide policy advice and support to the President & Cabinet, but regarded by stakeholders as not very strong                                                                                                                                                                                                        | Low                                                                                                                                                                  |
| Partners in Hope                             | Local NGO      | Local NGO                                                                                                            | Dashboard development: List of indicators systematically monitored (red/yellow/green)                                                                                                                                                                      | Low                                                                                                                                                                                                                                                                                                                                                       | Low                                                                                                                                                                  |
| Peace Corps                                  | International  | Implementing agency                                                                                                  | Response Volunteers - health systems strengthening at district/city/municipality level                                                                                                                                                                     | Low                                                                                                                                                                                                                                                                                                                                                       | Low. Some service mapping                                                                                                                                            |

## Malawi (cntd)

| Stakeholder | Classification    | Role                                                                                                                   | Projects                                                                                                                                                                                                                                                                                                                                                  | Influence                                                                                                                                                                                                | Interest                                                              |
|-------------|-------------------|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| PEPFAR      | International     | US Government; funder; service provision                                                                               | PROMIS<br>PEPFAR Expenditure Analysis<br>Working on NASA (from WA DC)<br>Funding for MC                                                                                                                                                                                                                                                                   | <b>Medium &gt;\$50M/year in funding</b><br>Less influence here than other countries due to limited \$ and strong Global Fund reliance. No PEPFAR clinics/facilities.<br>\$75M planned funding for FY2013 | <b>Medium</b><br>Parallel PEPFAR modelling processes - PMTCT model    |
| UNAIDS      | Intergovernmental | Intergovernmental organisation                                                                                         | Investment Case; Modes of Transmission; KYE/KYR; national estimates                                                                                                                                                                                                                                                                                       | <b>?Medium</b> Viewed by other orgs (USAID, civil society and others) as strong, respected voice (but losing country director in August 2013)                                                            |                                                                       |
| UNC         | Academic          | University (research, education, training)                                                                             | Central Hospital, Lilongwe (clinical trials, research, training)<br><b>Maternity waiting homes</b> (USAID funding)<br><b>Obstetrics training</b><br><b>Clinical trials</b> (HPTN 052, ACTG, MTN, IMPACT, CHAVI, HVTN, RNA pooling, microbicide trials, drug resistance)<br>College of Med: Strengthening public health<br>MSM study (with College of Med) | ?Med<br>Heavily involved in clinical trials, research, training                                                                                                                                          | Low direct involvement                                                |
| UNDP        | Intergovernmental | Intergovernmental organisation                                                                                         | Investing in NSO                                                                                                                                                                                                                                                                                                                                          | Unclear                                                                                                                                                                                                  | Unclear                                                               |
| UNFPA       | Intergovernmental | Intergovernmental organisation                                                                                         | Investing in NSO                                                                                                                                                                                                                                                                                                                                          | Unclear                                                                                                                                                                                                  | Unclear                                                               |
| UNITAID     | Intergovernmental | Intergovernmental organisation - funding                                                                               |                                                                                                                                                                                                                                                                                                                                                           | Low. Currently provide \$ for all paediatric ARVs and EID but ending in fall 2013                                                                                                                        | Low                                                                   |
| USAID       | International     | Implementing agency - Support role (increasing quality, health systems)                                                | Funding UNC Maternity Waiting Homes project<br>Treatment (largest area of work), work w PIH, Dignitas<br>VMMC; BBSS<br>Place (fund?) tech support at USAID<br>Funding EMR (national e-health)                                                                                                                                                             | Low. Plays support role in Malawi<br><br>Non-PEPFAR country<br>Implmntn partners: Jhpiego, JSI, PSI, PIHope (trtmnt), Dignitas (trtmnt)                                                                  | <b>Medium:</b> geo-spatial work                                       |
| WHO         | Intergovernmental | Intergovernmental organisation. Normative guidelines, natl systems strengthening, tech support, some financial support | PMTCT<br>NHA (w/USAID and ABBA associates)                                                                                                                                                                                                                                                                                                                | Respected, normative guidelines, seen as attached w/ gov, one in the same                                                                                                                                | <b>Medium:</b> Involved with validation of MoT & Investment Framework |

## Malawi (cntd)

| Stakeholder                                                    | Classification    | Role                           | Projects | Influence                                                                                                                      | Interest        |
|----------------------------------------------------------------|-------------------|--------------------------------|----------|--------------------------------------------------------------------------------------------------------------------------------|-----------------|
| The World Bank                                                 | Intergovernmental | Intergovernmental organisation |          | Low<br>No lead presence, no one in-country, \$ goes into HIV pool and spent by NAC, currently 1/4 of \$ for MC & 1/4 for PMTCT | Low, in-country |
| <b>Interest scales</b>                                         |                   |                                |          |                                                                                                                                |                 |
| <i>Low = Very low/no direct involvement with models</i>        |                   |                                |          |                                                                                                                                |                 |
| <i>Med = some direct use of models/moderate use of results</i> |                   |                                |          |                                                                                                                                |                 |
| <i>High = direct use of models/high use of results</i>         |                   |                                |          |                                                                                                                                |                 |

