Adding value to outpatient heart failure services and the patient journey through digital transformation of services

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Statement of originality

I, Arvind Singhal, hereby declare that, except where explicit reference is made to the contribution of others, this thesis is the result of my own work, and no part of this thesis has been submitted for any other degree. Publications and presentations arising from this work are listed on page 6. Information from other sources is referenced accordingly.

The Heart Failure Patient Working Group was organised by Servier, who collected and analysed narrative data. All other data collection and analysis was performed by me, as the main investigator of the studies. Studies were designed by me with input from my supervisors Professor Martin Cowie and Dr Jillian Riley.

Copyright Declaration

Abstract

Introduction

Heart failure (HF) is a chronic condition affecting over 900,000 people in the UK. The management of patients with HF frequently involves regular face-to-face appointments. Digital transformation of care with telemedicine, remote monitoring and mobile applications (Apps) may help improve patient experience and relieve demand on services. The Covid-19 pandemic resulted in an acceleration in telemedicine.

This thesis evaluates pre-pandemic HF services at the Royal Brompton Hospital (RBH), identifying potential areas for improving patient journeys.

Methods

Retrospective cohort studies including over 200 patients were used to analyse the activities and actions resulting from HF clinic appointments over 3 years.

Time-and-motion studies were conducted for each of the 4 consultant-led HF clinics at RBH, where flow through hospital was analysed for 58 patients.

Eight clinicians and 8 patients who had undergone telemedicine consultations were interviewed about their experiences and perceptions, with narrative data thematically analysed.

Focus groups and existing educational material were used to design an educational App for HF.

Results

Most HF patients under long-term follow-up were followed up twice yearly. At clinic visit, worsening HF symptoms and therapy change by clinicians were uncommon (21% and 36% of appointments respectively).

Patients spent a median of 103 minutes in hospital on the day of an appointment for a median 20-minute consultation. The majority of consultations ran late.

Clinicians and patients found telemedicine consultations generally acceptable, but both groups identified changes in time utilisation, clinical assessment, communication, and technology. Telemedicine appointments were shorter and involved less time waiting and travelling for patients. Patients and clinicians agreed that when patients are "stable", telemedicine is preferred.

A prototype HF educational "Avatar"-based App was produced.

Conclusion

Digital transformation of outpatient services, including telemedicine can improve patient and clinician experience, efficiency and rationalise limited resources, thus adding value to outpatient HF care.

Publications and published abstracts related to this thesis

Publications

1. Singhal A, Cowie MR. Digital Health: Implications for Heart Failure Management. Card Fail Rev. 2021 May 11;7:e08. doi: 10.15420/cfr.2020.28. PMID: 34035953

Published abstracts

1. Singhal A, Pan J, Cassimon B, Cowie MR. What actually happens in a specialist heart failure clinic? Heart 2021;107:A103-A104. British Cardiovascular Society Annual Conference 2021, Online.
2. Singhal A, Ng S, Cowie MR. Patient flow through a specialist heart failure clinic: a time and motion study. Heart 2021;107:A106-A107. British Cardiovascular Society Annual Conference 2021, Online
3. Singhal A, Riley J, Cowie MR. Clinician experiences of 1 year of telemedicine heart failure clinics: the video-HF study. Heart 2021;107:A90. British Cardiovascular Society Annual Conference 2021, Online.
4. Singhal A, Tandon J, Ringrose T, Cowie MR. Designing an educational app for patients with heart failure. Heart 2021;107:A98-A99. British Cardiovascular Society Annual Conference 2021, Online.
5. Singhal A, Pan J, Cassimon B, Cowie MR. What actually happens in a specialist heart failure clinic? Supplement Article. Eur J Heart Fail 2021, 23: 2-322. European Society of Cardiology Heart Failure Congress 2021, Online.

6. Singhal A, Ng S, Cowie MR. Patient flow through a specialist heart failure clinic: a time and motion study. Supplement Article. Eur J Heart Fail 2021, 23: 2-322. European Society of Cardiology Heart Failure Congress 2021, Online.

7. Singhal A, Riley J, Cowie MR. Clinician experiences of 1 year of telemedicine heart failure clinics: the video-HF study. Supplement Article. Eur J Heart Fail 2021, 23: 2-322. European Society of Cardiology Heart Failure Congress 2021, Online.

8. Singhal A, Tandon J, Ringrose T, Cowie MR. Designing an educational app for patients with heart failure. Supplement Article. Eur J Heart Fail 2021, 23: 2-322. European Society of Cardiology Heart Failure Congress 2021, Online.

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Acronyms and Abbreviations

Acronym/Abbreviation	In Full
ACE	Angiotensin Converting Enzyme
App	Mobile Application
ARB	Angiotensin Receptor Blocker
ARNI	Angiotensin Receptor/Neprilysin Inhibitor
BNP	B-type Natriuretic Peptide
CIED	Cardiac Implantable Electronic Device
CMRI	Magnetic Resonance Imaging
Covid-19	Coronavirus Disease 2019
CRT	Cardiac Resynchronisation Therapy
DES	Discrete Event Simulation
ECG	Electrocardiogram
EHR	Electronic Health Record
ESC	European Society of Cardiology
GDPR	General Data Protection Regulations
GFR	Glomerular Filtration Rate
GP	General Practice/Practitioner
HF	Heart Failure
HFmrEF	Heart Failure with mildly reduced Ejection Fraction
HFpEF	Heart Failure with preserved Ejection Fraction
HFrEF	Heart Failure with reduced Ejection Fraction
HR	Hazard Ratio
ICD	Implantable Cardioverter-Defibrillator
ICT	Information and Communications Technology
IT	Information and Technology

IQR	Interquartile Range
LVAD	Left Ventricular Assist Device
LVEF	Left Ventricular Ejection Fraction
LVSD	Left Ventricular Systolic Dysfunction
MDT	Multidisciplinary Team
MRA	Mineralocorticoid Receptor Antagonist
NHS	National Health Service
NICE	National Institute of Health and Care Excellence
NT-proBNP	N-Terminal pro B-type Natriuretic Peptide
NYHA	New York Heart Association
OECD	Organisation for Economic Cooperation and Development
PIFU	Patient Initiated Follow-Up
RCP	Royal College of Physicians
RBH	Royal Brompton Hospital
RCT	Randomised-Controlled Trial
RM	Remote Monitoring
RR	Risk Ratio
SD	Standard Deviation
SGLT2	Sodium Glucose Transporter 2
STS	Structured Telephone Support
USA	United States of America
UK	United Kingdom
WHO	World Health Organisation

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1 Introduction

1.1 Heart Failure

1.1.1 Disease background

Heart Failure (HF) is a clinical syndrome of characteristic symptoms (shortness of breath, ankle swelling and fatigue) caused by a structural and/or functional abnormality in the heart resulting in a reduced cardiac output or elevated intracardiac pressures.[1] The prevalence of HF rises steeply with age, and the mean and median ages of a person admitted to hospital with HF in the United Kingdom (UK) are 78.4 years and 81 years respectively.[2] Over 900,000 people in the UK are living with HF and the prevalence is increasing; the number of people living with HF increased by 23% between 2002 and 2014, predominantly owing to an ageing population.[3] HF is a chronic condition, but patients may have episodes of "decompensation" whereby their HF deteriorates significantly which may necessitate hospital admission.[1] Hospitalisation due to decompensated HF is a highly significant event; the chance of dying during a HF admission is roughly 9% in the UK, and amongst patients surviving to discharge, the one-year mortality is 39%.[2] Survival is significantly worse when patients are admitted to hospital near the time of index diagnosis; patients diagnosed with HF not admitted survive a median of 2.4 years longer.[4] Unfortunately, hospitalisation for HF remains the most common route to diagnosis; nearly 80% of diagnoses were first recorded in hospital.[5] The cost of HF hospitalisation to the UK National Health Service (NHS) is estimated at over £2000 per admission,[6] and HF-related care is estimated to account for up to 2% of the total expenditure of the UK National Health Service (NHS).[6]

1.1.2 Classification of HF

HF may be classified by the acuity of deterioration, by functional limitation, and by the left ventricular ejection fraction (LVEF) as measured by cardiac imaging. Chronic HF describes the long-term syndrome whereas acute HF refers to a more rapid deterioration in cardiac function typically necessitating hospital admission. Functional limitation is most commonly assessed using the New York Heart Association (NYHA) classification devised in 1928, which uses a I-IV scale, whereby NYHA Class I is no limitation of physical activity and Class IV is severe limitation of functional activity with symptoms of HF at rest.

HF may be divided into distinct phenotypes according to the LVEF. Traditionally it was classified simply into HF with reduced ejection fraction (HFrEF) and HF with preserved ejection fraction (HFpEF), but more recently European guidelines have created an additional category of HF with mildly reduced ejection fraction (HFmrEF).[1] In the most recent European Society of Cardiology (ESC) guidelines, an LVEF ≤40% constitutes HFrEF, an LVEF of 41-49% constitutes HFmREF and an LVEF of ≥50% constitutes HFpEF. Classification by LVEF is important for guiding therapy.

1.1.3 Treatment of HF

1.1.3.1 Acute HF

The treatment of acute HF, based on expert consensus opinion as opposed to robust clinical trial data,[1,7] is aimed at restoring euvolaemia, often with diuretics, providing cardiovascular or other organ support, and optimising cardiovascular medication. Survival rates for hospitalised patients have not changed significantly in the past 20 years,[2,4] reflecting the fact that management has changed relatively little during that time.

Much of the treatment of HF is therefore aimed at preventing hospitalisation and improving long-term outcomes with chronic therapy.

1.1.3.2 Drug treatment of chronic HF

Disease-modifying therapies for HFrEF target the maladaptive physiological response to left ventricular disease. In brief, a fall in cardiac output stimulates increased activation of the renin-angiotensin-aldosterone system and the sympathetic nervous system. In the short-term, the result is an increase in heart rate, contractility and vasoconstriction which can temporarily maintain organ perfusion. In the long-term, however, this combination results in salt and water retention, increased "afterload" (the resistance to left ventricular ejection), increased myocardial oxygen demand and adverse ventricular remodelling.[8] Drugs that counter these pathophysiological processes have significantly improved morbidity and mortality in HFrEF patients. Angiotensin-converting enzyme (ACE) inhibitors, which inhibit the conversion of angiotensin I to the vasoactive angiotensin II, were amongst the first drugs to demonstrate a reduction in mortality and hospitalisation in patients with HFrEF in two landmark randomised controlled trials (RCTs).[9,10] In patients who are intolerant of ACE inhibitors, for example due to chronic dry cough, angiotensin II receptor blockers (ARBs), which directly antagonise the angiotensin II receptor, may be used as an alternative.[11] Subsequent trials demonstrated that antagonists of beta-adrenoceptors (beta-blockers) and mineralocorticoid receptors (MRAs) also reduced mortality and hospitalisation in patients with HFrEF.[12–16] Importantly, these drugs work well in combination; most patients in beta-blocker trials were taking ACE inhibitors, and most patients in MRA trials were taking both ACE inhibitors and beta-blockers. A network meta-analysis estimated that combination therapy with these three drug classes was associated with a 56% relative risk reduction

in mortality compared with none of these three.[17] Thus, European and UK guidelines have recommended that patients with HFrEF should be treated with a beta-blocker, an MRA and either an ACE inhibitor or ARB provided there are no contraindications.[1,7] Survival rates for HF patients in the UK not admitted to hospital have seen a substantial increase alongside the widespread use of this combination of drugs; 5-year survival increased from 41% in 2000 to 48.2% in 2012.[4]

In recent years there have been further advances in drug treatment for HFrEF. In the PARADIGM-HF trial, replacing ACE inhibitors with angiotensin receptor blocker/neprilysin inhibitor combination (ARNI) treatment on top of standard combination therapy resulted in a further 20% relative reduction in the composite of cardiovascular death and HF hospitalisation.[18] Sodium-glucose cotransporter 2 (SGLT2) inhibitors, initially developed for the treatment of type II diabetes mellitus, have also shown reductions in mortality and HF hospitalisation in patients with HFrEF with and without diabetes.[19,20] Table 1.1 shows a summary of the ESC recommendations for drugs recommended in all patients with HFrEF.[1]

Class of drug	Recommendation
ACE inhibitor	An ACE inhibitor is recommended for patients with HFrEF to reduce the risk of HF hospitalisation and death
Beta-blocker	A beta-blocker is recommended for patients with stable HFrEF to reduce the risk of HF hospitalisation and death
MRA	An MRA is recommended for patients with HFrEF to reduce the risk of HF hospitalisation and death.
SGLT-2 inhibitor	Dapagliflozin or empagliflozin are recommended for patients with HFrEF to reduce the risk of HF hospitalisation and death
ARNI	Sacubitril/valsartan is recommended as a replacement for an ACE-I in patients with HFrEF to reduce the risk of HF hospitalisation and death

Table 1.1 - ESC guidelines for pharmacological treatments indicated in patients with HFrEF. ACE = angiotensin-converting enzyme; MRA = mineralocorticoid receptor antagonist; SGLT-2 = sodium-glucose cotransporter 2; ARNI = angiotensin neprolysin inhibitor; HFrEF = heart failure with reduced ejection fraction

Other drug therapy may be considered in selected patients with HFrEF to improve symptoms and reduce hospitalisation. The SHIFT trial showed that ivabradine, an I_f ("funny current") channel inhibitor, reduced hospitalisation in patients with an LVEF <35% in sinus rhythm with a heart rate >70 beats per minute.[21] Digoxin is a cardiac glycoside derivative of digitalis plants, which have been used for centuries in the treatment of HF. The DIG trial, largest RCT testing the use of digoxin found a 6% reduction in the risk of hospitalisation,[22] but importantly this was before the era of routine beta-

blocker use, and thus its utility in addition to beta-blockers is unknown. Vericiguat, an oral guanylate cyclase inhibitor, has also shown possible benefits. In the VICTORIA trial, patients with HF with an ejection fraction of less than 45% were randomised to receive either vericiguat or placebo.[23] Patients in the treatment arm had a 10% relative risk reduction in HF hospitalisation. These drugs have therefore been placed in the "may be considered" category for treatment of HFrEF in ESC guidelines.[1]

Drug trials for HF therapeutics frequently use different ejection fraction inclusion criteria, and the definition of HFpEF has also changed with iterations of HF guidelines.[1,24] The EMPEROR-Preserved trial was a recent study investigating the use of empagliflozin in patients with HF with "preserved ejection fraction" which they defined as >40%. Patients taking empagliflozin had a 21% relative risk reduction in the primary composite endpoint of death or HF hospitalisation, which was primarily powered by a reduced risk of hospitalisation.[25] Many of these patients under more recent guidance, however, would be considered to have "mildly reduced ejection fraction". Using the most recent European definition of HFpEF with an ejection fraction of ≥50%, no specific disease-modifying treatments have shown mortality benefits in HFpEF in large RCTs. Retrospective analyses of neutral trials such as PARAGON-HF,[26] which investigated the use of ARNIs in HFpEF, have suggested that patients with low normal ejection fractions may have a reduced risk of HF hospitalisation with ARNI therapy,[27] but this requires confirmation with prospective trials. Treatment of HFpEF is primarily aimed at managing comorbidities that exacerbate the condition, such as type II diabetes mellitus and hypertension, however, the treatment of these comorbidities significantly overlaps with treatment for HFrEF, and so in practice patients with HFpEF are ultimately treated with similar pharmacological therapy to patients with HFrEF.

HFmrEF is a recent concept, and there is little prospective trial data from evaluation of therapies in this group. Most RCTs of therapeutics for HFrEF patients used ejection fraction cut-offs of less than 40%, but retrospective analyses of trial data from studies that included patients with ejection fractions between 40 and 50% suggest that patients with HFmrEF are likely to benefit from the treatments for HFrEF.[27–30] Thus, ESC guidelines recommend that ACE inhibitors (or ARBs), beta-blockers, MRAs and ARNIs may all be considered to reduce the risk of death and HF hospitalisation in patients with HFmrEF.[1]

In all forms of HF, symptoms of congestion are managed with diuretics, usually loop diuretics such as furosemide or bumetanide.[1,7]

1.1.3.3 Exercise as therapy

Lifestyle measures are also important in the treatment of chronic HF. Exercise training with regular structured aerobic exercise is associated with improvements in exercise tolerance and quality of life scores,[31,32] and a meta-analysis of small RCTs suggested a probable reduction in HF hospitalisation, though no clear effect on mortality.[33]

1.1.3.4 Invasive therapies

Selected patients with HF may benefit from cardiac implantable electronic devices (CIEDs). Implantable cardioverter defibrillators (ICDs) reduce the risk of sudden cardiac death in patients with symptomatic HFrEF with severely reduced LVEF due to an ischaemic aetiology.[34,35] Cardiac resynchronisation therapy (CRT) improves symptoms, morbidity and mortality in HFrEF patients with broad left bundle branch block and severely reduced ejection fraction.[36,37] Less commonly, a left ventricular assist device (LVAD) may be considered for patients with advanced HF, usually whilst awaiting a heart transplant.[38]

1.1.3.5 Education

ESC and NICE guidelines recommend education for HF patients to enable patients to better understand their disease, effectively self-care and make healthy lifestyle choices.[1,7] Lifestyle education recommended by the ESC includes advice about exercise, sleep, fluid intake, diet, alcohol, immunisation, smoking, travel, sexual activity and symptom monitoring, although most lifestyle interventions are recommended on the basis of expert opinion rather than robust clinical trial data. Patient self-monitoring is discussed in more detail below (1.1.4.3 Self-monitoring).

1.1.4 Monitoring of HF

1.1.4.1 Monitoring of drug therapy

Drug treatment for HF may have significant haemodynamic effects, or unwanted side-effects, therefore titration of medicines must be supervised to ensure dose changes are appropriate and safe. ACE inhibitors, ARBs, MRAS, ARNIs, diuretics and beta-blockers can all cause hypotension, beta-blockers can cause bradycardia, and ACE inhibitors, ARBs, MRAs, ARNIs, diuretics and SGLT-2 inhibitors can all cause a reduction in glomerular filtration rate (GFR). HF itself can also cause a decline in GFR, through a fall in renal perfusion, increased renal congestion, or both.[39] All patients with HF therefore require regular monitoring of renal function; NICE guidelines recommend blood tests for renal function at least 6-monthly, or more frequently following medication changes, or periods of instability.[7]

1.1.4.2 Monitoring of disease

Given the high morbidity and mortality of HF admissions, as well as the high costs to health services, patients with HF should be monitored for disease progression and

decompensation. This may be through formal assessments in regular clinic reviews (either in specialist clinics or general practice), self-monitoring, remote monitoring or a combination of these.[40] ESC guidelines recommend an annual ECG to monitor for arrhythmia, conduction disturbances, and QRS prolongation, as patients may become candidates for CRT.[1]

1.1.4.3 Self-monitoring

Self-monitoring involves educating and empowering patients to monitor for symptoms and signs of decompensation and disease progression. This may involve regular recording of symptoms and measuring weight and blood pressure. An increase in weight may suggest accumulation of fluid, though measuring changes in weight alone has poor sensitivity for predicting HF decompensation.[41,42] Patients may experience HF symptoms in a variety of ways, and are often unfamiliar with symptoms that may suggest worsening HF (such as worsening peripheral oedema).[43] Thus, self-monitoring requires patient education as to what symptoms should prompt them to seek medical advice. A meta-analysis of 20 RCTs comparing self-management interventions with usual care showed a marginal reduction in HF-hospitalisation at 6 months (HR 0.96, 95% CI 0.93-0.995) and no one strategy was clearly superior to another.[44]

1.1.4.3.1 Shortcomings in self-monitoring

Suggested reasons for why self-care is often insufficient include misunderstandings, and variable health literacy (the ability of individuals to understand and use information in ways which promote and maintain good health).[45–47] Health literacy in HF is discussed further in section 1.3.2. A related concept to health literacy is patient activation, which is defined as an individual's knowledge skill and confidence for managing their health and health care.[48] Patients with lower levels of activation (as measured by a self-reported tool

called the Patient Activation Measure) are more likely to feel overwhelmed by the task of managing their own health and have little confidence in their ability to positively impact on their health.[48] Some organisations have tried to use simplified aide-memoires to help patients know when to seek help; an example of such a strategy is the "traffic light" system proposed by Pumping Marvellous (a UK charity for HF patients) whereby patients are told when to contact their HF team based on specific symptoms and changes in weight.[49]

1.1.4.4 Remote monitoring of HF

Remote monitoring (RM) is the use of telecommunication technologies to monitor patient status from afar, and technologies are primarily aimed at identifying decompensation early in order to potentially prevent hospitalisation. RM comes in different forms but the best studied are structured telephone support (STS), telemonitoring systems and implantable monitors.

Structured telephone support generally involves regular telephone contact with a member of the HF team or call centre staff to provide measurements, report symptoms and assess compliance with drug and lifestyle measures. Home telemonitoring systems use similar principles but generally use automated data transfer without direct telephone contact with the HF team. A 2015 Cochrane review of 41 studies assessing RM concluded that STS (HR 0.85, 95% CI 0.77 to 0.93) and telemonitoring systems (HR 0.71, 95% CI 0.60 to 0.83) reduced HF hospitalisations,[50] however, assessing effectiveness is challenging owing to the heterogeneity of interventions and variables collected. Furthermore, STS is relatively labour intensive.[51] These limitations may have contributed to a relatively lukewarm recommendation in international guidelines where RM "may be considered".[1,52]

1.1.4.4.1 Remote monitoring through implantable devices

More recently, implantable devices may be used for remote monitoring. CIEDs such as ICDs and CRT (discussed above) may be able to collect physiological data which correlate with HF status; an example of this is the HeartLogic™ algorithm which uses respiratory, heart rate, impedance, activity and heart sound data and had a 70% sensitivity at predicting HF decompensation with an unexplained alert rate of 1.5 events per patient-year. There is currently no evidence-based intervention to an alert, and so it is as yet unknown whether this will reduce HF hospitalisation.

Implantable haemodynamic monitors, on the other hand, have shown more promise at preventing hospitalisation. The CHAMPION trial randomised NYHA class III HF patients who had been hospitalised for HF in the previous year to remote daily pulmonary artery pressure monitoring (and titration of medications in response to pressures) to usual care and demonstrated that subsequent HF hospitalisation was 33% lower in the control group (HR 0.67, 95% CI 0.55-0.8).[53] More recently, the results of the GUIDE-HF trial, which included a broader cohort of patients, were published.[54] 1000 patients with NYHA Class II to IV HF and elevated natriuretic peptides were randomised to either CardioMEMS-guided therapy titration or usual care. Unfortunately, the Covid-19 pandemic made interpretation of the study challenging, as a significant fall in the rate of hospitalisation was seen in both groups. An analysis of data collected prior to the widespread transmission of Covid-19 showed a 28% relative reduction in the rate of HF hospitalisations (p=0.007).

Outside of trial settings, the use of implantable haemodynamic monitors is currently uncommon in Europe, where cost-effectiveness may be more challenging to prove.

Remote monitoring technologies are infrequently used in the UK, and most HF care is still delivered in-person.

1.1.5 Specialist HF clinics

1.1.5.1 Disease management programmes

As detailed above, the management of HF involves pharmacological and sometimes invasive therapy, exercise, education and monitoring. In order to deliver this, ESC and NICE guidelines recommend that HF care is delivered by a multidisciplinary team (MDT).[1,7] The composition of MDTs varies depending on the setting and available resources, but may include HF specialist consultants, HF specialist nurses, pharmacists, palliative care specialists or physiotherapists.[55] The goal of the MDT is to deliver a "disease management programme" which should be patient-centred and should focus on the prevention of disease progression, and improvement of symptoms and prognosis. The key components of a disease management programme according to the ESC include:

- Optimising management (lifestyle, pharmacological and devices)
- Patient education, with emphasis on self-care and symptom management
- Provision of psychosocial support
- Follow-up after discharge
- Easy access to healthcare, especially to prevent and manage decompensation
- Assessment of (and appropriate intervention in response to) changes in clinical status
- Access to advanced treatment options and palliative care.

A 2017 network meta-analysis in which 10 RCTs compared disease management programmes to usual care in patients recently hospitalised for HF found that disease management programmes were associated with a 20% reduction in all-cause mortality relative to usual care (RR 0.8, 95% CI 0.67-0.97).[56] A similar Cochrane review was performed in 2019 examining different disease management interventions in HF.[57] The study included 47 RCTs, of which 28 were case management ("the active management of high-risk people with complex needs, with case managers"), 7 were clinic-based models (such as enhanced or novel service provision, e.g. a new nurse-led HF clinic), 9 were multidisciplinary interventions ("a system of co-ordinated healthcare interventions and communications… in which patient self-care is significant") and 3 could not be categorised as any of these. The Cochrane review found limited evidence for the effect of disease management programmes on mortality due to HF, though case management and multidisciplinary interventions were associated with a probable reduction in all-cause mortality and HF readmission. A key limitation is that interventions were heterogeneous and that the comparator of "usual care" also differs greatly in different settings. It is therefore not clear which components of a disease management programme confer the most benefit, and how best they should be delivered.

Traditionally, outside of emergency hospitalisation, the majority of HF care including diagnosis, treatment and education has been delivered through periodic outpatient clinic appointments. It is therefore important to explain the historical context of outpatient clinics.

1.2 Outpatients

1.2.1 History

Outpatients are those who visit a hospital for medical care without being admitted (i.e. allocated a bed allowing for an overnight stay). Some form of outpatient care has likely always accompanied hospitals, but the first recognised outpatient departments appeared in Paris in the 17th century where a group of physicians scheduled regular sessions to advise patients who were not able to be admitted into hospital wards.[58] The first recorded outpatient clinic in the UK was the Royal College of Physicians dispensary, founded in 1696, but in the 18th century several hospitals opened outpatient departments primarily providing care on a charitable basis for patients who could not afford inpatient admissions.[58]

The number of attendances to outpatient departments increased dramatically in the mid-19th century, such that in 1878 the physician and later Poet Laureate, Robert Bridges, calculated that he was seeing an average of 148 patients per day:[59]

> *"What a busy scene he will picture to himself! Where in the world, he will ask, do all these patients come from? What is the matter with them? Have they anything the matter with them? What becomes of them afterwards? Do they ever go there again?... What does it all cost? Who pays for it and what is the use of it?"*
>
> – Robert Bridges

Hospital overcrowding and tensions between hospitals and general practitioners (GPs, who at the time were losing income from patients going to outpatient departments) led to growing clamour for reform. Thus, at the end of the 19th century, many outpatient departments gradually introduced requirements for patients to be referred by GPs to

control the number of outpatient appointments, and designate GPs as the "gatekeeper" to hospital care.[58]

Whilst care provided by hospital outpatient departments had been provided on a predominantly charitable basis, most patients had to pay to see their GP, leaving many without easy access to medical care. The National Insurance Act of 1911 ensured that all low-paid and manual workers were insured against sickness and had access to medical treatment,[60] but after the First World War, the demands on healthcare services meant that most hospitals, run by a combination of charity and local government, were in deficit.

Following the establishment of the Ministry of Health in 1919, Lord Dawson's "Interim Report on the Future Provision of Medical and Allied Services" of 1920 laid the foundations for centralised provision of healthcare, based around a model of primary care, secondary care and teaching hospital services (Figure 1.1).[61] Primary health and domiciliary services comprised GPs, who would attend to patients in surgeries or at home, community nurses and pharmacies. Secondary care centres would offer specialist services either in outpatient departments or inpatient beds, and would be associated with a teaching hospital with a medical school. Although its recommendations were not actioned at the time, owing to a change in government, the report was highly influential and was a blueprint for the eventual centralisation of healthcare in the UK. In 1948, the NHS was formed by nationalising the UK's voluntary and municipal hospitals and implementing a system where each person would be registered with a specific GP as a point of entry into hospital system; services would be free at the point of use.[62] Although there have been numerous reforms to the NHS, this model of care delivery broadly remains in place.

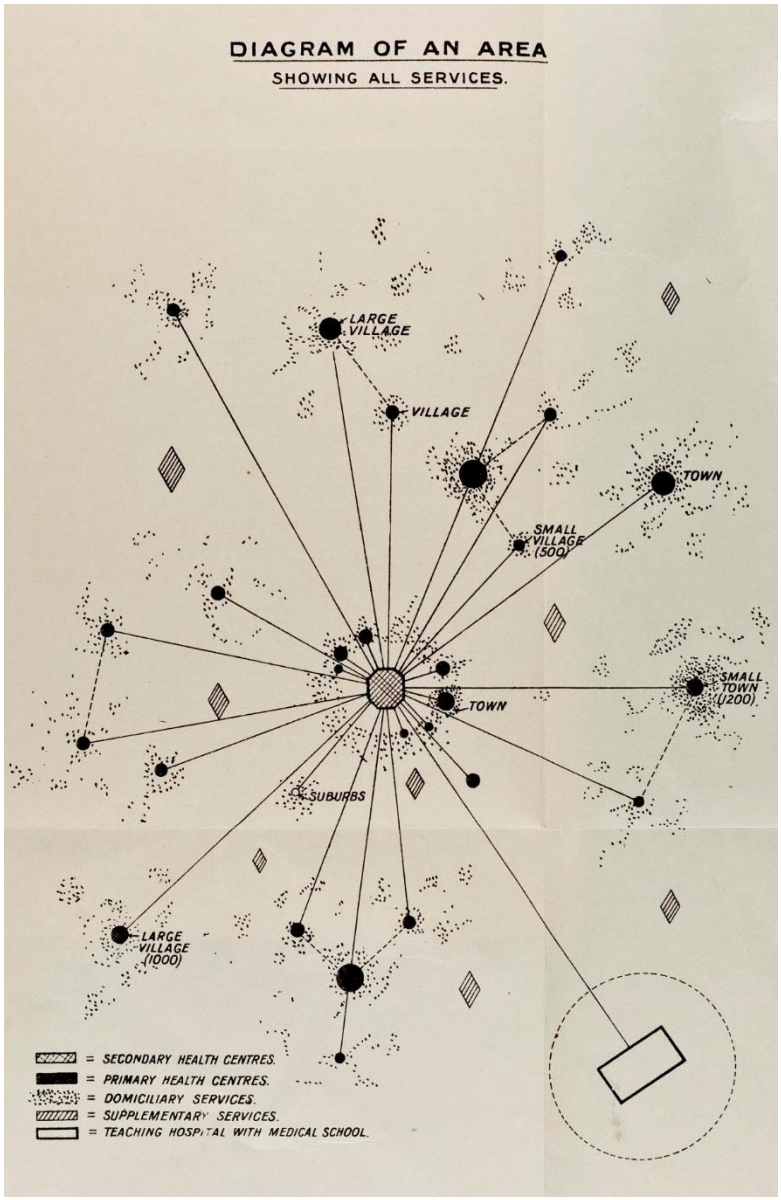


Figure 1.1 – Lord Dawson's model of health service provision. Dawson B. Interim Report on the Future Provision of Medical and Allied Services. The King's Fund Digital Archive.[63] Creative commons licence CC BY-NC-ND 4.0

1.2.2 Current model of outpatients

Despite changes to how outpatient departments are funded and organised, the actual mode of delivery of care has changed little since their inception; hospital clinicians still provide designated sessions for patients to come to into a hospital department for assessment and treatment, with GPs acting as the gateway to accessing hospital

outpatient services. Once again, however, outpatient departments are under increasing strain. The number of outpatient appointments in the England was over 120 million per year in 2019-2020, rising nearly 50% over the preceding 10 years (Figure 1.2).[64] Cardiology was the 5th largest outpatient speciality, with outpatient attendances comprising 3% of the total NHS total.[64]

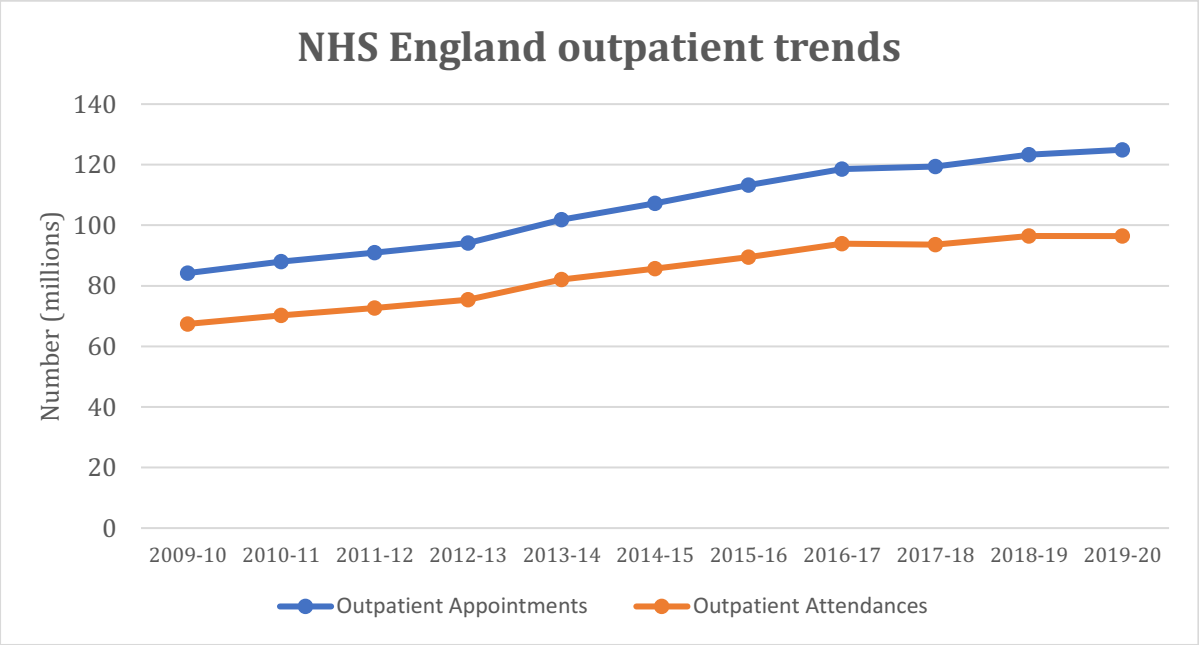


Figure 1.2 - Hospital outpatient attendances and appointments in England 2009/10 to 2019/20. Data from NHS digital[64]

1.2.3 Value-based healthcare

The growing demand on healthcare systems and the limited supply of resources has led to an increased focus in recent years on increasing the "value" derived from the available resources. The NHS constitution states that it is "committed to providing best value for taxpayers' money and the most effective, fair and sustainable use of finite resources".[65] There is, however, no universally agreed definition of value in healthcare, but a commonly used definition is "health outcomes achieved per dollar [or pound] spent".[66] Healthcare costs, however, are not only monetary and not only incurred by a single payor;

for example, even in a universal state-funded healthcare system, patients expend time, effort and money attending a hospital appointment, and these must be factored into the value equation.[67] Importantly, in a holistic view of value-based healthcare, health outcomes are not only "hard" endpoints such as mortality, but also subjective outcomes such as quality of life measures and experience of healthcare services. Several campaigns in the UK have focused in minimising low or negative value diagnostics and treatments such as the BMJ's "Too much medicine",[68] "Choosing Wisely" by the Academy of Medical Royal Colleges,[69] and the NHS "Getting it right first time" programme.[70] Few organisations, however, had examined the value of outpatient clinics until recently.

1.2.4 Outpatients: The Future

In 2018 the Royal College of Physicians (RCP) released the report "Outpatients: The Future – Adding value through sustainability" outlining several issues and proposed solutions for adapting outpatient care for modern needs using principles from value-based healthcare.[71] The traditional model of care was described as being "no longer fit for purpose" and unable to meet the growing demands and expectations placed on it. In focus groups, patients and clinicians agreed largely agreed on the general purpose of outpatient appointments; to deliver a specialist opinion to support the diagnosis and management of health conditions, and to oversee the management of complex patients (Figure 1.3).

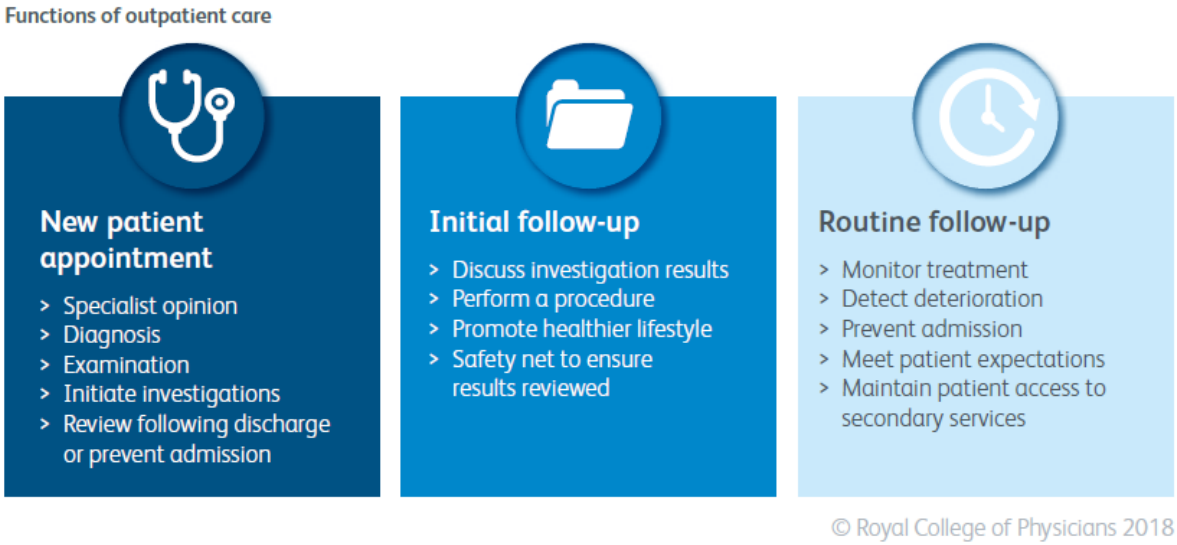


Figure 1.3 - Functions of outpatient care. Reproduced from: Royal College of Physicians. Outpatients: the future – adding value through sustainability. London: RCP, 2018.[71] Copyright © 2018 Royal College of Physicians. Reproduced with permission.

However, both clinicians and patients were frustrated by the increased demand for outpatient care, with patients reporting long waiting times and feeling that consultations were rushed. Amongst the report's "principles for good outpatient care" were that outpatient pathways should aim to minimise disruption to patients' lives, clinic templates should allow a realistic timeframe to avoid delays, alternatives to face-to-face consultations should be made available, and that access to follow-up appointments should be flexible and patient-initiated where appropriate.

1.2.5 NHS Long Term Plan

In 2019, NHS England published its "Long Term Plan" setting out its priorities for delivery of care over the next 10 years.[72] The report highlighted the pressures faced by NHS organisations, the increasing complexity of patients, and the need for redesign of care pathways, citing the RCP report as an example. The current model of outpatient care was described as "outdated and unsustainable". A key focus of the report was improving

efficiency and maximising value from limited resources. Amongst its main recommendations were that by 2024 all patients should have the right to online "digital" GP consultations, and that hospital face-to-face outpatient appointments should reduce by 1/3 over the same period; this was predicted to save the NHS over £1bn per year, allow patients to access care more conveniently, and free up significant medical and nursing time.

1.3 Digital transformation of care

Thus, digital technologies have been proposed by NHS England as an essential tool in delivering a sustainable outpatient service. Shortly after the publication of the NHS Long Term Plan, "The Topol Review" on digital transformation, commissioned by the Secretary of State for Health, was published. This independent report, led by Cardiologist Eric Topol, examined how digital technologies could impact the NHS and how best to prepare the workforce to deliver digitally enabled care.[73] The review proposed 3 guiding principles to support the deployment of digital technologies in the NHS:

- Patients should be included as partners
- The healthcare workforce needs expertise and guidance to evaluate new technologies
- "The gift of time": technologies should enable staff to gain more time to care for patients.

Amongst technologies predicted to have the greatest impact on the NHS over the next 20 years, the top 3 were telemedicine, smartphone Apps and sensors and wearables for diagnostics and remote monitoring (Figure 1.4).

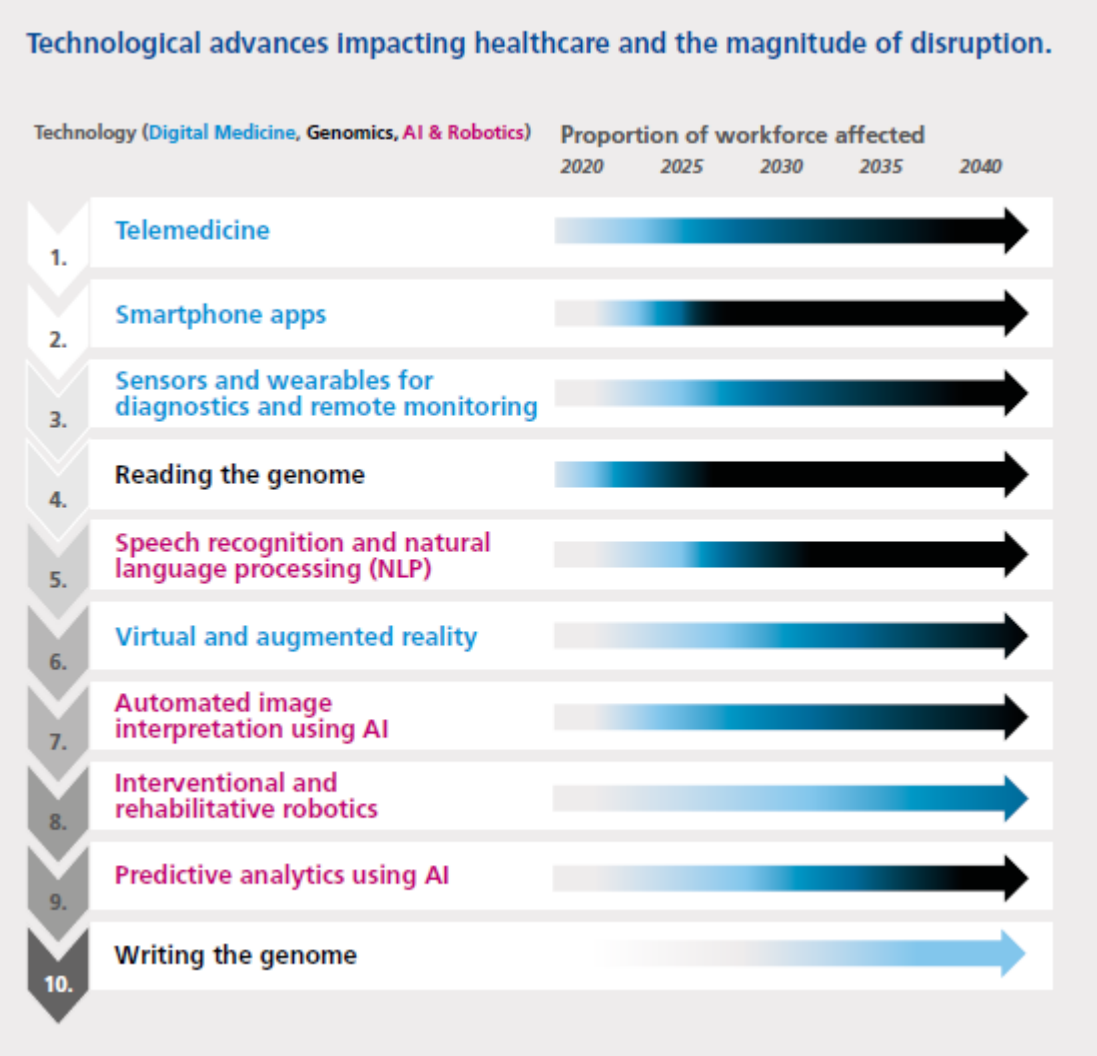


Figure 1.4 - Top 10 digital healthcare technologies and their projected impact on the NHS workforce from 2020 to 2040.[73] Arrow heat maps represent the perceived magnitude of impact on current models of care. Reproduced with permission from Health Education England

Remote monitoring has been discussed previously (1.1.4 Monitoring of HF). Telemedicine and smartphone Apps are discussed in further detail below.

1.3.1 Telemedicine consultations

Telemedicine, meaning "healing at a distance" is defined by the World Health Organisation as the "delivery of health care services, where distance is a critical factor…

using information and communications technologies".[74] The World Health Organisation recognises 4 key elements to telemedicine:

- Its purpose is to provide clinical support
- It is intended to overcome geographical barriers, connecting users who are not in the same physical location
- It involves the use of various types of ICT
- Its goal is to improve health outcomes.

Using telemedicine as a tool to reduce face-to-face contact is not a new concept; as early as 1879, a letter published by the Lancet suggested telephone consultations could reduce unnecessary doctors' visits, with an American doctor citing an example where he had diagnosed a child's cough over the telephone, thus saving a late-night home visit. Nonetheless, most doctors of the time remained against the idea, with an editorial in the Lancet 1883 expressing concern about telephone consultations making doctors too easily accessible: "when people can open up a conversation with us for a penny, they will be apt to abuse the privilege".[75]

Telemedicine consultations can be either by telephone or, more recently, by online video. Use of telemedicine for delivery of outpatient services was relatively uncommon pre-Covid-19, even in developed countries. An Organisation for Economic Co-operation and Development (OECD) report on telemedicine published in 2020 estimated that telemedicine consultations represented approximately 0.1-0.2% of appointments in the USA, Canada, Australia and Portugal.[76] The most frequently cited barrier to adopting telemedicine services in these countries was the lack of clear reimbursement mechanisms. In the UK, however, nearly 4% of hospital outpatient appointments and

approximately 13% of GP appointments were conducted by telemedicine in 2019,[77] perhaps reflecting the efforts of the NHS to increase telemedicine use.

A 2018 report by the Health Foundation included a survey of over 2000 UK adults on their willingness to use telemedicine consultations for GP appointments.[78] 55% of respondents reported they would be willing to have a video consultation with their GP for an ongoing problem or condition, and there was little variation across age groups; nearly 50% of those aged over 65 would still be willing to have a video consultation for an ongoing condition, though importantly nearly a quarter of over 65s would not be willing to have a video consultation in any scenario tested. Interestingly, respondents were more willing to use video consultation with a previously unknown GP than their regular GP. There was also variation across income groups, with those in higher income brackets more likely to be willing to use video consultation.

Telemedicine has been most widely evaluated in primary care, where it has been in use for longer and with a greater proportion of consultations than secondary care. A more detailed literature review of studies evaluating patient and clinician experiences of telemedicine consultations is presented in the discussion of Chapter 5. In brief, those patients and clinicians who have used video consultations in primary care have generally reported good satisfaction,[79] with patients reporting reduced travel time and effort and decreased wait times,[80] and clinicians reporting improved efficiency and flexibility.[81] Evaluation of telemedicine consultations as a replacement for HF appointments (i.e. not remote monitoring in addition to usual care) has been limited so far.

1.3.2 Apps

Smartphone applications ("Apps") are computer programmes designed for a particular purpose for a mobile device. As discussed above, a key recommendation of ESC and NICE

guidelines for heart failure is improving patient education and self-management. There is, however, wide variation in health literacy. In a survey of 8000 patients across eight countries in Europe, 47% of participants had low or inadequate health literacy;[82] this rose to 61% for those with more than one chronic illness. Patients with HF frequently lack knowledge and a clear understanding of heart failure and self-care[45] and patients with heart failure report not being given enough information about their condition or being given complex information that they didn't understand.[83] Thus, new methods of communicating information overcoming literacy barriers whilst engaging patients are necessary to improve heart failure care.

Patients increasingly use online health resources for education; 63% of UK adults report using the internet to look for health-related information, more than doubling over the last 10 years.[84] The growing demand for online patient education resources has resulted in a proliferation of Apps; in 2017 it was estimated by the FDA that 325,000 healthcare Apps were available for smartphones.[85] Despite this, a 2020 review found only 10 Apps specifically designed for patients with HF on Google and Apple stores.[86] Online resources and Apps may help to deliver education in a way that is easier to understand; visual aids, animations and interactivity could theoretically help overcome health literacy barriers, but research into their use is limited.

"Avatar"-based Apps, i.e. those which make use of an interactive animated character, have undergone early evaluation for patient education in chronic diseases such as diabetes, rheumatoid arthritis and ischaemic heart disease. A 2019 systematic review of 8 studies using Avatar-based Apps for chronic diseases found that 4 studies reported a statistically significant improvement in knowledge and 3 showed improvements in self-management

behaviours, but of the 3 studies which examined quality of life and medication adherence, none showed a statistically significant benefit.[87]

1.3.3 The "digital divide"

Not all patients benefit equally from digital transformation. The digital divide refers to the gap between individuals and groups who benefit from digital technologies, and those who do not. Factors associated with low uptake of digital technologies include older age, low health literacy and lower socio-economic status.[88] A related concept is "digital literacy" which is the ability to use information and communication technologies to find, evaluate, create, and communicate information.[89] A 2019 report by Lloyds Bank estimated that 22% of the UK population did not have the essential digital skills needed for day-to-day life;[90] this includes 11% who cannot switch on a device and 13% who do not know how to open an App. Access to home internet varies significantly with income, with only 51% of households earning between £6000 and £10000 annually having a home internet connection, compared with over 99% of households earning over £40000.[84] The most common reason given by UK adults for not having home internet access was that they perceived they did not need it, followed by a lack of skills.[84] Co-design of digital interventions with patients is therefore essential for wide uptake and to ensure services are fit for target audiences. Financial support from healthcare systems to help purchase technology and access to high-speed internet for patients with low disposable incomes, and digital health education programmes have been suggested by the European Society of Cardiology as ways of addressing the digital divide in Europe.[88]

1.3.4 The acceleration of digital transformation due to Covid-19

SARS-CoV-2 is a human-to-human transmitted virus first reported in December 2019 in Wuhan, China, causing a respiratory syndrome later named Coronavirus disease 2019 (Covid-19). The disease was declared a pandemic by the World Health Organisation in March 2020 after significant and sustained global transmission.[91] Following rapid community transmission of the virus in the UK in March 2020, epidemiologists from Imperial College London modelled up to 500,000 UK deaths from Covid-19 unless strict social distancing measures were adopted nationally.[92] On the 16th of March 2020, the UK government announced advice that everyone in the UK should avoid all non-essential human contact and travel; this included advice on working from home, avoiding confined indoor spaces such as pubs and restaurants, and only using hospital services for emergencies.[93] On the 23rd of March, the Prime Minister announced a stay-at-home "lockdown" order; people were legally mandated to avoid all but essential interactions between members of different households in order to reduce transmission of the virus.[94] In addition, specific guidance was provided such that patients who were over 70 or had selected underlying health conditions (including HF) should avoid all non-urgent in-person contact with hospitals; hospital appointments were advised to be postponed or undertaken by telemedicine.[95] Consequently, the number of hospital face-to-face outpatient appointments in England fell from 7.3 million in February 2020 to 2.7 million in April 2020, whilst hospital telemedicine appointments rose from just over 300,000 to just under 1.5 million across the same period.[77] In general practice, the number of telemedicine consultations rose from 3.3 million in February 2020 to 7.7 million in April 2020, outnumbering in-person appointments.[77]

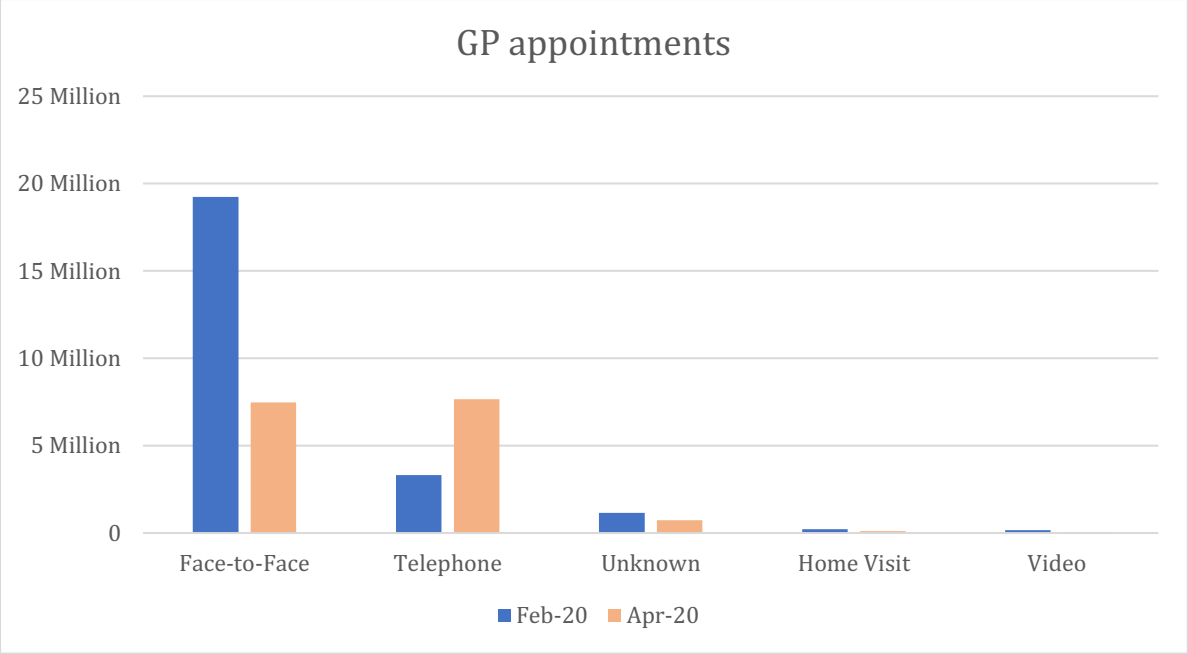


Figure 1.5 - GP appointments by consultation modality in February 2020 and April 2020. Data from NHS Digital.[96]

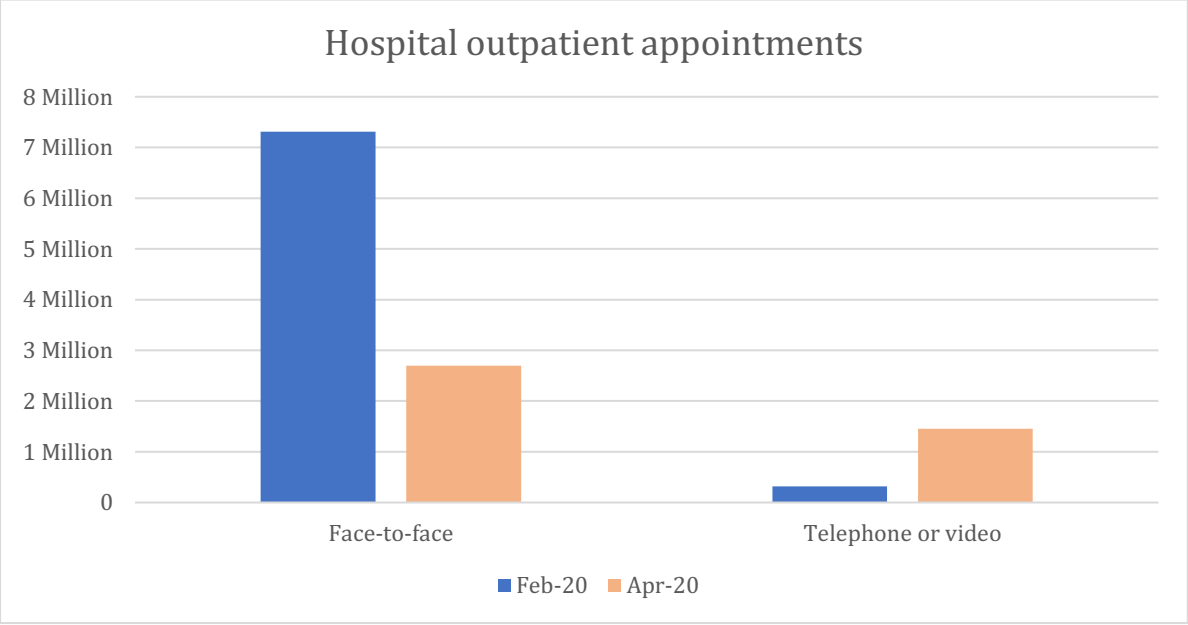


Figure 1.6 - Hospital outpatient appointments by consultation modality in February 2020 and April 2020. Data from "The remote care revolution during Covid-19" - QualityWatch[77]

1.4 The Royal Brompton Hospital

The Royal Brompton Hospital (RBH) is the largest specialist heart and lung hospital in the UK, providing tertiary level Cardiology, Respiratory and Intensive Care services. The HF service receives referrals from primary care, other hospitals and other care groups within the hospital. Prior to the Covid-19 epidemic, a Trust-wide transformation project, named the Darwin Programme, was launched to improve and "future proof" care. One of its key priorities was the redesign of outpatients, based on NHS priorities as identified above. The HF care group worked together with the Darwin team to enable video consultation for selected patients. The first video consultation by the HF team was conducted on 10th February 2020 using Microsoft™ Teams, however only 3 video consultations had been conducted before 16th March. Following the outbreak of Covid-19 and UK government's social distancing advice, the Royal Brompton Hospital adopted a "remote-by-default" approach to outpatient clinics on 16th March 2020; all outpatient consultations would be conducted by telemedicine except in exceptional circumstances. This is discussed further in Chapters 4 and 5.

1.5 Summary

Heart failure is a chronic syndrome associated with high morbidity and mortality. Heart failure clinics, based on a traditional outpatient clinic model, aim to improve prognosis and quality of life through a combination of medical and invasive therapy, education and monitoring. Demands on outpatient services have increased year-on-year such that the current model of outpatient care has been described as "unsustainable" and in need of reform. The NHS Long Term Plan has set a target for trusts to reduce the number of face-to-face appointments by 1/3 by 2024; telemedicine and delegation of activity to primary care have been suggested to reduce demand for in-person hospital outpatient

appointments. Telemedicine has been evaluated in primary care but has so far had limited evaluation in HF clinics. Patient health literacy and activation is important for adopting appropriate lifestyle measures and adherence to recommended therapies, but traditional patient education methods have had limited success for HF self-monitoring. Smartphone Apps can be used as tools for patient education but have had limited evaluation in HF.

1.6 Aims and hypotheses

This thesis aims to examine the traditional model of outpatient HF care at one specialist hospital and evaluate the shift towards telemedicine clinics. It will also consider the development and early evaluation of smartphone App for HF patient education.

Chapter 2 covers an in-depth analysis of specialist HF clinics at the Royal Brompton prior to the Covid-19 pandemic. It will explore the pathways of patients referred to the HF clinic, the actions performed, and processes involved in HF clinic appointments, and identify areas where face-to-face clinic appointments could be potentially avoided.

Chapter 3 is an examination of patient flow through specialist HF clinics, identifying areas of inefficiency and suggestions for improvement in patient flow.

Chapters 4 and 5 evaluate the experiences of clinicians and patients of telemedicine consultations for specialist HF appointments. This will be qualitative research.

Chapter 6 investigates the development of a smartphone App for HF patient education. The co-design process with patients is detailed, as well as early evaluation of the prototype App.

Chapter 7 is a discussion of the key findings of the research and its implications for redesigning outpatient HF care.

The hypotheses are as follows:

- The traditional model of HF outpatient care (pre-Covid-19) consisted of regular scheduled "routine" appointments; many activities resulting from clinic appointments did not require specialist care, and the activities performed could have been achieved in primary care or remotely.
- Face-to-face clinic appointments involve a large time expenditure for patients either side of the appointment. Attending appointments involves long journey times, multiple steps and waiting times for HF patients.
- Telemedicine consultations will be an acceptable alternative to face-to-face clinic appointments for both patients and staff who use the service.
- Patients and staff who use telemedicine consultations will find them more convenient than face-to-face clinic appointments.
- Some HF patients will not have the technology required nor enthusiasm for telemedicine consultations, and will prefer to continue with face-to-face consultations.
- An educational "avatar"-based smartphone App can be developed with patients to be used as an additional tool for patient education.
- Redesign of services could result in less unnecessary activity, increased clinic capacity and a more responsive service for patients with greatest need.

1.7 Methods

These hypotheses will be tested by a mix of quantitative and qualitative methodologies in patients with HF seen at clinics in the Royal Brompton Hospital. Detailed methods are

discussed separately for each study. Briefly, the analysis of the actions performed in clinic appointments uses a retrospective cohort study design, and quantitative analysis of data collected through electronic health records. The analysis of patient flow uses time-and-motion studies to evaluate when and how processes occur on the day of a HF clinic appointment. For the evaluation of clinician and patient experiences of telemedicine consultations, a qualitative design is used, with semi-structured interviews. Finally, for the development of the educational App, qualitative methods including focus groups are used.

2 An analysis of the actions performed in a specialist HF clinic

2.1 Introduction

Heart failure (HF) clinics provide outpatient services for the diagnosis and management of HF. According to the Heart Failure Society of America, the goals of HF clinics are "to reduce mortality and rehospitalisation rates, and improve quality of life for patients with HF through individualised patient care".[97] In the UK, National Institute of Health and Care Excellence guidelines recommend that HF care is overseen by a specialist multidisciplinary team (MDT) comprising a physician with subspecialty training in HF, a specialist heart failure nurse and a healthcare professional with expertise in specialist prescribing for HF.[7] The specialist MDT should diagnose HF, provide information to people newly diagnosed with HF, manage newly diagnosed, recently decompensated or advanced HF, optimise treatment and manage HF that is not responding to treatment.

Although guidelines outline the purpose of HF care, the optimal means of service delivery is often not discussed, or left to local decision making. Analysing what actions are performed in a specialist HF clinic and how frequently they are performed will allow HF teams to plan future care delivery and identify opportunities for service redesign based on patient needs and available resources, for example provision of remote care or delivery by community care teams.

The Royal Brompton Hospital is a tertiary centre providing specialist services for critical care, respiratory and cardiology, including HF. We aimed to examine HF clinic appointments in the Royal Brompton Hospital prior to Covid-19, when all scheduled appointments were face-to-face. We constructed two cohorts to capture activity at different stages of the HF patient journey; one cohort was of patients newly referred to the service for assessment of HF, and the second was patients who were already under follow-up by the HF service.

2.2 Methods

2 retrospective cohort studies were performed: first, a study of patients referred to HF clinics at the Royal Brompton Hospital, examining the purpose and source of referral, and what happened in each clinic visit; second, a detailed study of long-term attenders with HF, examining what happened during each clinic visit.

2.2.1 Setting

There are four consultant-led HF clinics staffed by 5 permanent consultants, and rotational training-grade doctors or clinical fellows. In addition, there is a specialist nurse-led clinic for patients under the care of one of the HF consultants.

2.2.2 Referrals to the consultant-led HF clinics

The first study examined new referrals to the HF clinics. A list of patients who were referred to any of the four consultant-led HF clinics between 01/01/2017 and 31/12/2018 was obtained from the Performance and Informatics department at the Royal Brompton Hospital. Electronic health records (EHRs) were reviewed for each patient. If they had attended an appointment between 01/01/2017 and 31/12/2018, the following data were extracted from their EHRs:

- Source of the referral
    - This was categorised into General Practice (GP), Royal Brompton Hospital outpatient department (from a non-HF consultant), follow-up after inpatient admission at Royal Brompton Hospital, referral from other hospital outpatient department, or private practice
- Reason for referral

- This was categorised into HF assessment, subspecialist assessment (e.g. referral for takotsubo or inflammatory cardiomyopathy), or other non-HF cardiology assessment

Following EHR review, patients referred for heart failure assessment were categorised into new diagnosis of HF, previously known diagnosis of HF, or HF excluded. Where the reason for referral was not stated explicitly in the referral letter or initial clinic visit, it was assumed to be for HF if the referral letter or initial consultation mentioned of one of the 3 cardinal symptoms of HF: shortness of breath, oedema or fatigue. For patients with a previous diagnosis of HF, they were further categorised by whether the diagnosis was recent (<12 months ago) or established (≥12 months ago). In instances where the diagnosis date was not specified in the referral letter, it was estimated using corroborating information such as duration of symptoms and medical therapy. In cases where the diagnosis was not stated in the clinic letter, HF was determined to be excluded if there was no mention of HF or left ventricular systolic dysfunction (LVSD) in correspondence, no LVSD on imaging and no commencement of HF therapy.

2.2.3 Detailed analysis of appointments

A detailed examination of the referrals for HF assessment was then performed. All patients who were referred and seen between 01/01/2017 and 31/12/2018 for diagnosis or management of HF, except those who had established HF (diagnosed >12 months ago) were included in the study. Patients with an established diagnosis were excluded in order to focus on patients at the start of the HF journey where patients had limited prior specialist input, and to provide a comparison with the long-term attender cohort.

EHRs were reviewed, and for each patient, investigations that had been performed or requested before the first HF clinic appointment were recorded. All clinic appointments were then examined between 01/01/2017 and 31/12/2019. For each clinic appointment note was made of the following:

- The presence of new or changing symptoms or signs of HF, or symptoms relating to HF treatment, as documented by the clinician
- Change in cardiovascular medications
- Phlebotomy request
- Echocardiogram request
- Other investigation request (including specialist imaging and arrhythmia monitoring)
- Documented patient education, advice, or discussion of HF plan
- Onward referral to another specialty or service
- Which grade of clinician saw the patient
- This was categorised into consultant, nurse specialist, or training grade doctor (e.g. registrar, fellow or core medical trainee)

In cases where it was ambiguous whether the documented action constituted HF discussion, advice, or education, discussion was assumed had taken place.

2.2.4 Long-term attenders to the consultant-led HF clinics

The second study was a detailed analysis of appointments of long-term attenders to HF clinics. A list of patients who had follow-up appointments in consultant-led HF clinics

between 1st January 2017 and 31st December 2019 was obtained from the Performance and Informatics team, and this was then compared with clinic appointment lists and electronic health records. Patients were selected for inclusion if they had completed 3 years of follow-up between 1st January 2017 and 31st December 2019 (i.e. patients had their first appointment in the HF clinic before 1st January 2017 and had follow-up booked after 31st December 2019) and met the following inclusion criteria:

- Diagnosis of heart failure with reduced ejection fraction (HFrEF – defined as left ventricular ejection fraction (LVEF) <50%)
    - Patients with left ventricular systolic dysfunction (LVSD) on echocardiography was included in this group, where a diagnosis of HF was not explicitly mentioned in the clinic letters
    - Patients who had HF with recovered LVEF were included in this group
- Diagnosis of heart failure with preserved ejection fraction (HFpEF – defined as HF with LVEF ≥50%)
- At least moderate valvular disease (defined by clinical or echocardiographic criteria) with symptoms of heart failure

A target sample of 100 patients was selected. Patients were screened sequentially until the target sample was achieved. For each clinic appointment, as per the new referral cohort, the following actions were recorded:

- The presence of new or changing symptoms or signs of HF, or symptoms relating to HF treatment, as documented by the clinician
- Change in cardiovascular medications

- Phlebotomy request
- Echocardiogram request
- Other investigation request (including specialist imaging and arrhythmia monitoring)
- Documented patient education, advice, or discussion of HF plan
- Onward referral to another specialty or service
- Which grade of clinician saw the patient
- This was categorised into consultant, nurse specialist, or training grade doctor (e.g. registrar, fellow or core medical trainee)

Patients' comorbidities were recorded as stated on their health records. Addresses of patients were recorded and an estimated journey distance to hospital was calculated by Google Maps™.

2.2.5 Statistical analysis

Data were tested for normality using the Shapiro-Wilk test. Categorical data are presented as numbers and percentages. Non-normally distributed numerical data are presented as medians with interquartile ranges (IQR). Comparisons between groups of categorial data used the Chi-square test. Comparisons between groups of non-normally distributed numerical data use the Mann-Whitney U test. A p-value of 0.05 or below was taken to indicate statistical significance. Data were processed using Microsoft Excel.

2.2.6 Governance considerations

This study was registered with the Royal Brompton and Harefield clinical audit service (Project Number 003965). Only members of the HF clinical care team accessed EHRs for the study. All patient records were pseudo-anonymised and stored in accordance with UK General Data Protection Regulations (GDPR).

2.3 Results

A total of 1868 unique patients attended appointments in one of the four consultant-led HF clinics between 1st January 2017 and 31st December 2019. A total of 5992 appointments were recorded over the 3-year period. The heart failure clinic saw a year-on-year increase in appointments. Figure 2.1 shows the total number of appointments each year.

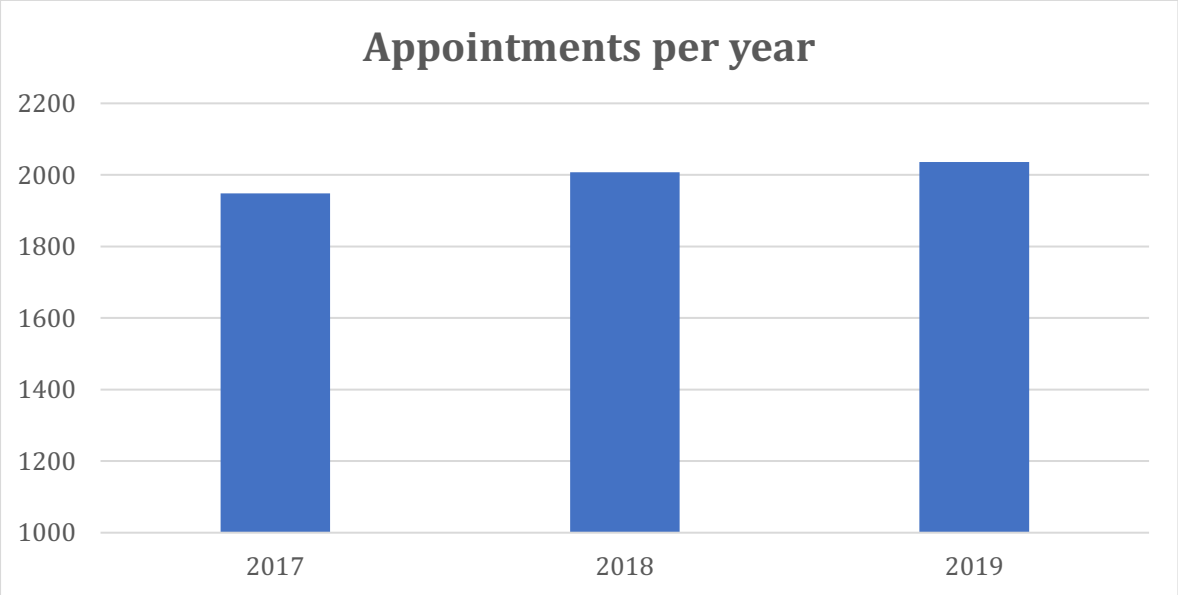


Figure 2.1 - Annual appointments in Heart Failure clinics at the Royal Brompton Hospital (2017-2019)

2.3.1 Overview of new referrals to the HF clinic

A total of 738 unique new patient referrals were made to HF clinics between 1st January 2017 and 31st December 2018. 489 of these patients attended an appointment during the same period, of which 254 (52%) were patients referred for diagnosis or management of HF; the remaining 235 patients were referred for a general cardiological opinion, or for assessment of other cardiology conditions (e.g. valvular heart disease not causing HF). Of the patients referred for HF assessment, HF had been previously diagnosed in 155 patients, and 35 patients were seen in subspecialty HF clinics for cardiomyopathy or inflammatory disease. Of the remaining 64 patients, 43 had HF excluded by specialist assessment, and 21 had a new diagnosis of HF made by the HF clinic. Figure 2.2 is a Sankey diagram depicting the outcomes of the patients referred to the clinic.

Of the 254 patients referred for HF assessment, 11 were miscoded as new referrals when they were in fact patients already under follow-up. The most common source of referral was an internal referral from another outpatient clinic within the Trust with 86 referrals (35.3%) followed by GP with 66 referrals (27.1%) and outpatient departments from different trusts with 43 referrals (17.7%). Patients who had been initially seen in private practice but then referred to the NHS comprised 31 referrals (12.8%), and finally referral following an inpatient admission comprised 17 referrals (7.0%). Figure 2.3 shows the sources of referral.

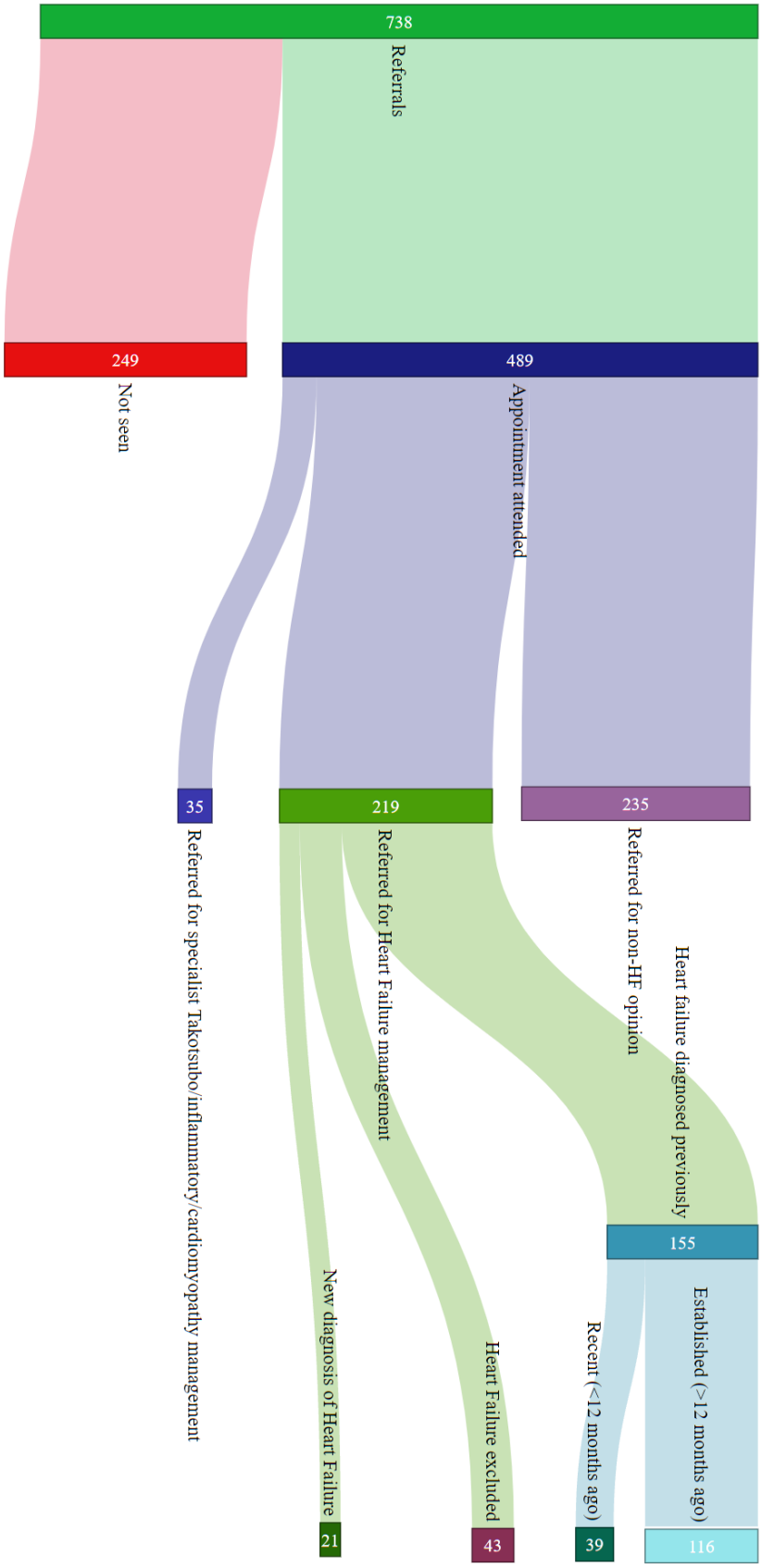


Figure 2.2 Sankey diagram showing outcomes of patients referred to HF clinic

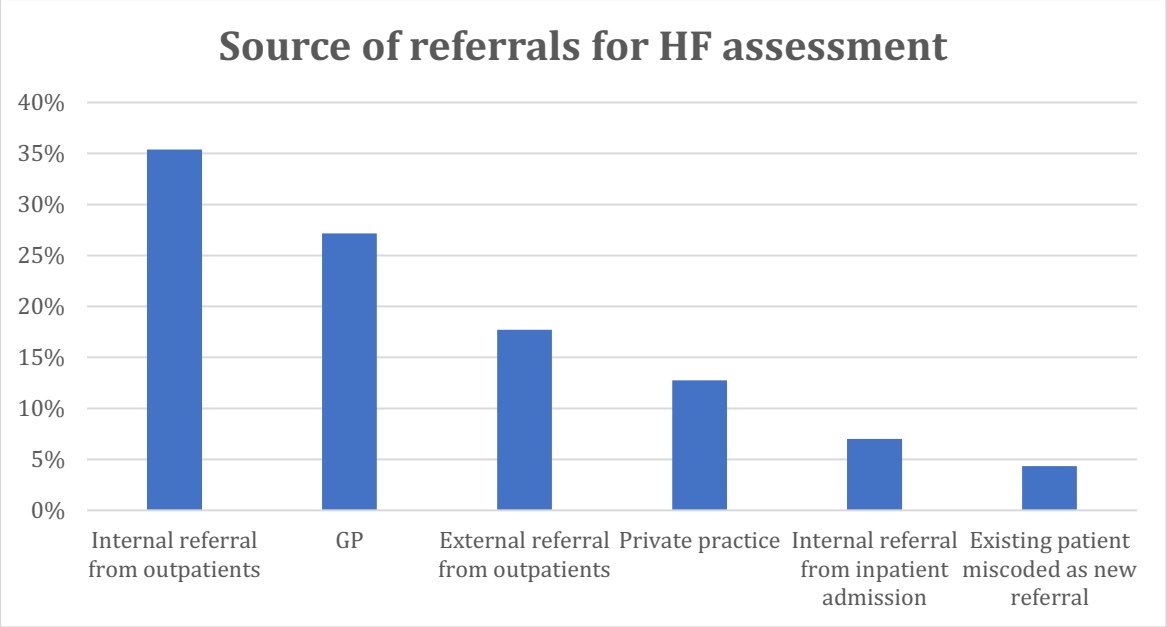


Figure 2.3 – Sources of referrals for new patients seen in HF clinics

2.3.2 Detailed analysis of new referrals

Appointments of all patients referred for HF assessment (excluding those who had established HF diagnosed >12 months ago) were analysed further. 103 patients were included for analysis; 39 had been recently diagnosed with HF (within the last 12 months) and 64 were referred for a diagnosis of possible HF. 21 of these had a confirmed diagnosis of HF, and 43 had a diagnosis of HF excluded. The median age of patients on 1st January 2017 was 67 (IQR 51.5-75) and 41 patients (40%) were female.

411 appointments were reviewed between 1st January 2017 and 31st December 2019. Patients had a median of 3 appointments (IQR 2-5) during the follow-up period.

Characteristic	Cohort (n=103)
Median age (IQR)	67 (51.5-75)
n Female (%)	41 (40%)

Table 2.1 – Demographics

2.3.2.1 Initial investigations

Most patients had already had been investigated for HF prior to assessment in the Royal Brompton Hospital HF clinic; 88 (84.6%) had echocardiograms, 41 (39.4%) had B-type Natriuretic Peptide (BNP) or N-terminal pro-BNP (NT-proBNP), and 14 (13.5%) had cardiac magnetic resonance imaging (CMRI) (Figure 2.4). 6 patients (5.8%) had none of these investigations requested or documented prior to or alongside referral to the HF clinic. Similar investigations were frequently requested on the initial visit to the HF clinic; 43 patients (41.3%) had echocardiograms, 39 (37.5%) had a BNP or NT-proBNP and 33 (31.7%) had a CMRI requested. 29 (27.9%) patients had none of these investigations requested on their initial clinic visit.

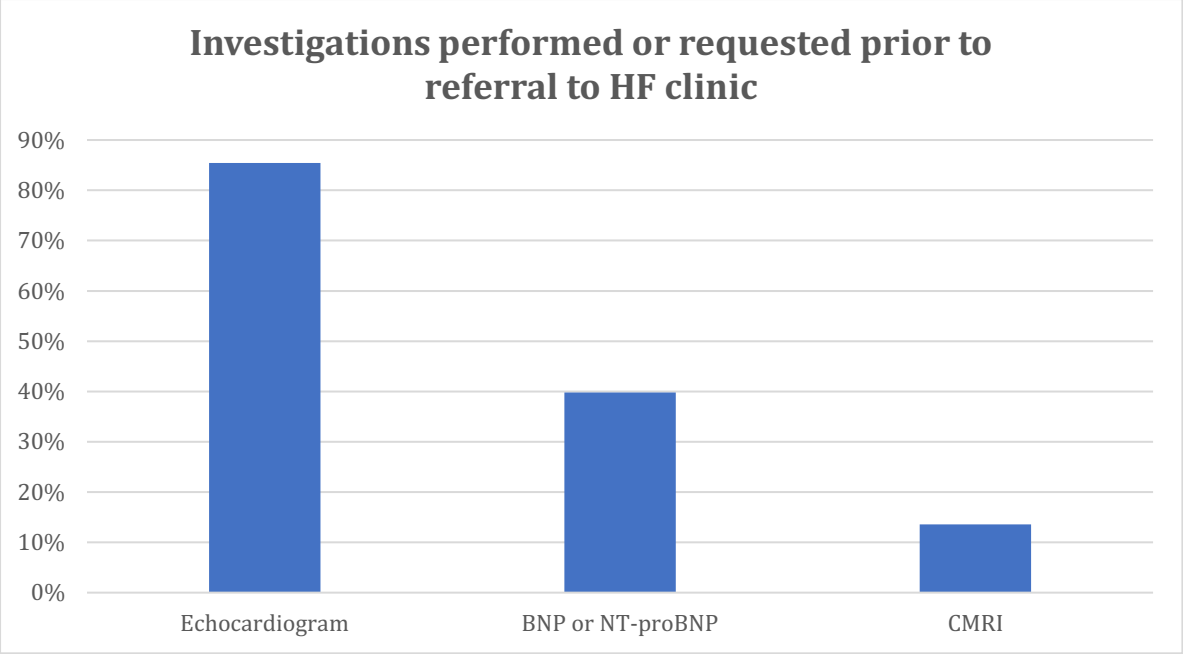


Figure 2.4 - Investigations requested or performed prior to referral to HF clinic (%)

2.3.2.2 Activity in HF clinic appointments

A summary of activity in HF clinic appointments is shown in Figure 2.5. A new or worsening HF symptom or sign was noted in 114 (27.7%) appointments. Clinicians documented education, advice or care plan discussion in 162 (39.4%) appointments and changed cardiovascular medications in 159 (38.7%) appointments. In terms of investigations, blood tests were requested in 196 (47.7%) appointments, echocardiography was requested in 124 (30.1%) appointments, and other specialist tests (such as CMRI, nuclear medicine, cardiac computed tomography or arrhythmia monitoring) were requested in 110 (26.8%) appointments.

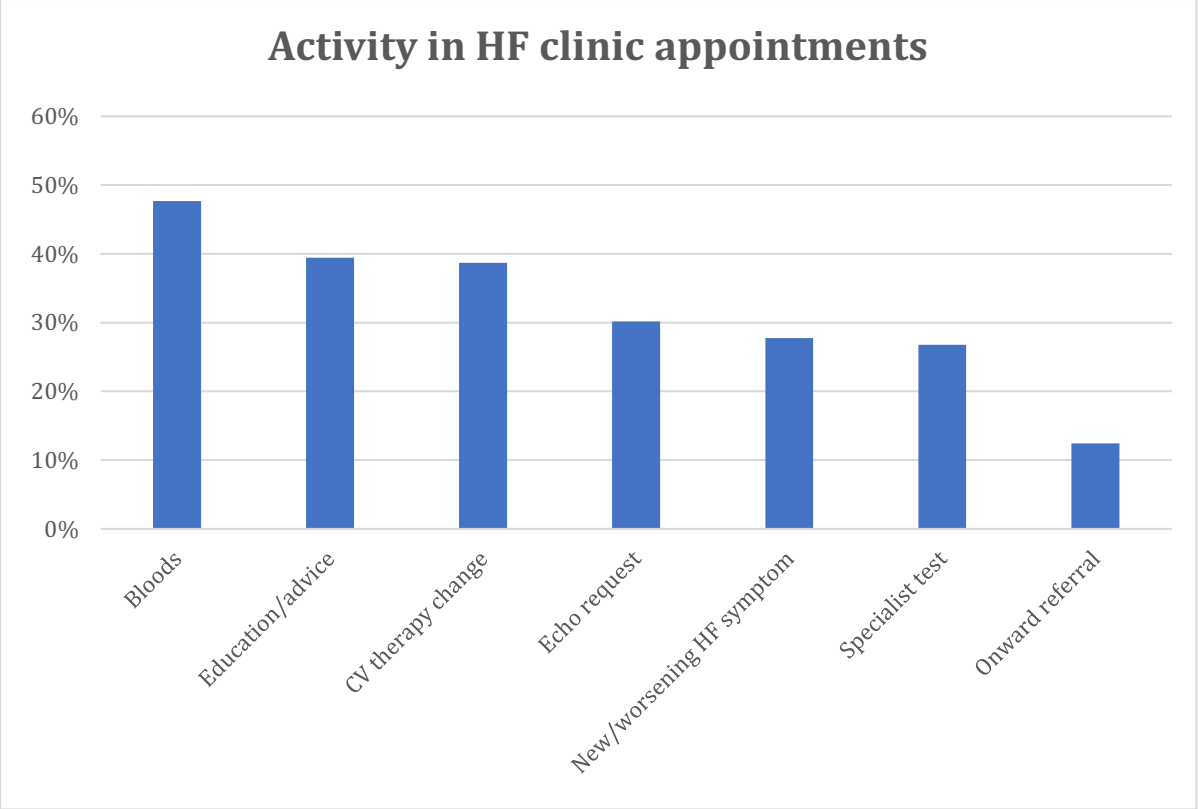


Figure 2.5 - Frequency of clinician actions or patient symptoms in HF appointments

Activities in clinic appointments differed depending on whether they were a first visit or a follow-up visit. Requesting blood tests, echocardiography and other specialist tests was more frequent on initial assessment compared with follow-up visits (Figure 2.6). New or changing symptoms were reported in 79 (76.7%) initial consultations compared with 35 (11.4%) follow-up consultations ($p<0.001$). Documentation of patient education, advice or discussion of care planning was more common in follow-up appointments (45.1% compared with 23.3%, $p<0.001$). Change in cardiovascular therapy occurred at a similar frequency in first visits and follow-up visits. Figure 2.6 shows a comparison of activities between initial visits and follow-up visits.

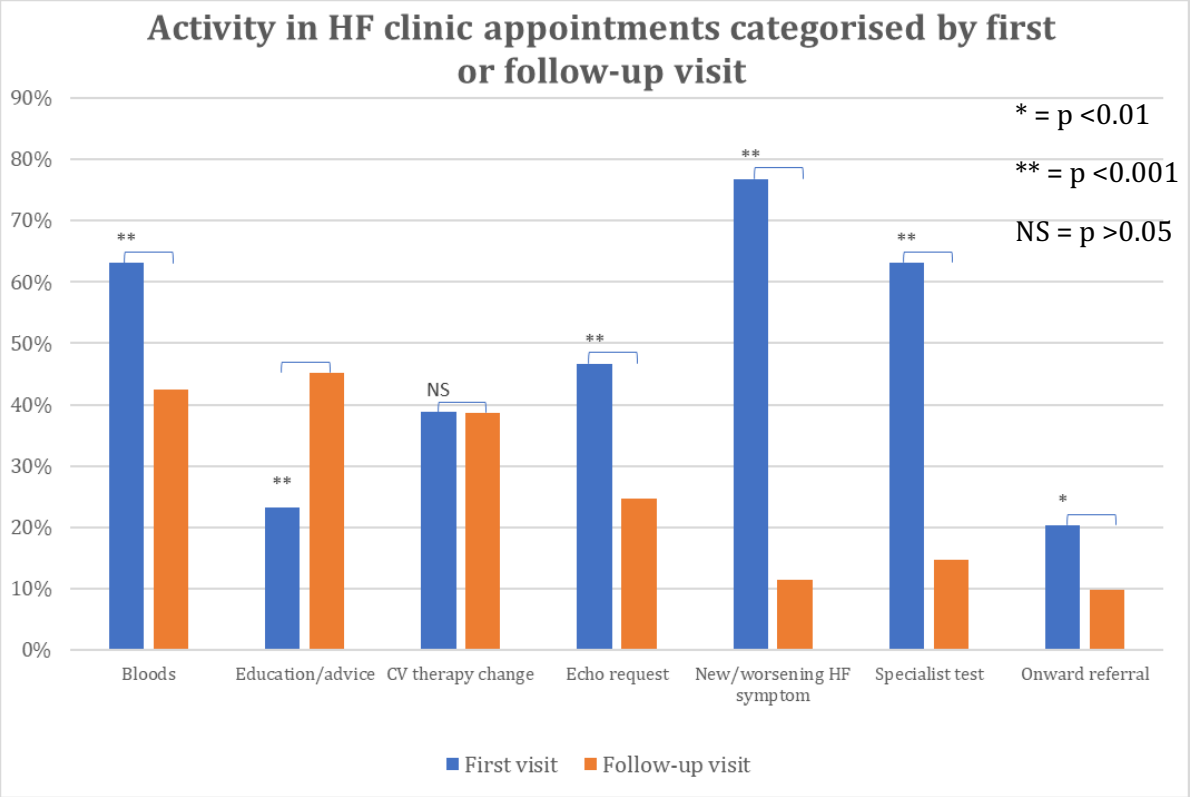


Figure 2.6 - Frequency of actions in HF clinic appointments categorised by first or follow-up visit

Patients were seen by consultants in 192 appointments (46.7%), training grade doctors in 162 appointments (39.4%) and clinical nurse specialists in 57 appointments (13.9%). Cardiovascular medications were changed in 43 nurse-led appointments (75.4%), 58 appointments led by training grade doctors (35.8%) and 58 consultant-led appointments (30.2%). Therapy change was therefore about twice as frequent in nurse-led appointments compared with doctor-led appointments ($p<0.001$, Figure 2.7), likely owing to patients being seen in nurse-led clinics specifically for medication up-titration.

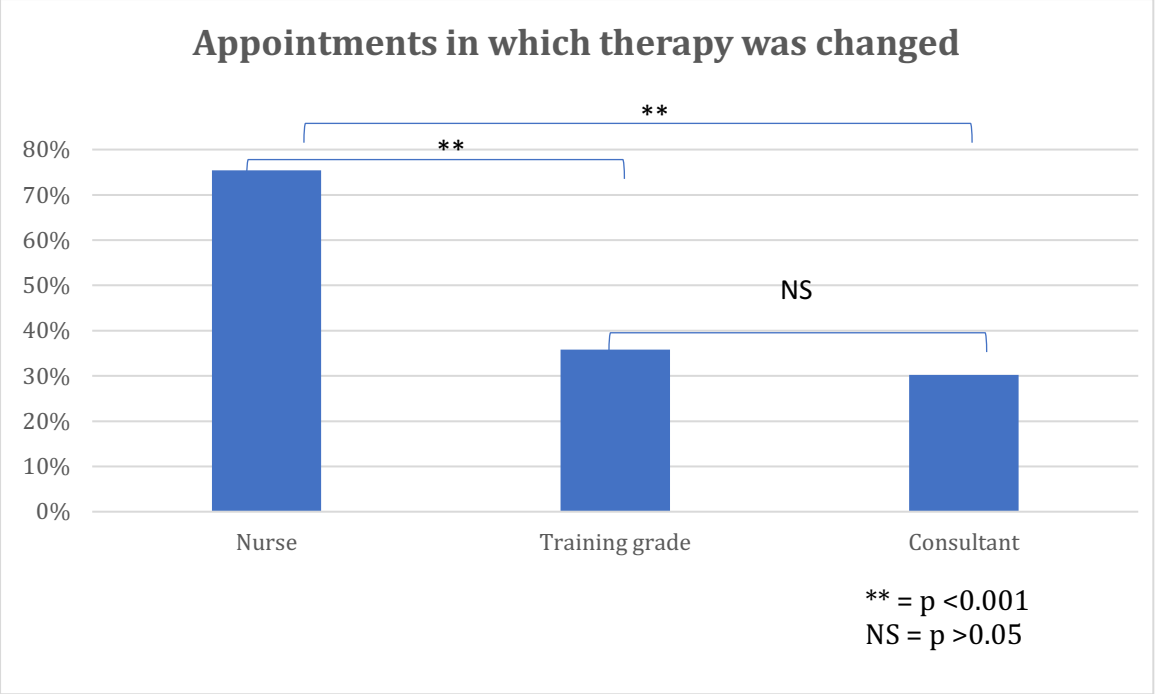


Figure 2.7 - % of appointments where therapy was changed by grade of clinician seeing patient

34 appointments (8.3%) had no documented action performed or worsening in HF clinical status. In a further 65 appointments (7.5%) the only action was a routine blood test or echocardiogram request, and in 141 appointments (18.5%) the only action was either a routine investigation request or documented discussion with the patient. Thus, in 141 appointments (34.3%) there was no documented new symptom or worsening of HF clinical status, change in cardiovascular therapy, onward referral or specialist investigation request (i.e. excluding blood tests and routine echocardiography). This is shown in Figure 2.8.

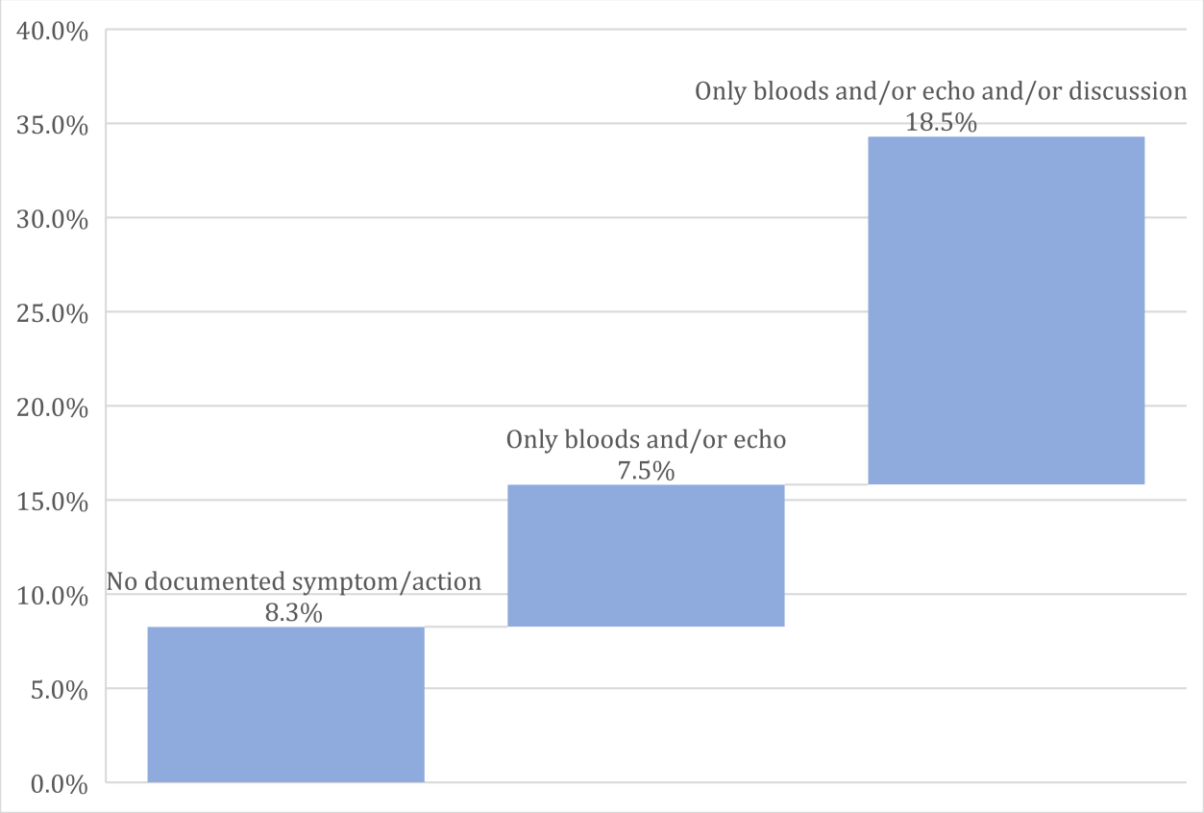


Figure 2.8 - % of appointments where only limited actions occur

90 patients (87.3%) had a follow-up appointment during the study period after their initial assessment. The median follow-up interval between appointments was 102 days (IQR 49-182), and the median follow-up interval between the initial assessment and first follow-up appointment was 93 days (IQR 63-182).

24 patients (23.3%) were discharged during the study period, and 10 patients (9.7%) died during the study period whilst under follow-up. Of the 41 patients in whom HF was excluded after assessment and investigation, 15 were discharged during the study period and 3 died whilst under follow-up. The median number of appointments before discharge was 2 (IQR 2-3.25).

2.3.3 Detailed analysis of long-term attenders

Appointments of 100 patients with HF were studied over a 3-year period. Patients were a median of 68 years old (IQR 61-74) on 1st January 2017, and 80% were male. 78% had HF with reduced ejection fraction, 11% had HF with preserved ejection fraction and 11% had HF due to heart valvular disease. Patients had a median of 3 comorbidities. Table 2.2 lists the frequency of comorbidities in this cohort.

Comorbidity	**%**
Ischaemic heart disease	46
Atrial arrhythmia	43
Valvular disease (at least moderate valve disease, or previous intervention requiring follow up)	41
Hypertension	33
Diabetes Mellitus	21
Chronic kidney disease	15
Obstructive airways disease	13
Obstructive sleep apnoea	10

Table 2.2 – Most commonly listed comorbidities of patients in cohort

666 appointments between 1st January 2017 and 31st December 2019 were examined. The median frequency of follow up was 2 appointments per year (IQR 1.33-2.67), and most patients were followed up between 1 and 3 times per year (Figure 2.9).

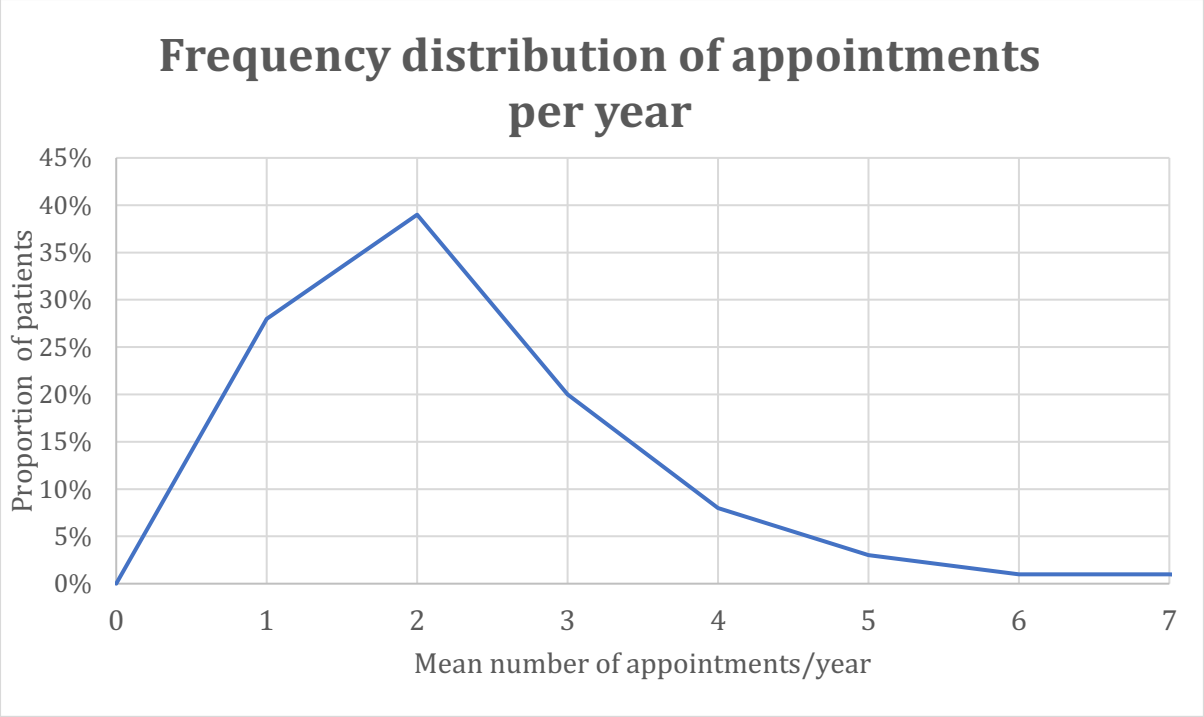


Figure 2.9 - Frequency distribution of patient appointments per year

In 311 (47%) appointments patients were seen by training grade doctors, 277 (42%) by consultants and 78 (12%) by clinical nurse specialists.

2.3.3.1 Activity in clinic appointments.

A summary of activity in clinic appointments is shown in Figure 2.10. Blood tests were the most common clinic activity, performed in 330 (49%) appointments. New symptoms were identified in 141 (21%) appointments, and 241 (36%) appointments involved a change in medical therapy.

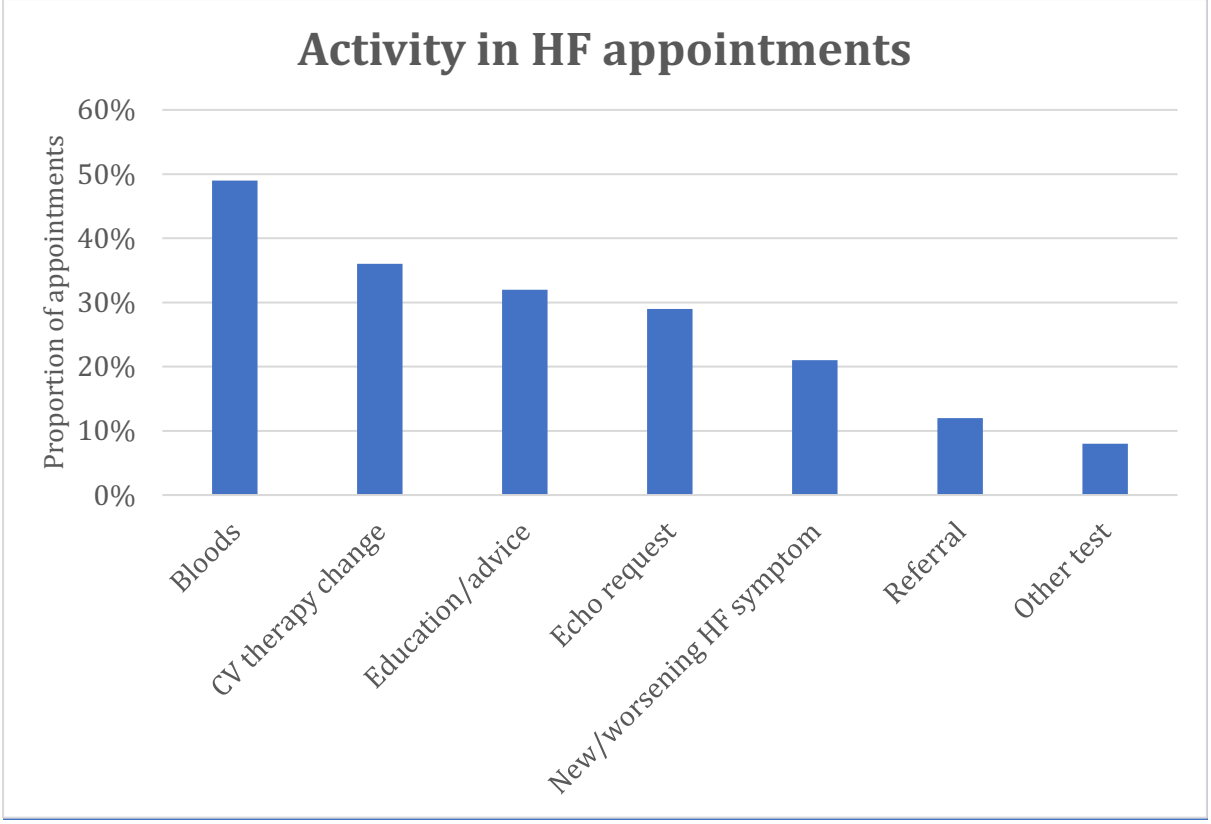


Figure 2.10 - Frequency of clinician actions or patient symptoms in HF appointments

No clinician action or worsening patient symptom was documented in 83 (12.5%) appointments, and in a further 114 (17.1%) appointments only bloods or routine echocardiography were requested. In 141 appointments (44.7%) the only action was either a routine investigation request or documented discussion with the patient, i.e. there were no new symptoms elicited, no change in therapy made, no specialist referral made, and no specialist test (excluding echocardiography and blood tests) was requested. 41 (41%) patients had no documented new or worsening HF symptoms throughout the entire 3 year follow up period. These patients accounted for 206 (30.9%) appointments.

359 appointments (53.9%) had no documented worsening or new HF symptoms or change in therapy. Where new symptoms were elicited, therapy change was more likely, occurring in 75 (53%) appointments where patients had new or worsening symptoms,

compared with 166 (31.6%) appointments without symptoms (p<0.001). Therapy change was most frequent in nurse-led clinics, occurring in 43 (55.1%) appointments, compared with 103 (37.2%) in consultant-led appointments and 95 (30.5%) appointments led by training grade doctors (Figure 2.11).

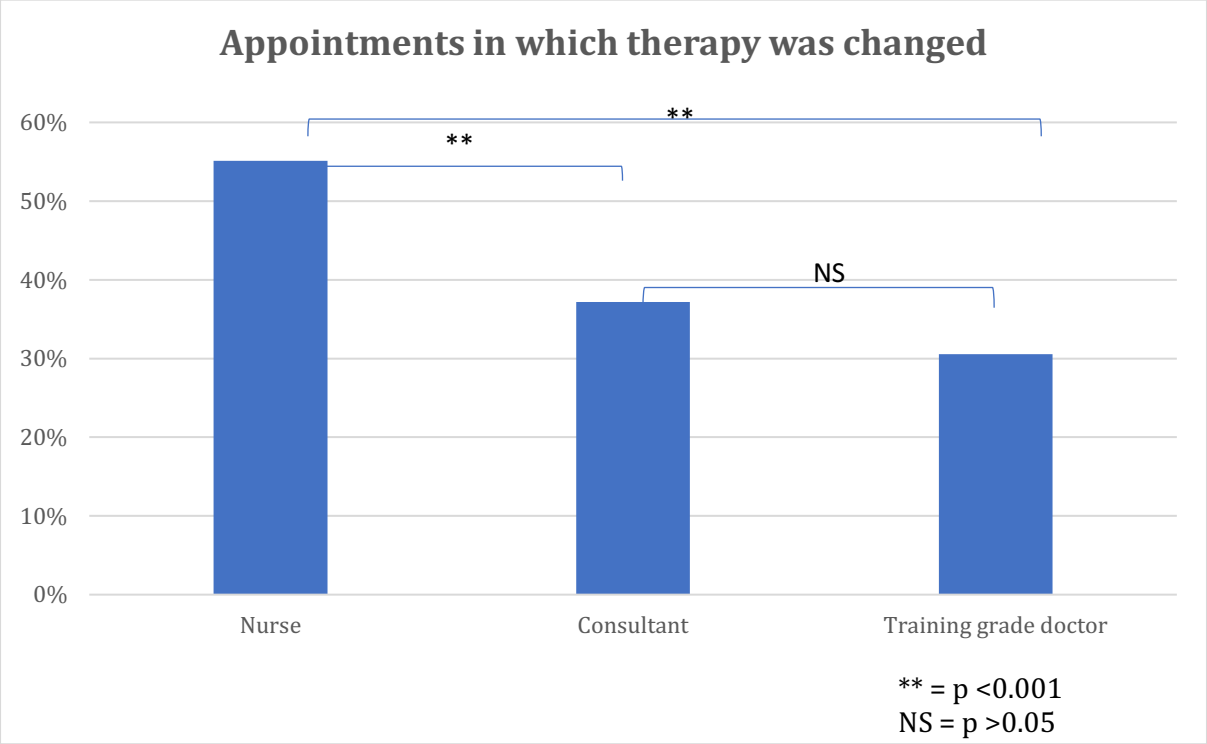


Figure 2.11 - Percent of total appointments where therapy was changed by grade of clinician leading appointment

Echocardiograms were requested in 198 (29.7%) appointments. There was no association between whether an echocardiogram was requested and whether patients had deteriorating symptoms or a change in therapy. A median of 2 echocardiograms was requested per patient during the study period (IQR 1-3). Figure 2.12 shows a histogram of echocardiogram request frequency.

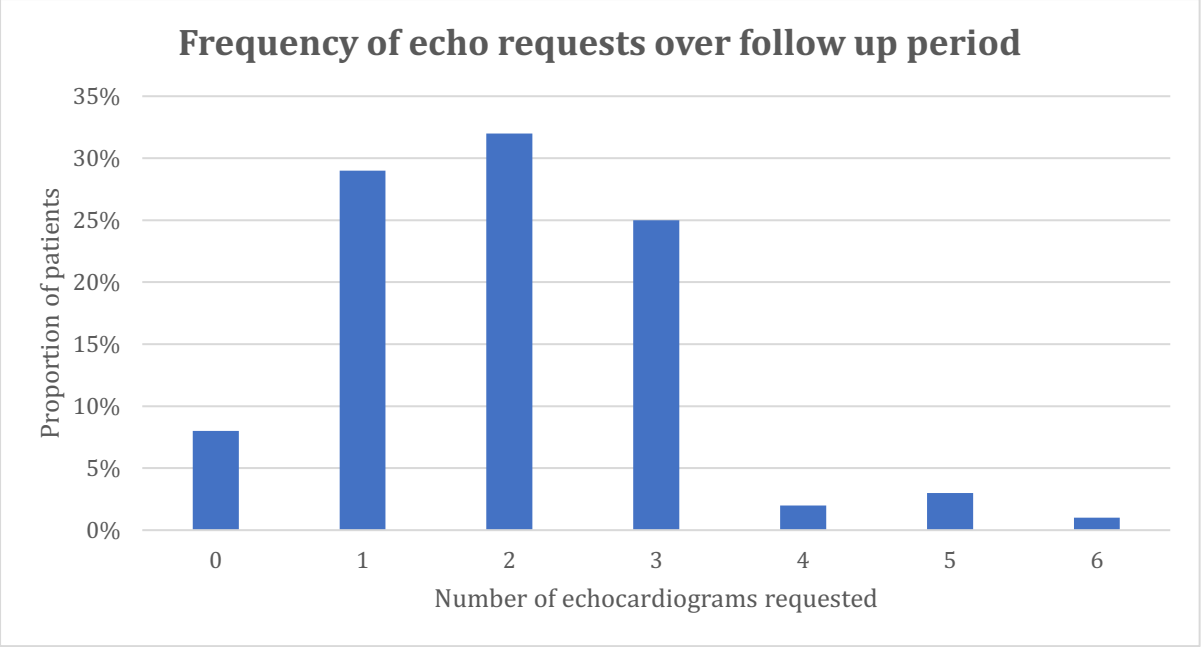


Figure 2.12 - Frequency of echocardiograms performed per patient

2.3.3.2 Follow-up intervals

The median follow-up interval between appointments was 140 days (IQR 76-189). Follow-up intervals between clinic appointments were shorter if patients had new or worsening symptoms, or if clinicians had made a therapy change; new or worsening symptoms was associated with a median follow-up interval of 106 days compared with 154 days ($p=0.0014$), and therapy change was associated with a median follow-up interval of 104 days compared with 161 days for no therapy change ($p<0.001$).

2.3.3.3 Travel times

Patients lived a median of 12.4 miles (IQR 6.3-30.0) from the HF clinic by car. The median driving time was 40.4 minutes in each direction (IQR 29.1-64.6).

2.4 Discussion

2.4.1 Summary of key findings

Cohort studies were performed of patients newly referred for HF assessment and patients under long-term HF follow-up at a specialist centre between 1st January 2017 and 31st December 2019.

Most referrals to the specialist HF clinic were not for assessment of HF, and the majority of patients referred for HF assessment had been previously diagnosed with HF. Of the 489 patients who attended a new referral appointment between 2017 and 2018, HF was newly diagnosed in 21 patients, and excluded in 43 patients. Patients referred for HF assessment had typically been investigated by echocardiography or natriuretic peptides prior to the initial assessment. Most patients had repeat assessment by echocardiography, natriuretic peptides or CMRI following the first clinic appointment. Most appointments did not reveal new or worsening symptoms, particularly after the first appointment; worsening symptoms were recorded in just 11% of follow-up appointments. Change in cardiovascular therapy occurred in nearly 40% of appointments and occurred twice as frequently in nurse-led appointments than doctor-led appointments; this is likely due to nurse-led titration of disease modifying therapy in new and recent diagnoses of HF. In approximately 1/3 appointments, the only action by clinicians was either a routine investigation request or discussion.

HF patients under long-term follow-up at the clinic predominantly had HFrEF (78%) and were majority male (80%). Patients were followed up a median of twice yearly, in keeping with NICE guidelines for monitoring of chronic HF. Worsening HF symptoms were uncommon (21% of appointments), and 41% of patients had no documented

deterioration in symptoms over the 3-year period. Therapy change occurred in 36% of appointments and was more frequent in nurse-led appointments. In 45% of appointments the only clinician action was "routine" investigation request or patient discussion. Echocardiograms were requested every 18 months on average. Follow-up intervals were slightly shorter if patients had worsening symptoms or if clinicians had made a therapy change, however median follow-up intervals were still over 3 months in both cases. Finally, patients' travel times to the clinic were estimated at 40 minutes in each direction.

2.4.2 Comparisons with other research

The mean age at diagnosis of HF in the UK is 77 and the mean number of comorbidities at diagnosis is 3.4.[3] In the present study, patients under follow-up for HF were nearly 10 years younger but similarly comorbid. The demographics of HF patients in the present study are similar to those previously reported in our centre; Guha *et al.* audited a cohort of 500 patients with HF in 2016, of whom average age was 68 years, 70% were male and 81% had HFrEF, similar to the present study.[98] Demographics also paralleled those reported by other centres; the European Society of Cardiology (ESC) Heart Failure Long-Term Registry (ESC-HF-LT-R, a study across 211 participating centres in Europe) reported a cohort of 7173 chronic HF patients with a median age of 66 years, 71.2% of whom were male and 83.7% of whom had HFrEF.[99] Thus, the demographics of HF patients in the present study are in keeping with reported data from other HF centres.

PINNACLE registry

PINNACLE is a large, national registry of ambulatory cardiovascular appointments in the USA. Allen *et al.*'s 2018 analysis of PINNACLE data for 550,581 patients with HF provides a useful comparison to the present study as it is the largest study measuring similar clinic

actions.[100] The mean age of participants in the PINNACLE cohort was 69, and 41.7% of patients in the PINNACLE cohort had HFrEF. Patients had a mean of 2.5 visits per year after the index visit, similar to the median of 2 visits per year in the present study cohorts. Changes in symptoms and signs recorded in the PINNACLE cohort were uncommon; new dyspnoea was recorded in 3.8% of appointments, NYHA class increased in 2.9% of appointments and HF signs on examination worsened in 6% of appointments. Thus, even if there were no overlap in the above (a maximum of 12.7% of appointments with documented deterioration of clinical state), symptoms deteriorated less frequently than in our long-term attender cohort (21%) and at a similar rate to follow-up appointments in the new referral cohort (11%). In the PINNACLE study, change in cardiovascular therapy was uncommon; disease-modifying treatment was altered in 12.7% of appointments and diuretic doses were altered in 9% of appointments. Furthermore, worsening symptoms infrequently led to change in therapy (diuretics were modified in 9.1% of visits and disease-modifying drugs were added in 15% of visits with worsening dyspnoea); in the present cohort of long-term attenders, 34% of all appointments 53% of appointments with worsening symptoms resulted in cardiovascular therapy change.

Thus, compared with a large national registry of HF patients in the USA, patients in the present study were of similar age and had similar follow-up frequency, but were more likely to have HFrEF, had more frequent recorded deteriorations in symptoms, and changes in therapy were more common. These differences may be related to cohort characteristics, differences in healthcare systems, or methods of recording data. Long-term attenders in the present study may have been more complex than the PINNACLE cohort owing to the Royal Brompton Hospital being a specialist centre. Furthermore, patients in the USA with HF are typically followed up in specialist regardless of their complexity, whereas more “stable” patients can be managed in primary care in the UK[7].

Patients in PINNACLE with HFrEF had similarly low rates of therapy change compared with the wider cohort, suggesting against the higher prevalence of HFrEF in the present study cohort as the reason for the more frequent changes of therapy. The PINNACLE registry used a mapping algorithm to extract data from EHRs and thus may also not have accurately captured all new symptoms and medication changes.

European HF registries do not routinely capture actions performed in clinic visits, and focus more on adherence to guidelines such as rates of disease-modifying drug prescription and device recommendation.[99,101] No comparable UK studies measuring actions performed in clinic were found.

2.4.2.1 Other studies

Echocardiograms were performed a median of 2 times over a 3-year follow-up in long-term HF attenders, and were not associated with therapy change or symptoms. Little published literature exists on the optimum frequency of repeat echocardiography monitoring in long-term patients. A 2011 study of 256 HF patients undergoing twice-yearly echocardiograms found that changes in LVEF correlated poorly with NYHA class and thus decline in LVEF could be missed by clinical assessment alone.[102] However, a 2013 review on appropriate utilisation of imaging in HF found no studies identifying an actual clinical benefit in routine serial imaging in patients when there had been no change in clinical status.[103] Nonetheless, expert consensus suggests regular monitoring of left ventricular function is reasonable.[104]

The majority of new referrals to the HF clinic in the present study were not for HF assessment, and even in patients referred for HF assessment without a prior diagnosis of HF, the majority did not have HF. This contrasts with a recent study of 1271 patients referred for HF assessment in 2 UK centres where 55% of referrals to specialist HF clinics

had an eventual diagnosis of HF.[105] The most common source of referral in the present study was an internal referral from outpatients, most of which came from the respiratory department, and thus it is possible that a high number of patients are referred with more diagnostic ambiguity but had predominantly respiratory pathology.

2.4.3 Significance and implications

We report attendances to specialist HF clinics increasing year-on-year, consistent with national outpatient trends.[64] The prevalence of HF in the UK is increasing with an ageing population, and thus demands for clinic services are likely to increase further.

Despite the present study taking place in a specialist centre reporting more frequent therapy change and deterioration in symptoms than other studies, the majority of appointments did not involve detecting worsening symptoms, therapy change or specialist test. Furthermore, when worsening symptoms or therapy change occurred, the interval to the next follow-up was a median of more than 3 months, suggesting clinic responsiveness could be improved. We suggest 3 themes of appointment that could be targets for community care or telemedicine (Table 2.3) to free up capacity for in-person appointments.

2.4.3.1 Targets for reducing face-to-face appointments

First, several appointments were "check-up" appointments whereby the purpose of the visit was clinical monitoring and routine planned review. Patients in a tertiary centre HF clinic such as in the present study may be more complex than can be monitored in general practice only, but where specialist input is still required this could feasibly be delivered by telemedicine. Furthermore, traditional outpatient monitoring at specific intervals is unlikely to correspond with patient needs and possible deterioration. NHS Improvement

is encouraging providers of ongoing care of long-term conditions to explore Patient-Initiated Follow-Up (PIFU), whereby patients who develop worsening symptoms can access care more quickly and following up stable patients less frequently.[106] This model should be explored for HF care and is discussed further in Chapter 7.

Changes in doses of medication require follow-up to ensure safety, tolerability and adherence, but we suggest that with for patients in whom dose escalation is planned at regular short intervals, for example up-titration of disease-modifying drugs, and patients have local access to blood tests and blood pressure monitoring equipment, telemedicine follow-up may be appropriate.

Finally, several appointments were made following a specialist test request to ensure the investigation was performed, the results were communicated to the patient and acted upon by the clinician. Sessions dedicated to the review of planned investigations, as seen in primary care, and telemedicine appointments to communicate results to patients could be a more efficient strategy. We created process maps of the current pathways, and proposed pathways for new referral and follow-up patients (2.6.1 - Appendix).

In addition, there is scope for reducing face-to-face contact in new referrals for HF assessment. Most patients referred for HF assessment had been properly investigated prior to being seen, with nearly 85% having already undergone echocardiography. Despite this, only 1/3 patients referred for assessment without a prior diagnosis of HF had a subsequent diagnosis of HF in clinic. Where HF is unlikely on the basis of the referral and investigations, clinician-to-clinician case discussion or telemedicine triage could reduce the demand for in-person appointments.

Purpose of face-to-face clinic visit		Why it happens	How it could be avoided
	**Routine "check-up"**	Patient/clinician feels comforted that they are being monitored	• **Telemedicine follow-up** clinic • Patient-initiated follow-up appointment • Community-led care
	**Change in dose of medication**	No current method to check it is safe to change dose	• **Telemedicine up-titration clinic:** patients have a local blood test and are reviewed in telemedicine clinic
	**Follow-up of test result**	Safety net – currently no system in place to review results	• Clinicians receive notifications when test result ready and review case notes • Communicate results by telemedicine

Table 2.3 – Targets for reduction in face-to-face contact

2.4.4 Strengths and limitations

2.4.4.1 Study population

The Royal Brompton Hospital is a specialist cardiac centre, and thus patients referred to and followed up by the HF clinic may not be representative of HF patients in non-specialist centres. All consultants working in the HF clinic are academic clinicians and may therefore have increased awareness of research and guidelines for HF management. The present cohort of new patients referred for HF assessment includes all patients referred to our centre who had not already had an established diagnosis of HF elsewhere;

therefore, there was no sampling bias. The cohort of long-term attenders, however, is a sample, as more than 2500 unique patients were seen in HF clinics during the 3-year study period. However, patient demographics in our sample corresponded well with previous studies in our centre suggesting against significant sampling bias. The long-term attender cohort only included patients who had completed 3 years of follow-up, and therefore patients who had died or been discharged were excluded. However, as the purpose of the study was to analyse activity in regular attenders, this limitation is inherent to the study.

2.4.4.2 Methodology

EHRs and clinic correspondence may not always be an accurate reflection of what happened in a clinic appointment; for example, it is possible that a clinician provided a patient with education but did not document it. All investigations performed by the Trust, however, are uploaded to the EHR, and as clinic correspondence is a medico-legal documentation of the consultation it is unlikely that clinicians would not record therapy change or worsening in HF symptoms. Thus, manual review of EHRs is likely to be highly accurate for capturing symptoms, therapy change and investigations, which is a relative strength of this study compared with registry data and automated capture.

2.5 Conclusions

We present 2 related cohort studies of patients referred for HF assessment and patients under long-term follow-up for HF over a 3-year period at a tertiary level HF service. Most patients were seen 6-monthly, and most appointments did not reveal a deterioration in symptoms or change in therapy. As clinical status changes were uncommon and may not have corresponded with clinic follow-up, a more flexible clinic model in which patients are seen in the community or by telemedicine in periods of relative stability could free up specialist HF clinic capacity to see patients sooner following deterioration, hospitalisation or new diagnosis. The following chapters will explore the time efficiency of in-person HF clinic appointments and evaluation of telemedicine HF appointments from both healthcare professional and patient perspectives.

2.6 Appendix

2.6.1 Process mapping of HF clinic activity

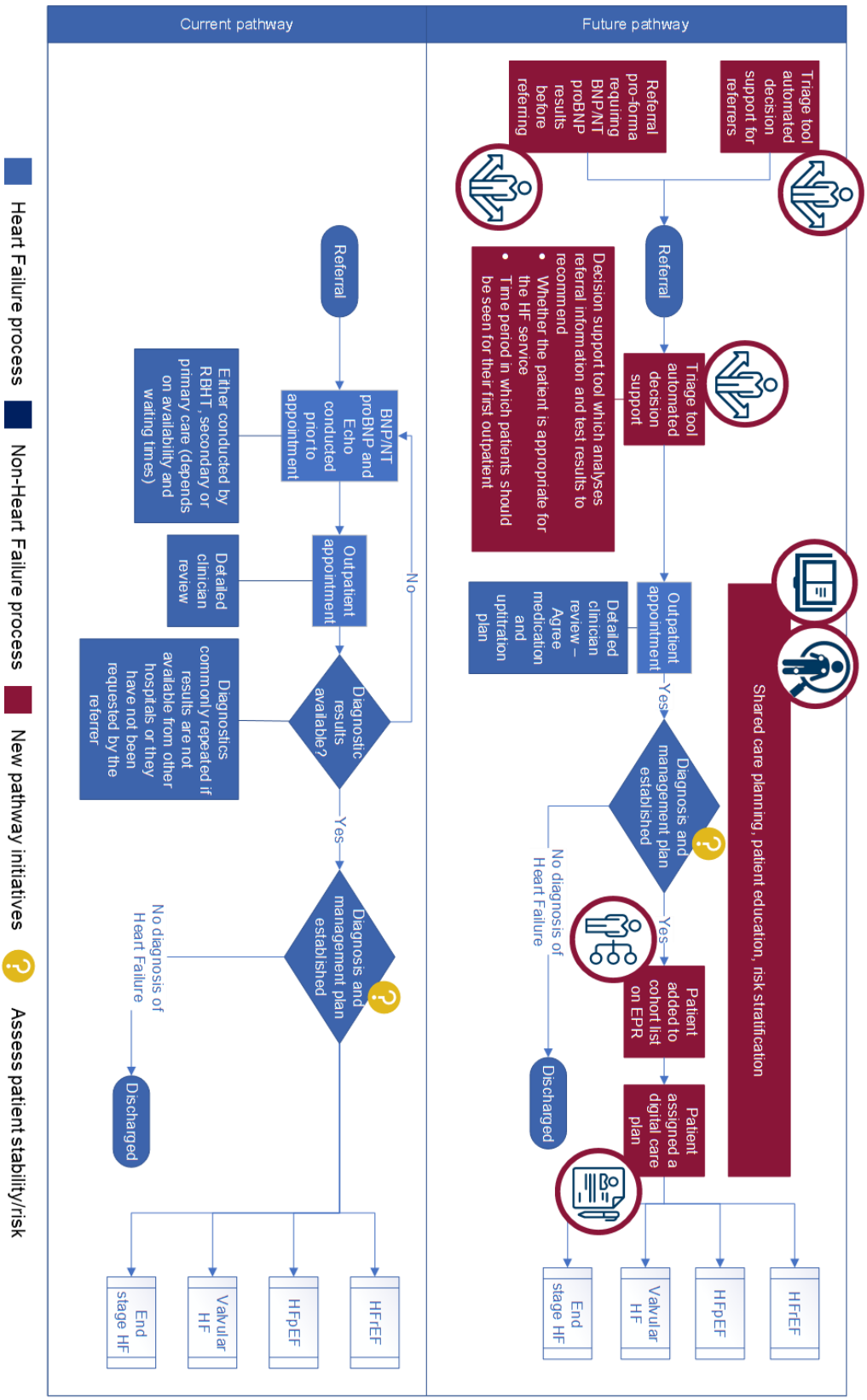


Figure 2.13 - Process maps of future and current pathways for new patient referrals to HF clinic

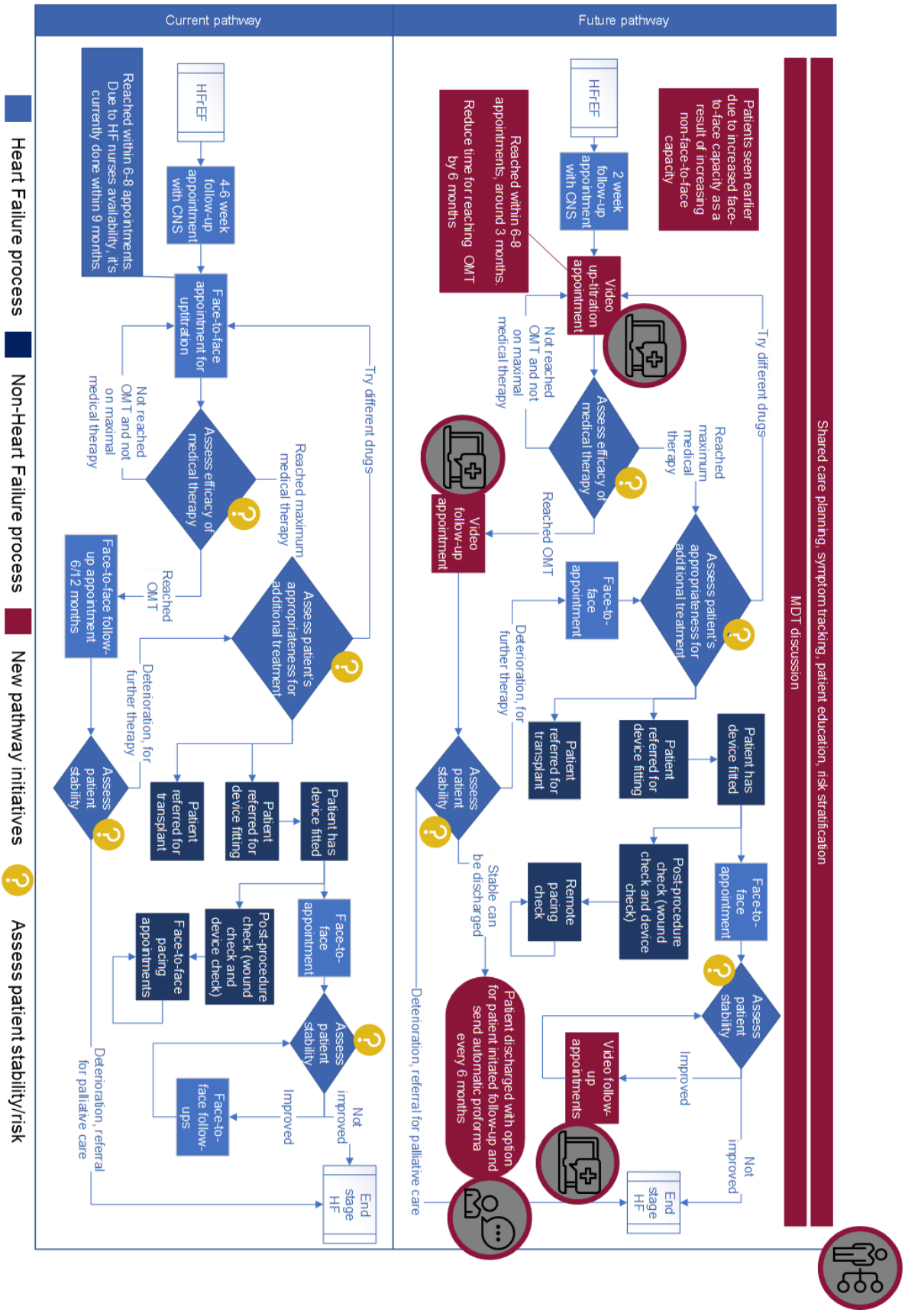


Figure 2.14 - Process maps of future and current pathways for follow-up patients

3 Patient flow through a heart failure clinic: time-and-motion studies

3.1 Introduction

Time studies, observing and timing workers performing specific tasks, were pioneered by Frederick Taylor in the early 20th century to quantify time inefficiencies from human processes.[107] Frank and Lilian Gilbreth built on these ideas and included the study of "work motions" which initially focused on the specific movements involved in an action and how to optimise a manual process, but their work soon extended into healthcare; an early observation of operating rooms was that surgeons spent more time searching for instruments than performing an operation, and that operating nurses could improve efficiency.[108] A "time-and-motion study" is a combination of these two study models, examining when (time) and how (motion) actions occur in a task. Time-and-motion studies are used in healthcare to examine workflows and processes, and identify inefficiencies.[109]

As demonstrated in Chapter 2, most HF patients at the Royal Brompton Hospital had in-person appointments for HF clinics a median of twice per year, in line with national guidance.[7] Efficient utilisation of HF clinic time therefore has potentially large implications for both patients with HF and HF services.

We sought to examine the flow of patients through the HF clinics at the Royal Brompton Hospital, and identify areas of inefficacy in the patient journey through the clinic.

3.2 Methods

The Royal Brompton Hospital has 4 consultant-led heart failure clinics, all of which occur on Tuesdays. Time-and-motion studies were conducted for each of these clinics, prior to the outbreak of Covid-19, with the patient as the focus of attention. Clinics were chosen to be representative of usual activity, i.e. with a typical number of scheduled patients and full complement of staff. Clinic schedules were obtained in advance from electronic health records, and were cross-referenced against appointments for echocardiography and pacing clinic. Clinic 1 was on 3rd December 2019, Clinic 2 was on 10th December 2019, Clinic 3 was on 17th December 2019, and Clinic 4 was on 18th February 2020. In each clinic, 2 investigators tracked the progress of patients through the clinic noting the time of arrival and departure of each patient in the following clinical areas:

- Electrocardiography (ECG)
- Echocardiography
- Pacing department
- Consultation room
- Phlebotomy
- X-ray.

Times were measured by synchronised mobile phone clocks. For ECG and phlebotomy, owing to staff availability, it was not possible to follow the patients inside the departments, and so waiting time for these investigations was not measured. Investigators focused on pre-booked appointments which were echocardiography, pacing and consultation. Patients were not observed during investigations or

consultations to ensure privacy and avoid changes in behaviour. The grade of clinician consulting the patient was also noted. If the exact time of arrival to or departure from a particular department was missed, time points were estimated based on corroborating data (for example time stamps on ECGs, chest x-rays and pacemaker reports) or omitted if they could not be estimated reliably. 2 patients were excluded from analysis owing to consultation times being missed. Estimated journey times for patients were calculated using Google Maps™, using patient postcodes as the origin and the hospital as a destination. Driving times were calculated under normal traffic conditions.

3.2.1 Statistical analysis

Data were tested for normality using the Shapiro-Wilk test. Categorical data are presented as counts and percentages. Normally distributed data are presented as means ± standard deviation (SD), whilst non-normally distributed data are presented as medians with 1st to 3rd quartile interquartile ranges (IQR). The strength of correlations between non-linear data are measured using Spearman's rank correlation coefficient (rho) test, and comparisons between groups of non-normally distributed data are performed by the Mann-Whitney U test. A p-value of 0.05 or below was taken to indicate statistical significance. Data were processed using Microsoft™ Excel.

3.2.2 Governance considerations

This study was registered with the Royal Brompton and Harefield clinical audit service (Project Number 004766). Consultations were not observed to protect confidentiality. All patient data were pseudo-anonymised and stored in accordance with UK General Data Protection Regulations (GDPR).

3.3 Results

71 patients were scheduled to have appointments across the four clinics. 3 patients (4%) cancelled or rearranged their appointments on the day of the clinic, and an additional 8 patients (11%) did not attend their appointment without any advance notice. Thus, a total of 11 patients (15%) did not attend their scheduled appointment with 2/3 not giving advance notice of non-attendance. Of the 60 patients who attended appointments, complete data were collected for 58 patients; data for consultation timings were not recorded for 2 patients in Clinic 2 and so they were excluded from analysis. 8 patients were new referrals and 50 were follow-up appointments. The mean age was 66.6 years (±13.2), and 31% of patients were female.

3.3.1 Staffing

Clinic 1 was staffed by a consultant, a middle-grade training doctor (registrar) and a junior-grade training doctor (core medical trainee). Clinic 2 was staffed by two consultants and a registrar. Clinic 3 and Clinic 4 were each staffed by one consultant and registrar.

3.3.2 Descriptive statistics

Clinic	Number of pts in study	Number cancelled/DNA	Mean age (±SD)	Female (%)	New referral (%)
1	24	2	64.5 (±13.2)	4 (17%)	1 (4%)
2	17	5 (+2 missing data)	70.4 (±13.2)	5 (29%)	4 (23%)
3	10	2	66.8 (±13.0)	5 (50%)	2 (20%)
4	7	2	64.6 (±14.1)	4 (57%)	1 (14%)
Total	58	13	66.6 (±13.2)	18 (31%)	8 (14%)

Table 3.1 – Descriptive statistics of clinics

3.3.3 Patient journey through clinic

Figure 3.1 illustrates the time spent by each patient in hospital, and when each activity occurred relative to their time of arrival.

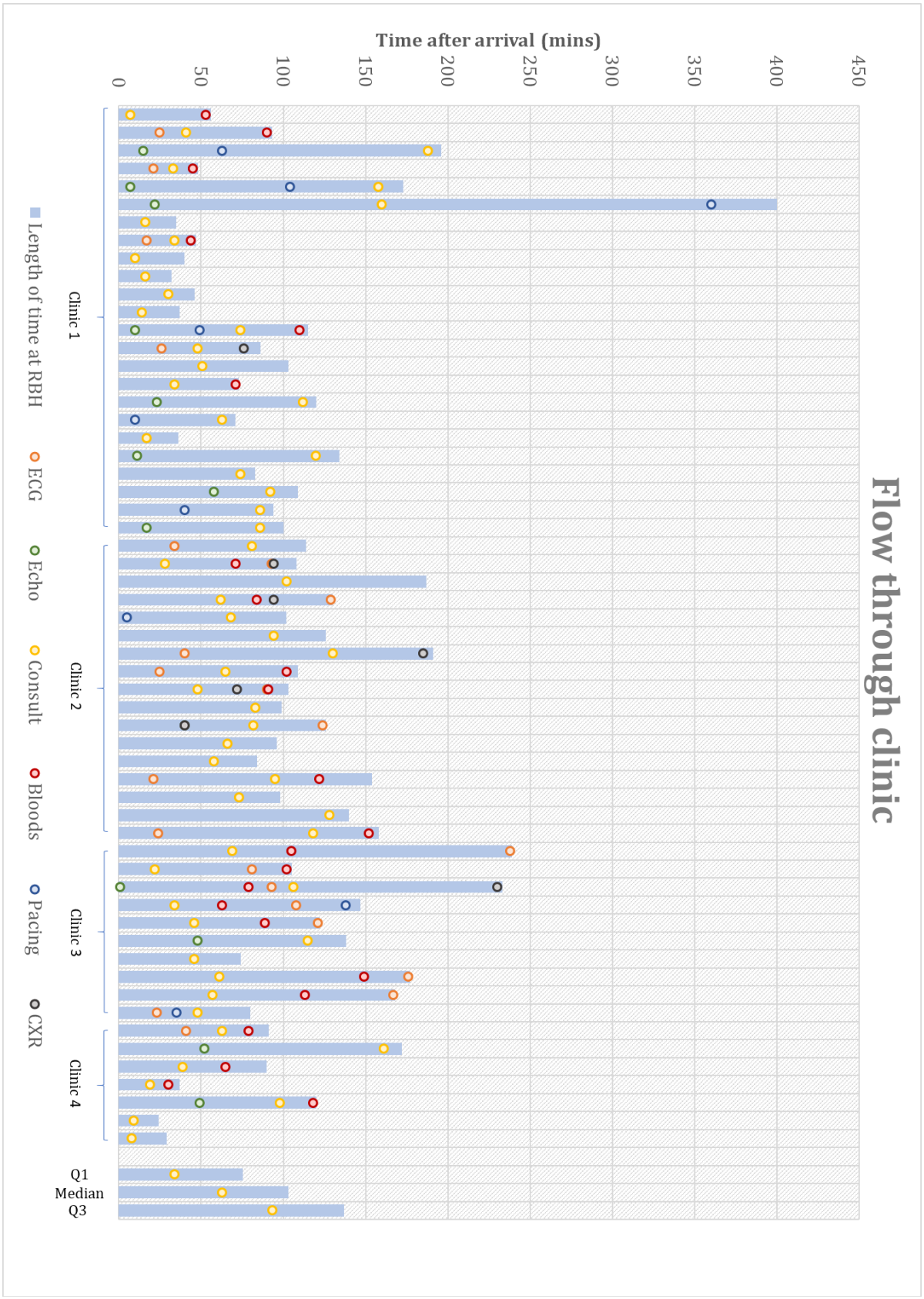


Figure 3.1 - Illustration of patient journeys. Bars represent time spent in hospital. Dots represent when investigations or consultation occurred relative to time of arrival

Patients spent a median of 103 minutes in the hospital (IQR 76 – 137 mins). Consultations were a median of 20 minutes long (IQR 14 – 27 mins), a median of 23 minutes after their scheduled time (IQR 6 – 74 mins) and a median of 93.5 minutes after patients arrived (IQR 34 – 94 mins). 49 patients (84%) were seen by clinicians later than their scheduled appointment time. Patients arrived a median of 12 minutes before their first scheduled appointment (IQR 2.75 mins late to 32 minutes early), with 16 patients (28%) arriving later than their first scheduled appointment. Patients arrived late to 12 out of 58 consultations (21%), and 10 out of 20 pre-booked investigations (50%).

3.3.4 Investigations

Table 3.2 shows the proportion of patients undergoing each investigation on the same day as their clinic appointment, and time spent in each investigation area. This includes the time taken for the test to be performed and the time spent waiting for the test.

Investigation	Count (%)	Median time spent in investigation area in minutes (IQR)
Echocardiogram	12 (21%)	29 (25 – 34)
CMRI	1 (2%)	39
ECG	22 (38%)	20 (5 – 25)
Pacing check	9 (16%)	15 (8 – 28)
Chest x-ray	7 (12%)	2 (2 – 4.25)
Phlebotomy	24 (41%)	2 (2 – 4.25)

Table 3.2 – Number of investigations performed, and the time spent in each investigation area by patients

Blood tests and ECGs were the most common tests. Pacing checks and echocardiograms usually had scheduled appointment times, usually before the clinic appointment. Of the 9 pacing checks, 2 (22%) were done after the clinic appointment without a prior pacing appointment. Pacing checks started a median of 30 minutes after their scheduled time (IQR 12 – 69 mins), however patients arrived late to 5 out of the 7 scheduled appointments. The two patients that arrived on time were seen exactly on time and 5 minutes early, respectively. Echocardiograms started a median of 14 minutes after their scheduled time (IQR 4.5 – 22 mins). 4 patients arrived late for their echocardiogram, and one did not attend the appointment. The times patients spent undergoing each investigation is illustrated in Figure 3.2. For ECG, X-ray and phlebotomy, the time includes the time spent waiting for the investigation to occur (as described in Methods). Phlebotomy and x-ray were rapidly performed, with patients spending a median of 2 minutes in each of those investigation departments, whilst patients spent a median of 20 minutes, 15 minutes and 29 minutes in ECG, pacing clinic and echocardiography respectively. One outlier who arrived late to their echocardiography appointment spent 84 minutes in the department. Patients with scheduled echocardiograms and/or pacing checks spent significantly longer times in the hospital (median time 123 minutes vs 94.5 minutes, $p = 0.005$).

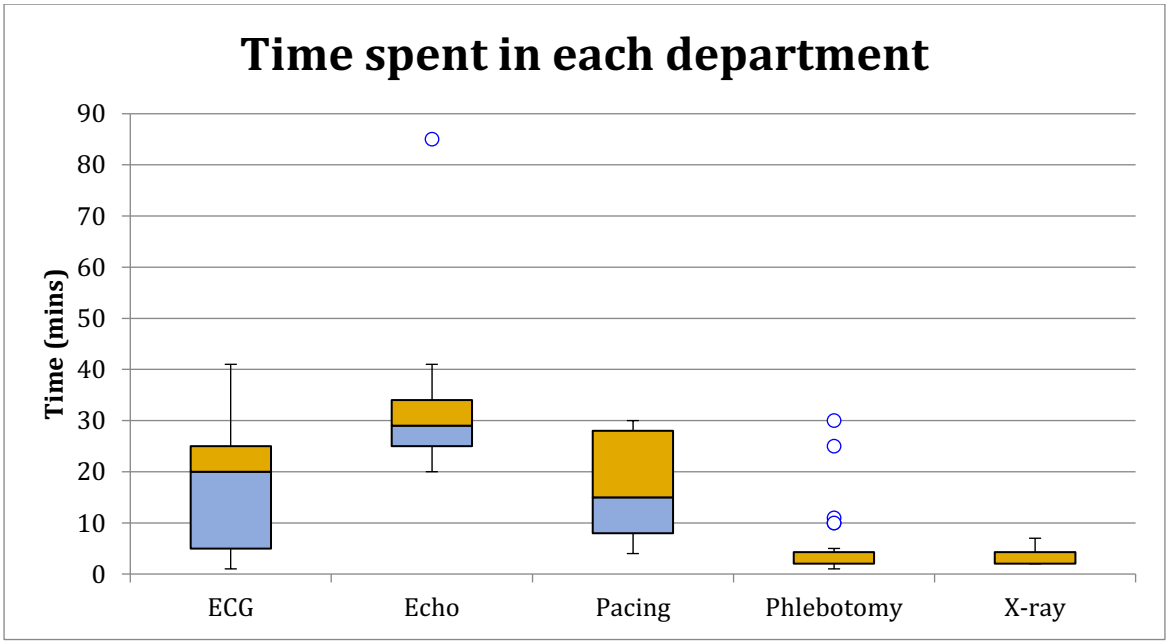


Figure 3.2 - Box and whisker plot (with outliers) of time spent in each investigation area (including waiting time). Boxes represent medians and quartiles; whiskers represent the range. Dots represent outliers (outside 1.5 x IQR of the 1st and 3rd quartiles).

3.3.5 Consultation analysis

Of the 58 consultations analysed, 27 patients were seen by 5 different consultants, 26 by 4 different registrars, and 5 by 1 core medical trainee. Consultants spent a median of 17 minutes with patients (IQR 11 – 24.5 mins) whilst registrars spent a median of 21 minutes in consultation (IQR 15 – 24 mins) ($p = 0.15$). A median of 8 minutes was spent by clinicians between patients (before calling in the next patient). Figure 3.3 is a box and whisker plot illustrating consultation duration by grade of clinician, and Figure 3.4 illustrates the time clinicians spent between patients. Outliers where there were long gaps between patients (longer than the 3rd quartile plus 1.5 times the IQR) were analysed; in all cases the next patient was late and/or engaged with an investigation, resulting in the clinician being unable to see the patient. New patients had longer consultations on

average, with a median of 28.5 minutes (IQR 21.5 – 37 mins) compared with 18.5 minutes for follow-up appointments (IQR 13 – 24 mins) (p = 0.018) and spent longer in hospital than follow-up patients (median time 150.5 minutes vs 101 minutes, p = 0.040).

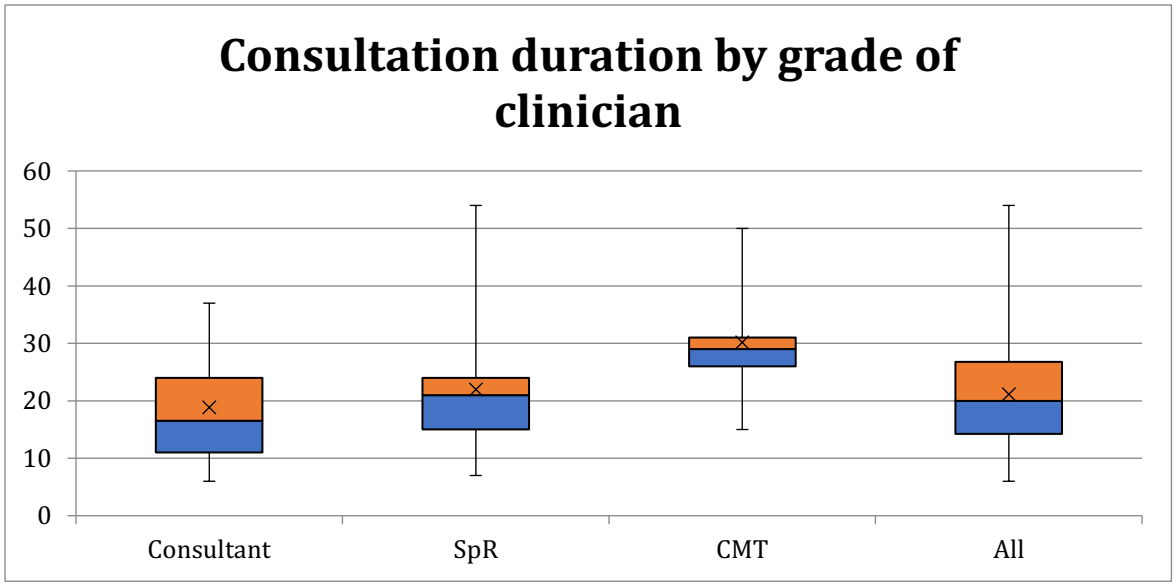


Figure 3.3 - Box and whisker plot of consultation duration by clinician seeing patient. Boxes represent medians and quartiles. Whiskers represent range. X represents the mean. SpR = Specialty registrar (middle-grade training doctor). CMT = Core Medical Trainee (junior-grade training doctor)

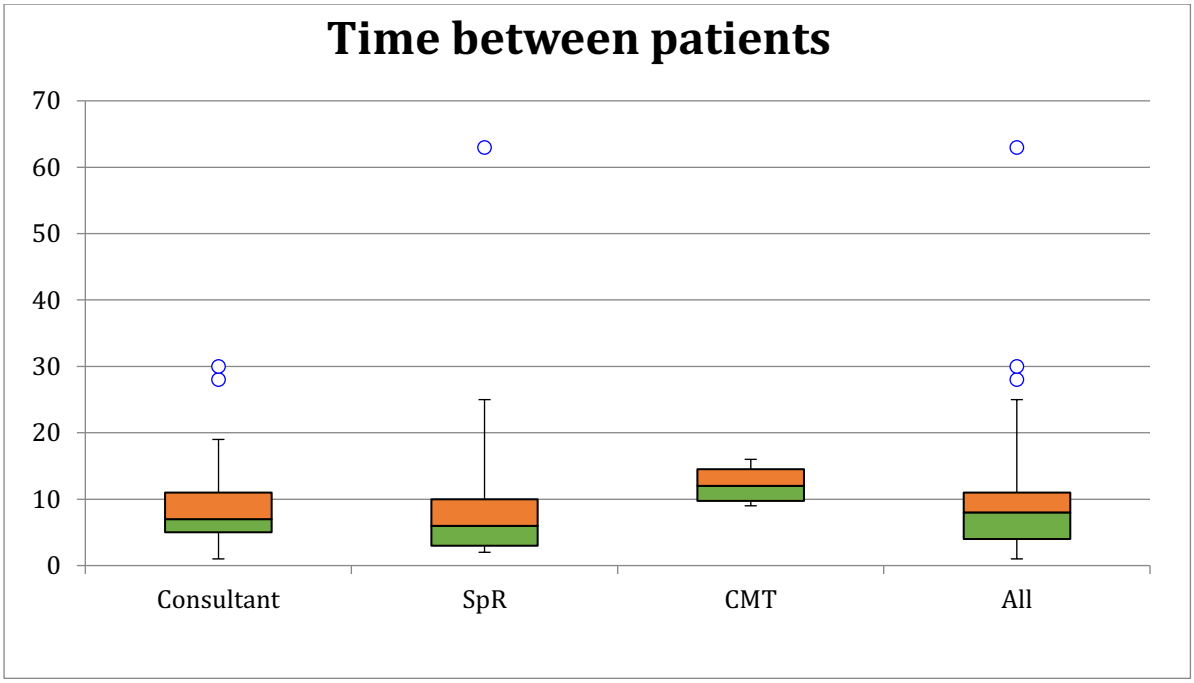


Figure 3.4 - Box and whisker plot (with outliers) of time spent by clinicians between patients. Boxes represent medians and quartiles; whiskers represent the range. Dots represent outliers (> 3rd quartile plus 1.5 x IQR of the 1st and 3rd quartiles)

3.3.6 Analysis of delays

Figure 3.5 shows the relationship between scheduled times and actual start times of consultations in the study.

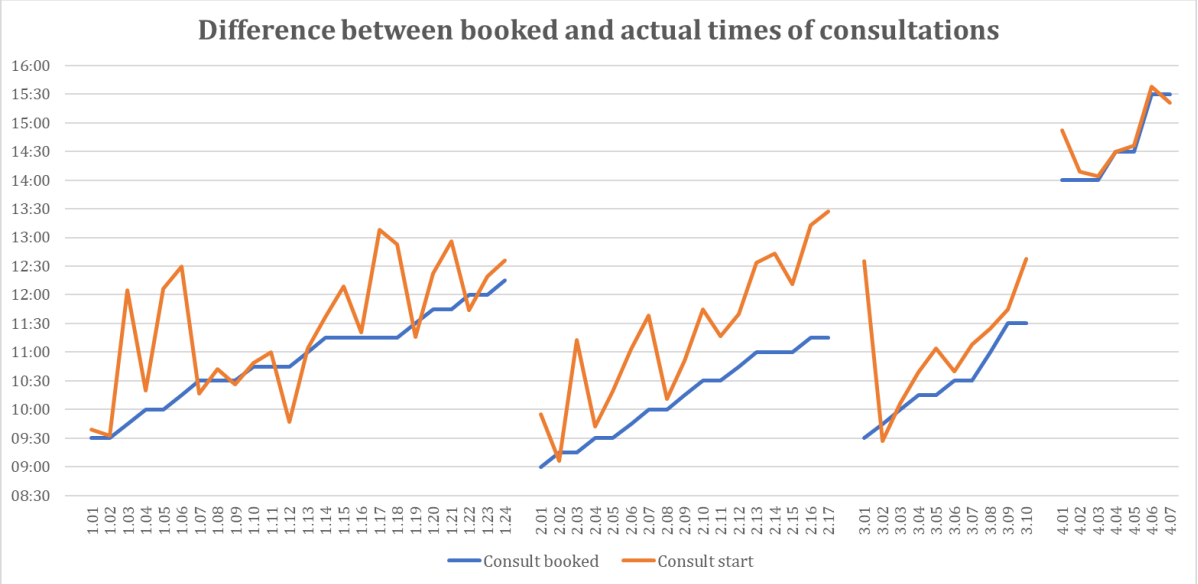


Figure 3.5 - Scheduled appointment time (blue) and actual consultation start time (orange) in each clinic

Consultation appointment slots were 15 minutes in each clinic. The timing of these slots was inconsistent and occasionally it was impossible for patients to be seen at the time of their appointment. For example, in Clinic 1 there were 5 appointments scheduled for 11.15, despite having only 3 available clinicians, and in Clinic 4 there were 3 patients scheduled for 14.00 despite only 2 clinicians being present.

Interdepartmental waiting time, i.e. the time patients spent in between waiting areas outside of consultation or investigation, was calculated for each patient. The median waiting time was 64.5 minutes (IQR 32 – 95 mins), and was longer when patients had pacing clinic and/or echocardiogram appointments (median time 84 minutes vs 52 minutes, $p < 0.005$).

Patients arriving late for their first investigation typically had knock-on effects. The following example is used to illustrate this: one patient had an appointment for echocardiogram at 09.00, pacemaker check at 09.30 and consultation at 10.00. The

patient arrived 28 minutes late for their echocardiogram appointment, though had their scan shortly after arrival (at 09.35), but subsequently missed their scheduled pacemaker appointment, which then eventually was able to occur at 11.12, and the consultation started at 12.06, over 2 hours after it was scheduled to occur.

3.3.7 Driving travel times

Patients lived a median of 12.6 miles away from the hospital (IQR 6.2 – 52.3 miles). Travel times (by car under normal traffic conditions) were estimated to be a median of 45 minutes in each direction (IQR 29 – 87 mins), and therefore a median of 90 minutes for a round trip. The estimated combination of travel time and time spent in hospital was a median of 190 minutes (IQR 149 – 283 mins).

There was no association between the distance patients travelled into hospital and their scheduled consultation time (Spearman rho -0.02, p=0.88) or first scheduled appointment time (Spearman rho -0.12, p=0.39, Figure 3.6), suggesting patient journey times are not factored into appointment scheduling. One patient, for example, lived nearly 120 miles from the hospital and had an CMRI booked for 08:40. There was no significant association between estimated journey times and whether or not patients arrived late for their first appointment (p=0.48).

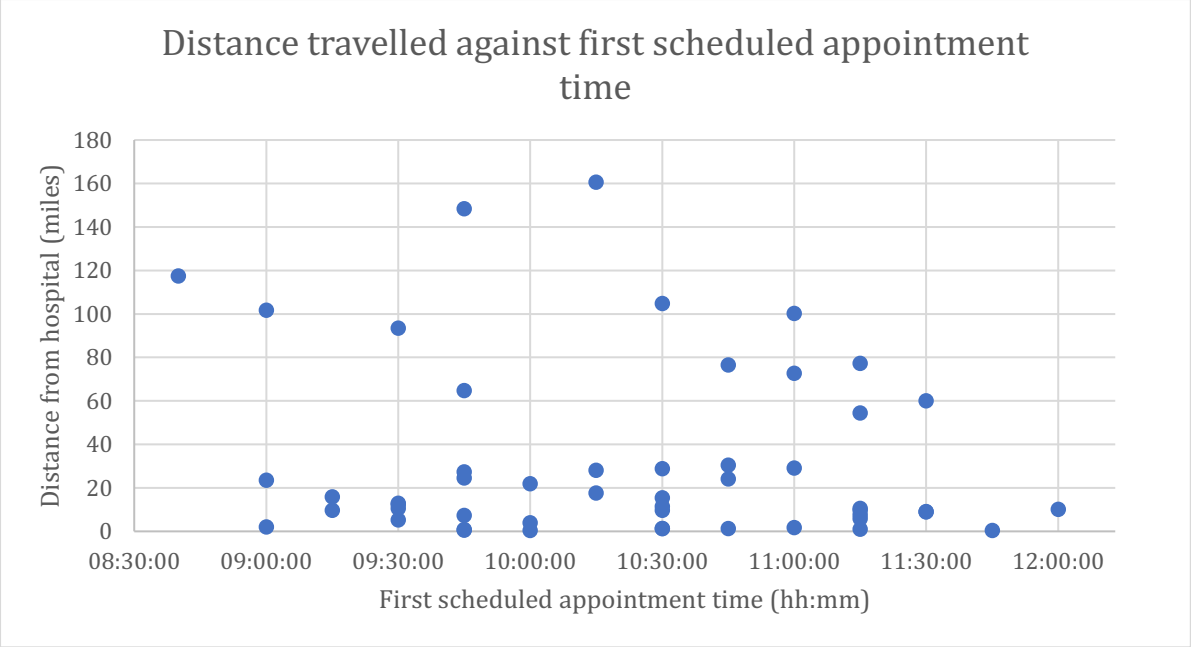


Figure 3.6 - Scheduled appointment time and distance travelled to appointment (for morning clinics)

3.4 Discussion

3.4.1 Summary of key findings

Patients spent a median of 103 minutes in hospital on the day of a clinic appointment, and even if they had no pre-booked investigations, they spent a median of 94.5 minutes in hospital. A median of 20 minutes was spent in consultation, and the time spent on investigations varied depending on which tests were performed. Consultations with new patients were longer and new patients spent longer in hospital. Clinicians spent a median of 8 minutes between patients. Patient interdepartmental waiting time accounted for a median of 64.5 minutes (excluding waiting for ECG and phlebotomy), and total estimated travel times were a median of 90 minutes per patient. When measuring total in-hospital patient-time across the cohort, 19% was spent in consultation, 17% in investigation and 64% waiting between activities. Estimated travel time accounted for 50% of the total patient-time for a hospital appointment (Figure 3.7). The vast majority of consultations ran late. Clinic appointment templates did not accurately reflect the reality of the clinic; appointment slots were usually 15 minutes (whereas clinicians spent a median of 20 minutes consulting and 8 minutes between patients) and sometimes there were more appointment slots than available staff for a given time. This is despite the fact that 11 out of 71 patients (15%) did not attend or rearranged their appointment on the day. Half of patients arrived late to a pre-booked investigation, which usually resulted in downstream "knock-on" delays to consultations. Appointment scheduling did not take into account how far patients needed to travel for the appointment, but there was no association with estimated travel time and whether or not patients arrived late.

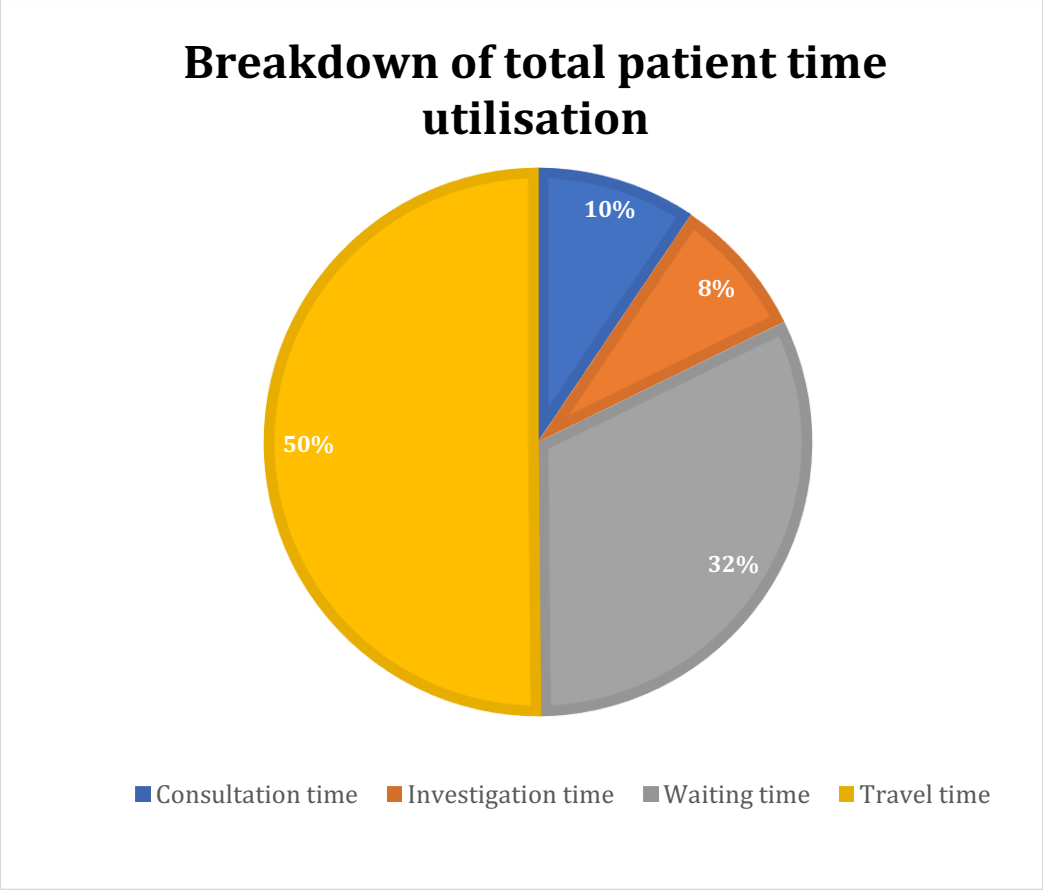


Figure 3.7 - Total patient-time spent in consultation, investigation, waiting between activities and estimated travel time

3.4.2 Process mapping of patient journeys through clinic

Patient journeys were varied, depending on which investigations were performed. Figure 3.8 is a process map for patients attending the HF clinic. Pre-booked investigations were usually requested by clinicians at their previous appointment, but were not always scheduled to occur on the same day as the appointment; post-hoc analysis revealed 6 patients (3 echocardiograms and 3 pacemaker checks) had investigations on a separate day before the appointment. A further 4 patients had echocardiograms on a separate day after the appointment. There was inconsistent co-ordination of echocardiograms, pacemaker checks and clinic appointments; one patient who had a pacemaker check on

the day of the study had an echocardiogram on a day prior to the appointment, and one patient who had their clinic appointment brought forward a week did not have their echocardiogram appointment re-arranged, which was therefore scheduled to be performed 1 week after the appointment. One other patient, who spent the longest duration in hospital in this study, was overbooked into a pacemaker appointment as their appointment had been scheduled for the following week, and they preferred to avoid an additional journey. This lack of co-ordination likely resulted from the different computer systems used to book different appointments. This may also have led to patient confusion on the day; one patient missed their echocardiogram appointment and was late to their pacemaker appointment as they did not know they had other appointments.

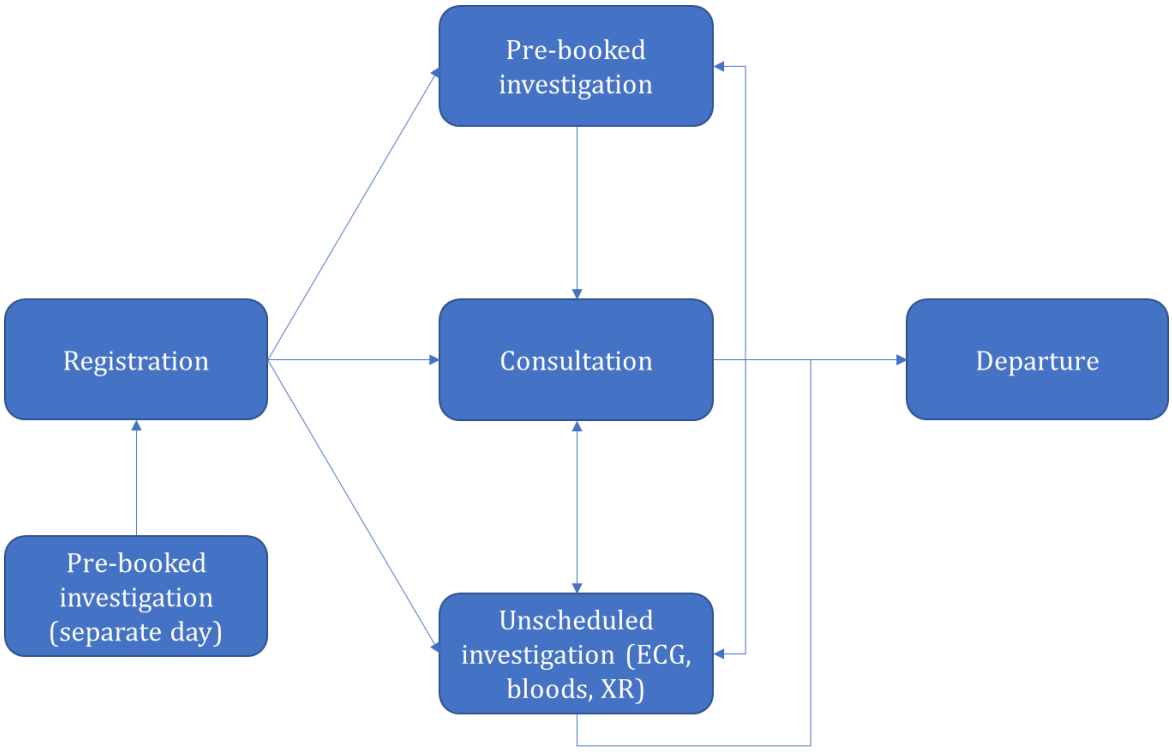


Figure 3.8 - Process map of patients attending HF clinic. XR – X-Ray

3.4.3 Comparisons with prior research

A literature search was performed to identify related research on the Medline (PubMed) database. Time-and-motion studies tended to analyse inpatient processes, and relatively

few studies analysing comparable outpatient services were found. Several studies were found for clinics in lower income countries such as Uganda, Mozambique and Kenya,[110–112] perhaps owing to the high need for efficiency in low-resource, high-demand settings. Time-and-motion studies in different specialities and healthcare systems are difficult to compare owing to differences in patient demographics, healthcare needs, investigations performed and available resources, but relevant studies in similar settings are presented here.

3.4.3.1 Time-and-motion studies

Mamlin and Baker performed a large time-and-motion study of 471 American general medical outpatients in 1971 using automated time recordings.[113] Patients spent an average of 149 minutes in the hospital and an average of 80 minutes waiting, and 31 minutes with the physician; these figures are similar to those reported in the present study.

A before and after intervention time-and-motion study of diabetes outpatient appointments in a tertiary centre in Singapore found patients spent an average of 103 minutes in the hospital for a single outpatient appointment at baseline.[114] Similar to the present study, they found that high variability in the time clinicians spent with patients, patient lateness and suboptimal appointment scheduling resulted in mismatched demand and supply of appointment slots. The intervention of redesigning their appointment template, sending patients appointment reminders amongst other changes did not result in a significant reduction in time patients spent in hospital, but the percentage of patients seen by a doctor within 60 minutes increased slightly from 80 to 84%.

Patients in the present study frequently underwent scheduled investigations alongside their clinic visit, adding greater complexity to scheduling. A study in an American haemophilia clinic found that at baseline patients spent an average of 150 minutes in the department, seeing an average of six providers (including investigations).[115] A quality improvement intervention consisting of changes in staff flow co-ordination and earlier scheduling of patients who required time-sensitive blood tests and did not result in a change in the average time patients spent in clinic.

Similarly, a time-and-motion study performed in a cancer centre in Canada, where patients generally had multiple steps in a hospital visit, found that patients spent an average of 129 minutes in hospital for a physician visit, and the average total time patients were waiting between clinic steps was 77.6 minutes,[116] which is similar to the 64.5 minutes found in this study.

16% of patients in the present study had an appointment in the pacing (cardiac implantable electronic device - CIED) clinic on the same day as their consultation. Pacing checks for most modern cardiac implantable devices are now able to be performed remotely. Seiler *et al.* performed a time-and-motion study across several centres in the USA and Europe comparing remote and in-person pacing checks.[117] Mean staff time required per in-person visit ranged from 38-51 minutes depending on the device, compared with 9-14 minutes for remote monitoring checks. Heart Rhythm Society guidelines recommend at least annual in-person follow-up for patients with CIEDs,[118] but in between annual checks, remote monitoring may be potentially time-saving for staff and suitable patients.

3.4.3.2 Patient flow modelling

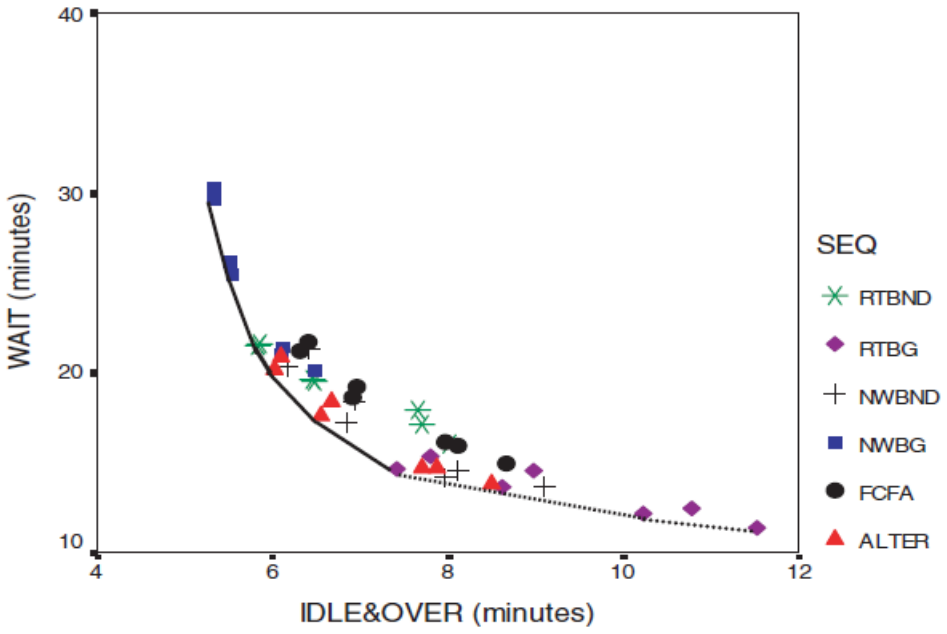
As demonstrated in the present study and similar time-and-motion studies, consultation duration and patient punctuality vary; such variations pose challenges for scheduling outpatient clinics. When no patients are waiting to be seen (for example if patients are late or appointment slots are overly generous) clinicians are "idle", and less able to productively contribute to the clinic. On the other hand, when all clinicians are occupied, for example due to consultations overrunning, then subsequent patients wait longer to be seen. Several modelling papers have suggested ways of optimising patient flow, considering patient waiting times and clinician efficiency.[119] White and Pike's 1964 modelling study used data from medical and surgical outpatient departments in London and Scotland and performed discrete-event simulation (DES) to estimate clinician idle time and patient waiting time in different scenarios.[120] In their simulation, grouping appointments into blocks (e.g. 3 patients every 15 minutes as opposed to 1 patient every 5 minutes) significantly reduced clinician idle time whilst having only a modest impact on patient waiting time. In smaller clinics (<20 patients) and those where consultation times were more variable, however, there was more variability in both patient waiting times and clinician idle times, and such templates were less effective.

Cayirli and colleagues built on the work of previous modellers by also modelling the effect of sequencing of patients based on factors that may affect appointment length (e.g. new or follow-up patients).[121] They modelled 42 different scenarios (7 appointment template rules with 6 different sequencing rules, Table 3.3).

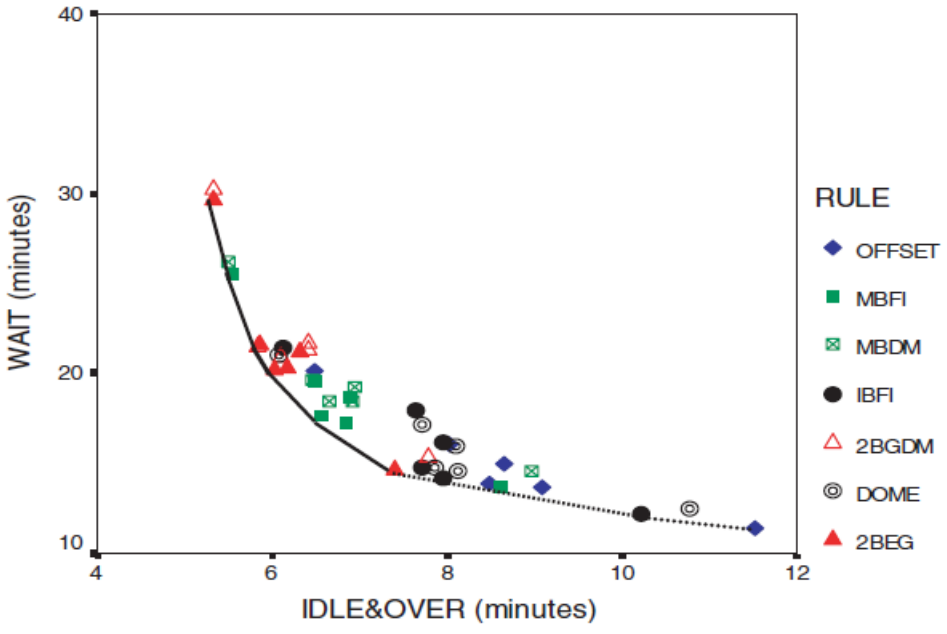
Appointment rules	
Individual-block fixed interval	**IBFI** **2BEG**
Individual-block variable interval	**OFFSET** **DOME**
Multiple-block fixed interval	**MBFI**
Multiple-block variable interval	**2BGDM** **MBDM**
Sequencing rules	
No sequencing	**FCFA**
New patients at the start	**NWBG**
Follow-up patients at the start	**RTBG**
Mix of new and follow-up patients (alternating or in blocks)	**ALTER** **NWBD** **RTBND**

Table 3.3 - Scenarios modelled by Cayirli et al.[121]

Interestingly, no one appointment rule or sequencing rule was superior. All rules were trade-offs; models with low clinician idle time all had longer patient waiting time and vice versa. Figure 3.9 illustrates this trade-off. For example, the appointment rule "2BEG" (2 patients booked in the first appointment slot, with the remainder of patients booked at fixed intervals) ensured that there was nearly always a patient waiting, and thus clinician idle time was low but patient waiting time was high.



(a) Grouping by sequencing rules



(b) Grouping by appointment rules

Figure 3.9 - Modelled patient waiting times (WAIT) and clinician idle times (IDLE&OVER) of different appointment and sequencing rules. Reproduced with permission from Cayirli et al.[121]

Similarly, the sequencing rule "NEWBG" (scheduling new patients first, whose appointments were longer) meant that early appointments overran; subsequent appointments were therefore later meaning patients waited longer but clinicians had less idle time. On the other end of the spectrum, the "RTBG" sequencing rule (follow-up patients at the start of the clinic, with new patients at the end) was associated with longer clinician idle times and lower patient wait times. We apply these concepts to our own clinics in the discussion on scheduling (3.4.4).

Reducing patient lateness may reduce idle time and therefore reduce clinic delays. Williams *et al.* aimed to improve patient punctuality to a pain clinic in the USA with an intervention enforcing tardy patients to reschedule. Over a 12-month period, patients arriving on time rose from 90.4% to 95.4%, and discrete-event simulation modelled that this intervention increased the likelihood of completing the clinic at 12:00 from 38% to 51%.[122]

The British historian and author Cyril Parkinson once wrote "it is a commonplace observation that work expands so as to fill the time available for its completion," with this adage being commonly known as "Parkinson's law".[123] This adaptive behaviour may also be true of consulting clinicians and thus affect efforts to optimise clinic workflow. A modelling study by Chambers and colleagues using data from over 20,000 visits to 3 pain management clinics in the USA found that when clinicians were behind schedule (determined by when patients had arrived earlier than their appointment time but were seen later than their appointment time) they processed patients in 0.84 times the average time, whereas when they were ahead of schedule (when patients arrived early and were seen before their scheduled appointment time) processing times were 1.22 times the average time, 45% longer than when they were running late.[124]

3.4.4 Appointment scheduling

The median consultation length was 20 minutes, and clinicians spent a median of 8 minutes between patients. Thus, on average clinicians required nearly 30 minutes to cycle between patients, however appointment slots in clinic templates were 15 minutes. Furthermore, the median consultation time for new patients was 28.5 minutes, and thus the number of new patients per clinic may influence its running time. Appointment templates were inconsistent, and did not reflect the number of clinicians in the clinic; for example, in Clinic 1 there were five patients scheduled to be seen at 11.15, despite only having 3 available clinicians. The combination of shorter than required clinic slots, and more slots than clinicians for a given time slot ensures delays are inevitable.

Scheduling of investigations ranged from overly optimistic times between appointments, to having large gaps in time; one patient had an echocardiogram booked for 09.00, a pacemaker check booked for 09.30 and a clinic appointment booked for 09.45. The patient's echocardiogram was delayed and overran, leading them to miss their scheduled pacemaker appointment slot, and the subsequent delay to that appointment resulted in the patient missing their consultation slot. Such "knock-on" episodes can have significant impacts on disruptions of schedule. A further factor, not measured in the present study which focused on patient journeys rather than clinician workflow, is the delay in investigations being reported and uploaded onto electronic records; clinicians are likely to want to wait for this to occur before seeing patients in a consultation.

On the other end of the spectrum, one patient had a 2-hour scheduled gap between their echocardiogram and consultation start times. Given the broad range of times taken for echocardiograms and pacemaker checks, it is challenging to schedule them minimising both delays and prolonged waits between activities. This issue is further compounded by

inconsistent patient arrival time; 16 (27.6%) patients were late to their first appointment of the day.

3.4.4.1 Changes to scheduling of clinic appointments

The modelling papers discussed above suggest that (assuming variation in patient punctuality) clinician idle time can be minimised by booking patients in multiple block fixed intervals with new patients being seen earlier in the clinic. Booking too many new patients in early slots, however, can lead to later appointments being delayed. Furthermore, many new patients required investigations before their consultations, and so booking new patients into the earliest appointments may result in them being late.

We suggest a new appointment template below (Table 3.4), based on the above considerations, using Clinic 2 as an example (as Clinic 2 had the greatest delays). Clinic 2 had 24 scheduled patients between 09:00 and 11:15, although in reality the last consultation finished at 14:00. 5 patients did not attend, and there were 4 new patients. In the suggested template, patients are booked in groups of 3 every 30 minutes, and new patients are preferentially booked earlier in the clinic on the assumption that they will take longer, minimising clinician idle time. Patient wait times would be improved by having more realistic appointment intervals with appointments overrunning by less.

Old template		New template	
09:00		**09:00**	
09:15		**09:00**	
09:15		**09:00**	
09:30		**09:30**	New patient (without needing prior investigation)
09:30		**09:30**	
09:30		**09:30**	
09:30		**10:00**	New patient
09:45		**10:00**	
10:00	New patient	**10:00**	
10:00	New patient	**10:30**	New patient
10:00		**10:30**	
10:00		**10:30**	
10:00		**11:00**	New patient
10:15		**11:00**	
10:30		**11:00**	
10:30		**11:30**	
10:30		**11:30**	
10:45		**11:30**	
10:45		**12:00**	
11:00	New patient	**12:00**	
11:00		**12:00**	
11:00		**12:30**	
11:15	New patient	**12:30**	
11:15		**12:30**	

Table 3.4 - Changes to appointment schedule template for Clinic 2

3.4.5 Possible other solutions

Aside from changes to appointment templates propose the following solutions to improve the efficiency of HF clinics:

Telemedicine clinics should be provided as an option. This would eliminate travel time (a median of 90 minutes), and waiting time would be in the comfort of the patients' own home, rather than in a hospital waiting room. Investigations would need to be organised and performed in advance if they are required.

Appointments and investigations should be co-ordinated. Echocardiograms and pacemaker checks should be booked on the same system, and where possible done on the same day as each other at a reasonable interval (e.g. 45 minutes apart). Patients should be given the choice of whether this should be on the same day as their clinic appointment or on a different day in advance. Patients should be given a personalised timetable and reminder of all appointments on the day of a hospital visit to minimise non-attendance.

Patients travelling from further away should be booked for later appointments. This may improve patient satisfaction by avoiding patients having to get up very early for a long journey, and may reduce the chance that patients would arrive late, thus potentially reducing delays.

Figure 3.10 shows a suggested process map for organising follow-up appointments in the clinic, incorporating these suggestions.

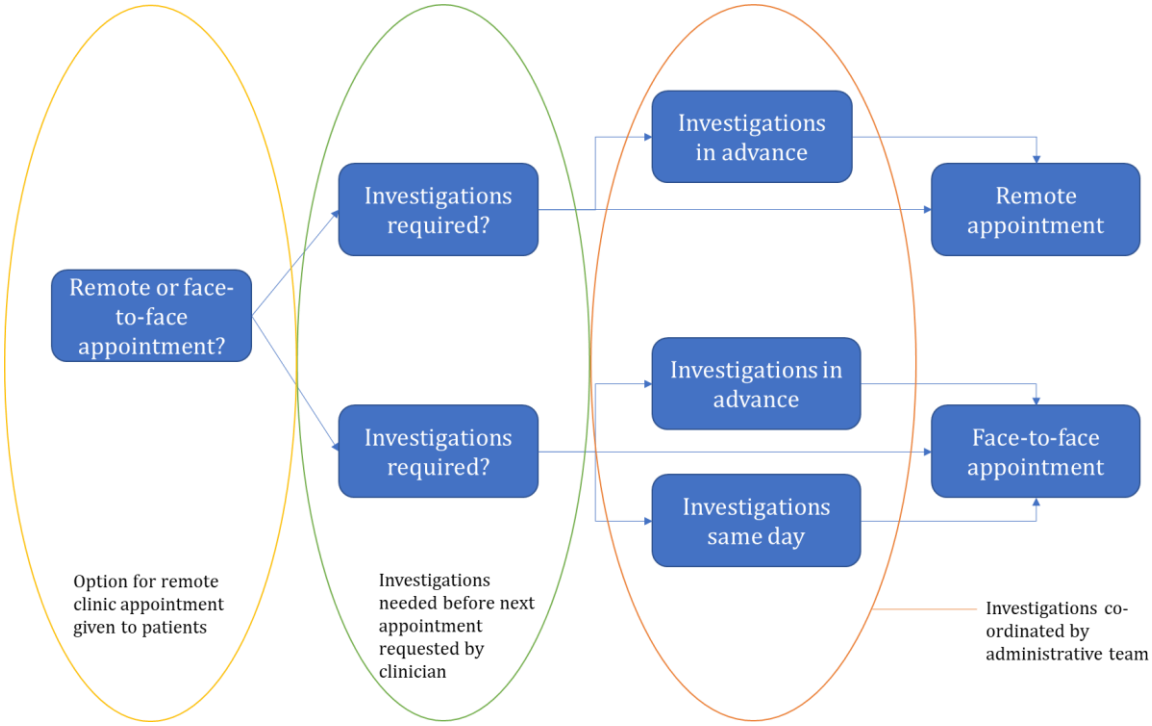


Figure 3.10 – Suggested process map for organising follow-up appointments in HF clinic

The above recommendations were presented initially to the HF care group and subsequently to the Outpatients Board of the Royal Brompton and Harefield Hospitals Foundation Trust (as it was then known) on 28th February 2020. The HF clinic was selected as an "early adopter" for telemedicine consultations and clinic pathway redesign, however two weeks later, before changes were able to be implemented, the Covid-19 pandemic resulted in the cessation of in-person clinic appointments. This will be discussed in more detail in Chapter 4.

3.4.6 Discussion of methodology

The present single-centre study included 58 patients. While clinic sessions studied were representative of the usual size of the clinic, we cannot guarantee that patients were representative of the whole cohort given the small sample size, however the age and sex

are similar to those reported in Chapter 2. Furthermore, only one time-and-motion study was performed for each clinic; it is possible that clinics vary significantly in different weeks, but it was not possible to examine this in the present study. Patient travel times were estimated based on driving times from their address under normal conditions. This cannot account for traffic, parking, or whether patients took public transport instead. Estimated public transport times were not calculated owing to the numerous different routes by which the journeys could be made. However, estimated public transport times tended to be longer than driving times. Furthermore, traffic in London before 9am is likely to be significantly worse than under normal conditions; thus, our patient travel times are likely an underestimate.

This study focused on patient journeys rather than clinician workflows. As such we are unable to analyse consultations and draw conclusions on clinician and technician-related processes. For example, we did not measure the time taken to report an echocardiogram or pacemaker check and make that report available to the clinician, and we did not measure the time taken for clinicians to document the consultation or dictate letters.

3.5 Conclusion

Patients attending HF clinics at the Royal Brompton hospital spent an estimated average of more than 3 hours away from home, of which 20 minutes were spent in consultation. Patients spent more than half of their time in hospital waiting; several process inefficiencies, including inconsistent investigation scheduling and unrealistic consultation scheduling, resulted in significant delays for patients waiting to be seen. Travel times could be eliminated by remote consultation for appropriate patients, and patient waiting times could be reduced by co-ordination of investigations and appropriate consultation scheduling. Further research is needed to confirm these hypotheses, but given the growing HF epidemic, and increasing burden on NHS outpatient clinics, efficiency improvements are essential for a sustainable service. Rapid community transmission of Covid-19 shortly after these time-and-motion studies prevented implementation of the full set of recommendations, but resulted in a rapid shift to telemedicine. The following chapters evaluate patient and clinician experiences of telemedicine consultations for HF.

4 Clinician perspectives on telemedicine HF consultations: a qualitative study

4.1 Introduction

Telemedicine, meaning "healing at a distance" is defined by the World Health Organisation as the "delivery of health care services, where distance is a critical factor… using information and communications technologies".[74] In March 2020, rapid community transmission of Covid-19 in the UK resulted in a dramatic shift towards telemedicine appointments in order to minimise the risk of transmission and to allow redeployment of staff to hospital Covid-19 response.

The Royal Brompton Hospital adopted a "remote-by-default" model for all HF clinic appointments from 16th March 2020, with face-to-face appointments only in rare, exceptional circumstances. We aimed to evaluate the experiences of clinicians and patients who had participated in telemedicine consultations. In this chapter we present interviews with clinicians, and in the following chapter we present interviews with patients and further discussion of the results of both sets of interviews.

4.2 Methods

The Royal Brompton Hospital has 4 specialist HF clinics led by 5 consultants and 3 clinical nurse specialists. All scheduled HF clinic appointments for new patients and for routine follow-up were initially converted to telephone appointments, and from July 2020 onwards the option of video consultation was made available. Video consultations were conducted using the "Attend Anywhere" platform. Briefly, Attend Anywhere is a nationally used web-based video consultation platform; no additional software is required for consultations. The platform uses a virtual "waiting area" where clinicians can see which patients have logged on waiting, and clinicians may then call patients into their virtual clinic room (screenshots in Appendix).

4.2.1 Study design

We used a qualitative study design. Clinicians were invited to participate in semi-structured interviews about their experiences of telemedicine clinics. Semi-structured interviews are defined as being "organized around a set of predetermined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewee/s".[125]

5 prompt questions guided the interview. Questions were chosen to be open-ended but ensuring key areas of interest were covered:

- Please describe your experience of telemedicine consultations
- How did you find the technology?
- What was your experience of the clinical interaction?
- How could the experience of consultations be improved?

- How would you like future consultations to be conducted, and why?

4.2.2 Data collection

A purposive sampling technique was used for recruitment. Senior members of the HF clinical team (except for the investigators) were invited to take part in the study by e-mail to ensure a good mix of doctor and nurse responses. All interviews were conducted by AS following training by JPR. Interviews were conducted using Microsoft Teams and recorded. Interviews were transcribed verbatim using a two-step process; first a draft transcription was produced my Microsoft Teams voice-to-text functionality, and then transcriptions were checked against recordings and edited to ensure accuracy. Interviews were conducted between 24th February 2021 and 17th March 2021.

4.2.3 Data analysis

Participants were pseudo-anonymised and narrative data were analysed by thematic analysis.[126–128] Briefly this is an inductive process whereby data are described and organised using codes, and transcripts are compared iteratively, identifying patterns in the data through which themes emerge. The first two interview transcripts for both clinicians and patients were co-analysed by AS and JPR to ensure consistency and rigour, and emerging themes were identified and agreed on. Later interviews explored emerging themes in greater detail whilst still being receptive to emerging themes. Study recruitment was planned to end once themes reached "saturation" as agreed by two investigators, i.e. when themes were fully developed and additional interviews did not lead to new themes.[126,129]

4.2.4 Ethical consideration

The study was registered as the "VIDEO-HF" study with the UK Integrated Research Application System (IRAS number 284625) and received ethical approval from South West - Frenchay Research Ethics Committee (20/SW/0096).

4.3 Results

Between 16th March 2020 and 15th March 2021 there were 2797 HF clinic appointments, of which 2761 (98.7%) were by telemedicine. Most telemedicine consultations were by telephone rather than by video conference, but it was not possible to gather an accurate breakdown as consultations were not coded separately in hospital IT systems.

4 consultants (all except the senior investigator), 3 specialist nurses and one rotational training-grade doctor were interviewed. Interview duration was between 25 and 36 minutes, and transcripts were typically around 5000 words.

Participant	Sex	Role
S01	Male	Consultant Cardiologist
S02	Female	HF Clinical Nurse Specialist
S03	Female	Cardiology Registrar (training-grade doctor)
S04	Female	HF Clinical Nurse Specialist
S05	Male	Consultant Cardiologist
S06	Female	HF Clinical Nurse Specialist
S07	Male	Consultant Cardiologist
S08	Male	Consultant Cardiologist

5 key themes emerged from clinician interviews:

- Clinical assessment
- Communication and rapport
- Time utilisation

- Technology and logistics
- Choice and flexibility of consultation modality

4.3.1 Theme 1: Clinical assessment

In the traditional in-person model of consultation, clinicians were able to perform physical examinations on patients, measure observations such as blood pressure, and perform same-day investigations such as electrocardiography, phlebotomy and chest radiography. Telemedicine consultations meant that different methods of information gathering were required to assess patients and make clinical decisions.

The lack of physical examination was deemed by most clinicians to be a significant downside of telemedicine consultations:

> *"The examination can often pick up something and I don't find it very satisfactory to have someone sort of use the camera to go 'here are my legs look at my oedema' or not."*
>
> – S05, HF Consultant

Examination of oedema was possible by video but perceived to be less reliable than a physical examination:

> *"At least you can, you know, turn the camera around so you can have a look and see what- what that person's legs look like, so it's a bit of a halfway house in that sense in terms of your clinical assessment."* – S03, Training grade doctor

Some clinicians, however, did not see this as a major issue as they thought that most HF patients did not need to be regularly examined, and specialist diagnostic imaging such as echocardiography was more informative:

"It's useful to know the blood pressure and the heart rate, those kind of basic observations so that we can up-titrate drugs as needed. But for the vast majority of patients, you probably don't need to examine them actually."

– S07, HF Consultant

However, when not all tests that had been requested were performed it was difficult for clinicians to then make an assessment:

"If they don't get all the tests that we wanted, and then they've gone home, when now you have a consultation, you realize that some pieces of data are missing, you can't rectify that."

– S05, HF Consultant

Clinicians gained useful information to aid their decision making where patients were able to use their own equipment for self-monitoring, such as weight scales and blood pressure monitors. Some patients were able to also get blood tests from the community:

"I mean one thing I do find very useful is that there are patients who were able to take their own observations at home, their weights, their blood pressure, heart rate, and they've had a recent check of their blood test with their GP and that is almost equivalent to what we would be doing clinic."

– S08, HF Consultant

Without physical examination and when patients did not have easy access to monitoring equipment, clinicians were more reliant on the patient history for making an assessment:

"You're more reliant on the patients to give you an accurate history which is, uh, I guess, prone to failure, but none of us are infallible ourselves either…"

– S04, HF Nurse

Some clinicians stated that taking histories was more challenging without visual feedback, and that non-verbal cues were important for clinical assessment, making telephone assessment more challenging:

> *"So yeah, those- those kind of visual clues, but also it's quite difficult to pick up somebody's mood, it's very difficult over the phone sometimes, you can mask it very easily."*
>
> – S02, HF Nurse

Similarly, in face-to-face clinics, some clinicians would make functional assessments as patients walked into the clinic room. This was not possible by telephone, and challenging by video due to the narrow viewing angle of cameras, so clinicians used other methods for functional assessment:

> *"So, the dexterity, the functional ability is more difficult to tell, but you get round that with experience by asking them to go and get their tablets and so- and talk to you whilst they're walking so you can pick up how breathless they are, um, when they're walking."*
>
> – S02, HF Nurse

4.3.2 Theme 2: Communication and rapport

Clinicians stated that there was a difference in "chemistry" between in-person and remote consultations that altered the clinician-patient relationship.

> *"There is a chemistry you have when there's another person next to you, another person in any room … the intimacy and the confidence of being in the close*

presence of some- someone else is all part of how they come to trust you and listen to you."

– S01, HF Consultant

This was particularly important for new patients; clinicians almost unanimously agreed that new patients were better seen face-to-face to develop a "connection" which was felt to be important for patients to trust clinicians and thus speak freely, but also for clinicians to best interpret the significance of patient histories:

"But I think it's very difficult with new patients to build up a rapport, to fully understand them. It's also difficult because when you don't know the patient very well, you don't know how good a historian they are, and you don't know the significance of what they're telling you."

– S02, HF Nurse

Telemedicine consultations were deemed more natural with patients who were well-known to clinicians, as a good rapport had already been established. Video was deemed to be superior to telephone for establishing rapport with new patients due to being able to pick up non-verbal cues and assess their reactions, but telephone was believed to be an appropriate alternative for patients with whom the clinician felt they had already established a rapport:

"I think the majority of patients I've been speaking to I've seen at some point before,… on video conferencing that rapport is definitely much better compared to the patients who I'm meeting for the first time or first and second time on the phone,… if you're friendly on the phone with the patient and you developed that rapport you can make it as much as possible to a real-life encounter."

– S08, HF Consultant

The personal aspect of face-to-face consultation was thought to be particularly important when having a difficult conversation around a sensitive topic; breaking bad news or advanced care planning was thought to be inappropriate by telemedicine:

> *"It's an end-of-life discussion and we're talking about ICD de-activation. I don't want to do that on the phone or by video; it's a very sensitive matter and I wanted to see the patient."*
>
> – S07, HF Consultant

Finally, some clinicians expressed concern that remote consultations risked removing the personal dimension to consultations, making them feel more like a "robot" or that the job could be done by a "machine":

> *"You know otherwise, we could be easily replaced with machines and I don't think that's happening anytime soon. I think there is something about looking somebody in the eye and telling them something."* – S01, HF Consultant

4.3.3 Theme 3: Time utilisation

Clinicians described how telemedicine changed how they spent their time in consultation and how they prepared for the clinic. They perceived that consultations were overall shorter, but more administrative and preparation time was required:

> *"I do think that if you add up the duration of all the consultations, overall, it's shorter. Maybe also the time that one would spend doing a physical examination, getting a patient on and off a couch that may be frail undressed and dressed, so- so there's those times savings, but it's then offset by the preparation time."*
>
> – S05, HF Consultant

Time was saved by not performing physical examinations, and less time was spent between consultations waiting for patients. Some clinicians perceived telemedicine consultations to be more "efficient":

> *"Overall, I think they are shorter in my opinion…. I find that that's probably because I'm more efficient on the phone…. you get straight to the point on the telephone sometimes, or on video with some patients."*
>
> – S08, HF Consultant

One clinician also added that telemedicine consultations allowed them to multi-task:

> *"I can do things like typing up my clinic letters as I'm going through the consultation, which gives a more accurate reflection of what actually went on in the patients' notes afterwards, and saves me some time as well, obviously."*
>
> – S03, Training grade doctor

In clinics with more than one clinician, extra preparation time was required by the lead clinician to allocate patient lists in advance of the clinic, though this helped to "streamline" the clinic. There was a mix of opinions as to whether telemedicine resulted in net time loss or gain. One HF nurse perceived a significant increase in workload, in large part due to the extra effort of acquiring external results:

> *"You know, the workload has doubled basically for that one consultation…. I then have to contact the GP surgery and request for [blood tests] to be e-mailed to me and I can't make a medicine change in the consultation until I've got those blood tests, so I've got to phone them back… once I've received them."*
>
> – S06, HF Nurse

Clinicians described feeling guilty that patients travelled for long distances or waited a long time, and they described how the face-to-face consultations were therefore longer than they needed to be. Telemedicine allowed consultations to be kept brief without clinician guilt:

> *"I think there is less "chat" because … you haven't got that same guilt where, you know, that they've waited for a period of time."*
>
> – S04, HF Nurse

Telemedicine also allowed the possibility of clinicians working from home and avoiding a journey into hospital, which could save time and be more convenient for staff:

> *"If you're not needing to travel into a hospital, the half an hour or hour that you would have travelled, you can use it product- productively."*
>
> – S05, HF Consultant

No ethical or governance concerns of working from home were raised by clinicians.

4.3.4 Theme 4: Technology and operational issues

Occasionally, technical disruptions would occur on the video platform, often due to internet connection issues, which could have a significant impact on the timing of the clinic. Clinicians described how they would then revert to telephone. Most clinicians had experienced some technical difficulties during a telemedicine consultation:

> *"And when it crashes, oh my goodness, that's a disaster. You know, when you can't use it, that's quite stressful."*
>
> – S06, HF Nurse

In cases of technical disruption, it was not always obvious who to ask for help, and often it was difficult to access technical support. Due to limitations of clinic scheduling and administration, it was not possible to know whether patients were planning to attend their telemedicine appointment by telephone or video. Therefore, if a patient was not in the video "waiting room", it was unclear whether they preferred telephone, were running late or were having technical difficulties. Clinicians were also concerned that patients who had trouble accessing the video platform had no way of informing clinicians until they were called:

> *"[It] doesn't seem to be very clear if the patient's in the waiting room and they can't get- no one's picking up for them, or they can't get on, who do they contact?"*
>
> – S02, HF Nurse

Video consultations required access to a computer with a webcam, personal headset and high-speed internet, ideally in a private space; such spaces were sometimes difficult to find, and computers were not always set up properly:

"[Examples include] our computers not being properly set up, or there not being enough private rooms in- on site to actually, you know, carry out these consultations properly with respect for confidentiality etc."

– S03, Training grade doctor

Face-to-face consultations, on the other hand, needed dedicated clinic rooms and support staff which are in limited supply. Some clinicians therefore saw telemedicine as an advantage and a possible way of expanding clinics:

"You can roll out and expand clinics much more easily. You can keep monitoring follow-ups much more easily. And you're not restricted by physical space."

– S07, HF Consultant

A disadvantage of video consultation was that occasionally latency issues (i.e. the delay between transmission of information and receipt on the other end) resulted in disrupted conversational flow:

"When you speak, it's clear that there's a one, you know, fraction to one second delay, and there's the risk of speaking over each other."

– S05, HF Consultant

Some clinicians believed that telemedicine posed privacy challenges; patients and clinicians may not want others to see their home environment, and unlike in a consultation room, it was not always clear who was able to see or hear the consultation:

"You think about confidentiality and even in their home, you know, if they're in their living space or- or their dining room and there's other people you can see in the background… other people might be hearing."

– S05, HF Consultant

At the time of interview, Attend Anywhere did not provide functionality for blurring of backgrounds, but this has subsequently been added.

4.3.5 Theme 5: Choice and flexibility of consultation modality

Clinicians believed telemedicine offered advantages and disadvantages as detailed above. It was therefore deemed that the choice of modality was very much dependent on the patient and on the situation. Patient choice was essential, as some patients may not be comfortable with using telemedicine or have the necessary equipment for video consultations:

> *"I think it's really important to give patients the choice, 'cause we are tech savvy and happy with either, but they, I think, fall into different groups…"*
>
> – S05, HF Consultant

Clinicians also had preferences based on the purpose of the consultation and needs of the patient. Where patients described worsening symptoms, the clinician stated a preference for in-person appointments to make a full assessment including physical examination. On the other hand, more "routine" appointments such as conveying test results could be done by telemedicine:

> *"Any sick patient who has the risk of being admitted to hospital should be seen face to face.... and the ones who are stable, who have had a few tests here and there and you're just giving them feedback about their tests, and you're not going to make any major changes to their treatment plan, may benefit from having telephone follow-up."*
>
> – S08, HF Consultant

There was a perception that patients had a mix of preferences for how they would like to be seen, with many wanting to return to in-person consultations and some preferring the convenience of telemedicine. Clinicians thought, however, that most patients who had tried video consultations had generally had a good experience, and that age wasn't a barrier to access as relatives could help set up the consultation:

> *"A few patients … [who] got a relative to set it up because they were finding it hard to do, they've actually enjoyed it 'cause they wanted the personal interaction…. And then I've spoken to the relative as well about their family member."*
>
> – S06, HF Nurse

Some patients needed spend significant amounts of money, on top of the time taken for a journey, in order to make a hospital appointment. This was particularly an issue if patients needed to travel the day before to make a morning appointment, and thus telemedicine should be offered to these patients:

> *"[Some patients] would come the night before, check into hotel, come to the clinic with a suitcase and then see you, and then go back home to wherever they came from and then have to come back again another day for the test. So, it's a huge expense to the patients."*
>
> – S07, HF Consultant

Clinicians perceived that patients and healthcare systems were more receptive to the idea of telemedicine consultations owing to the Covid-19 pandemic, and adoption would otherwise be much slower:

> *"There was no option in the in the beginning of the lockdown last year, I think people have begun to accept this technology much more quickly than they would*

have otherwise…. If we had no pandemic and we were to say 'look we're going to go to video for everyone', I think there would be a lot of resistance, and it probably wouldn't happen for another 10 years I think."

– S07, HF Consultant

With telemedicine consultations being the default for an extended period of time, clinicians deemed that clinics were unlikely to return to how they were before Covid-19, and that a mix of in-person and telemedicine consultations would be the model going forward:

"I think Covid, for better or worse, has catalysed digital health in so many different fields, and telemedicine is one of them, and we're never gonna turn it back, are we? So, I think the good news is it's here to stay. How do we deliver it and make sure that … all the stakeholders … get the best of this, I think we're still learning, aren't we?"

– S05, HF Consultant

Some clinicians, however, expressed fears of top-down diktats for future delivery of care, with rigid policies such as quotas for telemedicine patients, restricting flexibility for how clinicians choose to run their own clinic, or not allowing patients to choose their mode of appointment:

"The health service has got a great tradition of making up its mind as to what the patient thinks, and then giving it back to them…"

– S01, HF Consultant

This consultant added:

> *"I think that the best form of practice will be knowing your patients well enough to be able to make a call on [mode of appointment], tailored to that patient."*
>
> – S01, HF Consultant

Figure 4.1 illustrates the key themes of clinicians' experiences with telemedicine for HF consultations

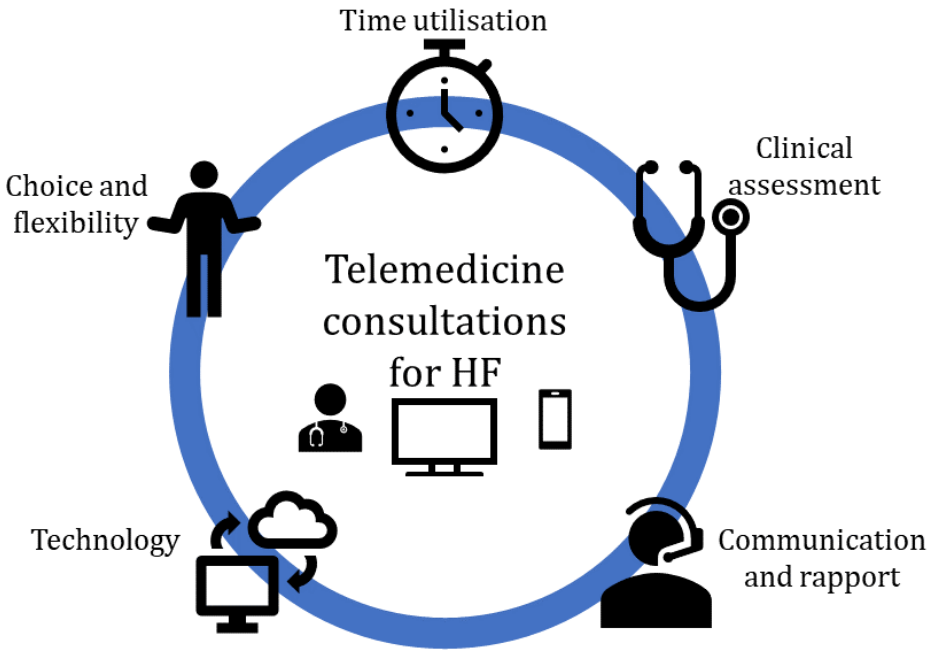


Figure 4.1 - Key themes of clinicians' experiences with telemedicine consultations

4.3.6 Perceptions of patients' experiences

Most clinicians stated that they perceived long journeys to the hospital and waiting in hospital waiting rooms as a significant inconvenience for some patients attending face-to-face appointments, which they perceived could be mitigated by telemedicine:

> *"We've got quite a number of patients … who might travel for hours to come for what is … a cursive, uh, consultation in some instances. You put this person through a lot of time and effort, and actually the state to a lot of expense in paying for their transport, for not a very good reason."*
>
> – S01, HF Consultant

Some clinicians perceived that some patients struggled with the technology for video consultations:

> *"I think there is an equity issue for some patients that they are- they would like to see us, but they can't because they can't manage the technology, um, and that's difficult for some of our patients."*
>
> – S02, HF Nurse

Others thought that most patients had become familiar with video calling technology during Covid-19 in order to communicate with their families during social restrictions:

> *"The thing about Covid, of course, is it's meant everybody's had to get familiar with these video platforms to communicate with their families, so they have got used to using these things."*
>
> – S06, HF Nurse

One clinician, however, thought that the use of video technology in patients' social lives meant that some patients were "fed up" of seeing people by video:

"People are fed up, fed up of doing things by Zoom."

– S02, HF Nurse

Although generally clinicians saw clear advantages of video consultation compared with telephone consultation as detailed above, some perceived that patient enthusiasm for video was mixed, although those who had tried it tended to have a positive experience:

"There's quite a lot of people who actually tell me they prefer a phone call, but for those who did do the video call when they were invited for it, they were actually very enthusiastic about it and liked having a bit more of a genuine interaction."

– S03, Training grade doctor

Some clinicians perceived that patients had higher expectations of timekeeping for telemedicine clinics, particularly video consultations, compared with in-person consultations where they were perceived to be more understanding of delays:

"With the video clinic, usu- most patients do expect to be seen on the dot, at the time and then they start getting a bit frustrated if that's not happening."

– S06, HF Nurse

This was thought to be compounded by the lack of feedback in a video waiting room, where patients may be unsure of the cause of the delay:

"When they open the virtual waiting room on video, they kind of expect to start on the- on the minute… they don't know if that's because of an IT problem, is it because the doctor's forgotten, is there some other reason?"

– S07, HF Consultant

4.4 Summary of key findings

We identified 5 main themes in clinicians' perceptions of telemedicine consultations for HF: clinical assessment, communication and rapport, time utilisation, technology, and choice and flexibility of consultation modality (Figure 4.1).

Clinicians gathered information for clinical assessment in different ways by telemedicine as physical examination was not possible, and so clinicians relied more on history, test results and a rudimentary examination of oedema via the video link. Home equipment monitoring parameters such as weight, blood pressure and heart rate was helpful for clinicians to make decisions.

Clinicians perceived it was more difficult to establish rapport by telemedicine, and this was particularly challenging for new patients. Clinicians believed that new patients should be first assessed in person to build a "connection". Video was better than telephone for rapport owing to being able to pick up on non-verbal cues. Although patients who were well-known to clinicians were considered suitable for telemedicine consultations, face-to-face consultations were preferred for sensitive topics such as breaking bad news.

Clinicians described how telemedicine consultations were more efficient owing to time saved on examination and calling patients in from a physical waiting room. Consultations could be briefer because clinicians felt less guilty about patients having travelled long distances. More administrative time, however, was spent preparing for clinic and acquiring external investigation results. Telemedicine sometimes allowed clinicians to do consultations in their own home which could avoid a journey into hospital and was more convenient.

Most clinicians described the technology as easy to use, but technical disruptions had the potential to add a significant amount of time to a clinic, and latency issues in video consultations could occasionally result in broken or interrupted conversation.

Clinicians believed that in the future choice and flexibility for both patients and clinicians was essential, as the appropriateness of a telemedicine consultation would depend on the patient and the situation. There was concern that health services may not accommodate such flexibility.

We conducted similar interviews with patients in order to gain their views, and compare their experiences with clinicians. As there is considerable overlap in methodology, limitations and relevant literature with regards to clinicians and patient experiences, a full discussion will follow in Chapter 5.

4.5 Conclusion

Following the Covid-19 pandemic clinicians performed a high volume of telemedicine appointments for HF care. Telemedicine HF consultations were acceptable for clinicians, but changed workflows and consultation dynamics, including how clinicians developed rapport and trust and how clinicians and patients exchanged information to make a clinical assessment. We will now move onto the experiences of patients.

4.6 Appendix

4.6.1 Screenshots of Attend Anywhere

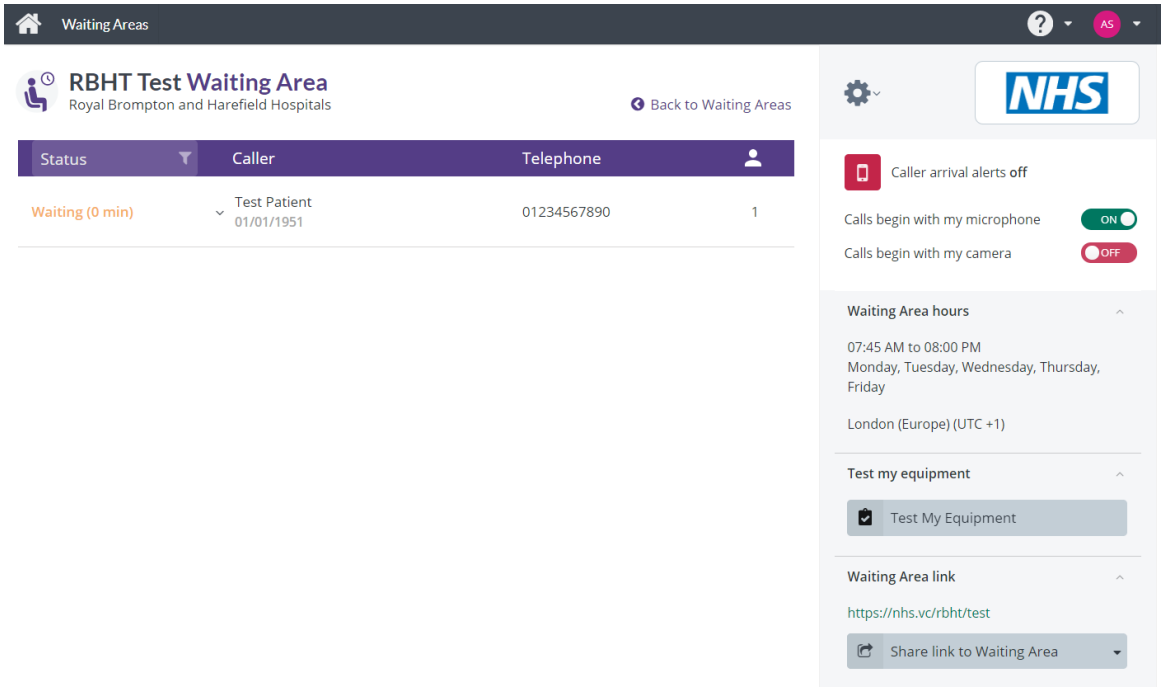


Figure 4.2 - Clinicians' view of waiting area in Attend Anywhere (via desktop Google Chrome browser)

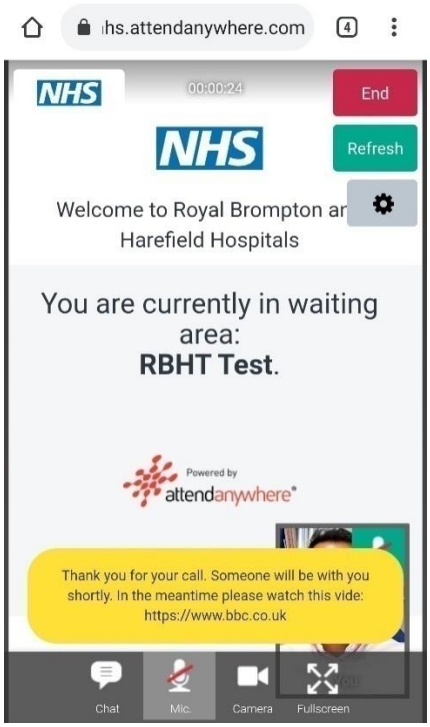


Figure 4.3 - Patients' view of waiting area (via mobile phone browser)

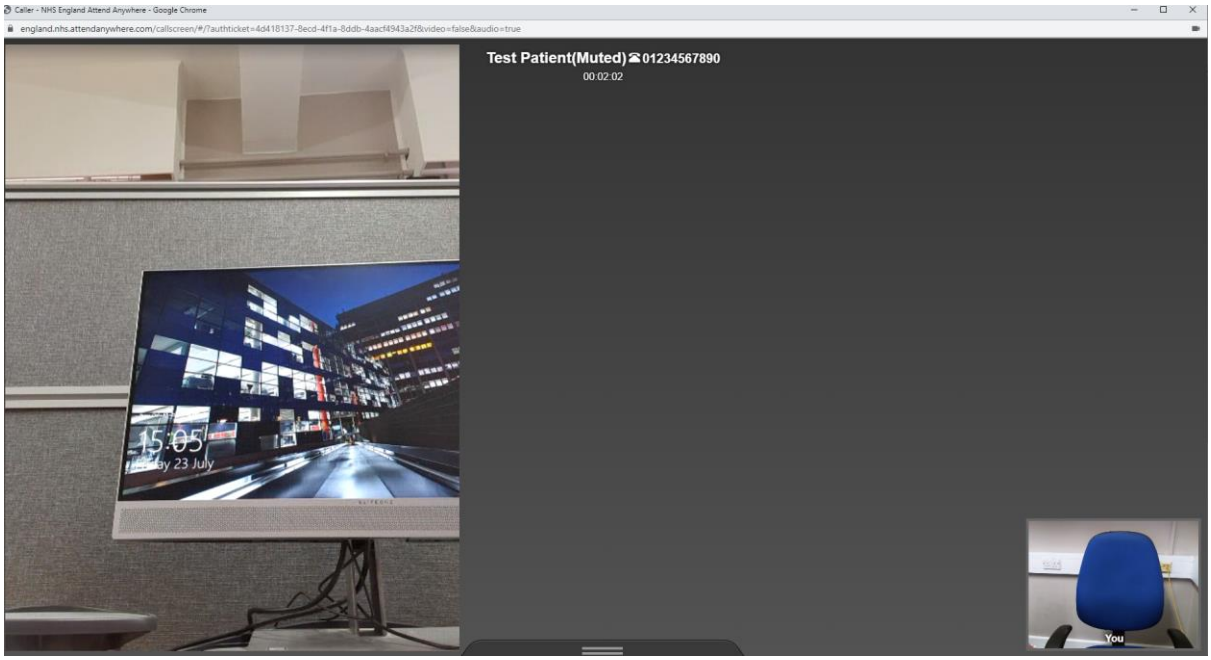


Figure 4.4 - Attend Anywhere consultation (via desktop Google Chrome browser)

4.6.2 Coding table

Overarching theme	Codes	Transcripts where code was applied
Clinical assessment	Importance of examination	S01, S02, S05, S07, S08
	Examination not essential for the majority of patients	S04, S07
	Difficult to examine by telemedicine appointments	S01, S02, S05
	Different ways of examining using video	S03, S04, S05, S06, S08
	Importance of non-verbal information	S02, S06, S07, S08
	Assessing functional capacity	S02, S06
	More reliant on history	S04, S05, S06, S07
	Use of monitoring equipment at home for assessment	S04, S05, S07, S08
	Use of imaging for assessment	S04, S05, S07
Communication and rapport	Face to face more appropriate for new patients	S01, S02, S05, S07, S08
	Possible to do remote consultations with new patients	S04, S08
	How well clinicians know patients influences appropriateness of telemedicine	S01, S02, S04, S05
	Difficulty building rapport with new patients by telemedicine	S02, S03, S05, S08
	Different chemistry with patients in person vs remote	S01, S02, S05
	Remote consultation more business-like	S03, S04
	Video better than telephone for rapport	S01, S03, S04, S07, S08
	Difficult conversations more appropriate face to face	S04, S05, S07, S08
	Differentiating human clinicians from machines	S01, S03, S05
	Confidentiality/privacy issues	S03, S05, S08
Time utilisation	Saving travel time for clinicians	S05, S08
	Can use telemedicine from any location	S02, S03, S05
	Shorter consultation time for clinicians	S03, S04, S05, S08
	More efficient	S04, S07, S08
	More preparation for telemedicine clinic	S01, S05, S07, S08
	Feeling guilt when patient has travelled	S04, S05

Technology and operational issues	Difficulty in getting technical support	S02, S03, S06
	Issues with sufficient space/computers	S02, S03, S04
	Issues with high-speed internet	S06, S07, S08
	Good overall experience of technology	S01, S03, S07, S08
	Experienced technical difficulties	S02, S03, S04, S05, S06, S07, S08
Choice and flexibility of mode of consultation	Dependent on patient and situation	S01, S02, S04, S05, S06, S07 S08
	Difficulty assessing complex/unwell or deteriorating patients by telemedicine	S03, S04, S06, S07, S08
	Giving clinicians power and flexibility to determine clinic format	S01, S02, S04, S05
	Avoiding rigid policy	S01, S02
	Telemedicine as default for stable patients	S03, S05, S07, S08
	Communicating test results by telemedicine	S01, S05, S08
	More flexibility for patients in telemedicine	S02, S05
	Clinicians working from home	S04, S05, S06, S08
	Quicker adoption of technology due to Covid-19	S05, S07, S08

5 Patient perspectives on telemedicine HF consultations: a qualitative study

5.1 Introduction

In Chapter 4 we presented the experiences of clinicians who undertook telemedicine consultations. Here evaluate patient experiences.

5.2 Methods

Detailed methodology for design of the study is discussed in Chapter 4. We used semi-structured interviews to gather narrative data of patients' experiences. The same prompt questions from clinician interviews were used:

- Please describe your experience of telemedicine consultations
- How did you find the technology?
- What was your experience of the clinical interaction?
- How could the experience of consultations be improved?
- How would you like future consultations to be conducted, and why?

Patients who had a scheduled appointment in either a consultant or nurse-led HF clinic between 1st January 2021 and 28th April 2021 were sent a text message link to an anonymised quality improvement survey in which patients were invited to participate in interviews. Patients' records were checked to confirm a diagnosis of HF and recent clinic attendance and interviewees were selected by purposive sampling to ensure a range of ages and both sexes were represented. Patients were screened sequentially until data were saturated and recruitment stopped. Interviews were conducted using Microsoft Teams, or Zoom where patients were unable to use Teams, and were recorded and transcribed verbatim as per the methodology discussed previously in Chapter 4.

5.3 Results

1296 patients were sent a text message link to the survey, and 128 patients (9.9%) completed the survey. Eight patients were interviewed between 9th April and 29th July 2021.

Patient	Age at interview	Sex	Modalities used	Under RBH HF clinic since:	Primary diagnosis
P01	57	Male	Video and telephone	Oct 2014	HFrEF – dilated cardiomyopathy
P02	65	Male	Video and telephone	Oct 2020	HFrEF – cardiac sarcoidosis
P03	70	Male	Telephone	Apr 2014	Valvular heart failure
P04	56	Female	Telephone	Apr 2018	HFrEF – dilated cardiomyopathy
P05	63	Female	Video and telephone	Apr 2011	HFrEF – Takotsubo cardiomyopathy
P06	75	Male	Telephone	Oct 2017	Valvular heart failure
P07	45	Female	Telephone	March 2018	Valvular heart failure
P08	72	Male	Video and telephone	October 2019	HFrEF (undifferentiated)

4 key themes emerged from the narrative data:

- Time utilisation

- Clinical assessment
- Communication and rapport
- Technology

5.3.1 Theme 1: Time utilisation

A major theme emerging from patient interviews was that telemedicine consultations saved time and were more convenient compared with in-person consultations.

Most patients stated that the primary advantage of telemedicine consultations was saving the time, effort and expense of travelling to hospital:

> *"That's the big benefit for me, I think, just the saving in time and expense of travel. It takes me 2, 2 1/2 hours to get there from home, so it saves me a good half day, plus the train fare. So yeah, I can see very real benefits."*
>
> – P03, 70M

Being a specialist centre, many patients live far from the hospital and needed to make long journeys in order to make an appointment. One patient, for example, lived 168 miles away from the hospital and needed an overnight stay for an in-person appointment:

> *"Well, I usually make it a two-day trip because I can never get there in time for the appointment, and I don't want to be like manically trying to get to the Royal Brompton from Yorkshire…. so, I tend to come down the day before and stay overnight so that, you know, I can just get up and go to clinic and then get a train back…"* – P05, 63F

Patients who did not live locally often apportioned extra time for journeys to allow for potential delays. One patient commented that travel delays could be stressful as they feared missing their appointment, and that this concern was negated by telemedicine:

> *"If you're if you're running late, you're not gonna be here. You might all be flustered or- or whatever, or you might literally miss your slot…"*
>
> – P01, 57M

Some patients, however, did not mind the journey to the hospital, and they often combined the appointment with other social events to make the most of a trip to London, as one patient who lived 96 miles from the hospital commented:

> *"[The journey] doesn't really bother me, and in normal times I would normally sort of turn it into something else, maybe go and meet a friend for lunch, go and do some shopping."*
>
> – P04, 56F

Some patients stated that waiting for an in-person appointment took longer than telemedicine appointments; in-person appointments tended to be delayed whilst telemedicine appointments tended to start closer to their scheduled time:

> *"Well, coming to the hospital, you have to queue, [which] takes time… being on phone consultation or video consultation, it's on time, [or] maybe you have to wait 30 minutes, 15 minutes, but that's not so bad."* – P07, 45F

Most patients preferred waiting at home to waiting in a hospital waiting room, as they found it more comfortable and were able to do other things whilst they waited:

> *"Oh, it's obviously better to be waiting at home. I can be doing other things. Sitting in front of the computer doing stuff."* – P02, 65M

However, some patients did not mind waiting for appointments as they perceived delays as resulting from clinicians giving patients appropriate time in consultations, and were therefore understanding of delays:

> *"I would sooner not feel rushed, I would sooner wait."*
>
> – P01, 57M

> *"Sometimes you have to wait, but, um, I don't mind that because I think that, you know, [the clinician] gives people time. And, you know, I think that's- that's worth waiting for, really."*
>
> – P04, 56F

Patients did not perceive that telemedicine consultations were shorter, brief or rushed, but some patients thought that it would be more efficient for clinicians, which they saw as an advantage:

> *"Well, I feel it is inevitable, and I think it's a good idea because I think it allows you to be more efficient."* – P06, 75M

5.3.2 Theme 2: Clinical assessment

In the previous chapter clinicians described different ways of gathering information for clinical assessment for telemedicine consultation compared with in-person assessment; patients noted similar changes in the consultation.

Physical examination was not possible by telemedicine, but most patients did not perceive this to be a problem for them, but rather more a challenge for the clinician:

"I think it's- it's just the physical side of checking the condition of your patient, i.e. blood pressures, temperatures, that sort of thing…. So again, it would be more of a clinician's problem than a patient's problem, I would have thought."

– P02, 65M

Most patients thought that physical examination was not a vital part of the heart failure consultation, particularly if they were symptomatically stable:

"Where it is a straightforward review of the medication, how am I, checking on blood pressure, checking those sorts of things that can be done at arm's length, then [video consultation] is perfect." – P08, 72M

One patient stated that routine examination added very little as it wasn't possible to assess cardiac function by examination alone:

"No one can see your heart, it's inside you so [laughs]… I don't think I would be- I would be bothered for that- for that kind of thing." – P05, 63F

This patient added, however, that when she developed worsening symptoms, she was less reassured by a telephone consultation owing to the lack of examination and easy access to tests:

"I'd had this change and that in itself was a shock, but then not to be able to go back down to London and see somebody and be examined and have those tests that I should've had, that was hard." – P05, 63F

After the telephone consultation, she had tests arranged locally and was then reassured by the follow-up video consultation, as she perceived that the results allowed the clinician to make an appropriate clinical assessment and communicate an update to her, and video allowed for some visual assessment:

"I think that from a clinician's point of view that's part of the diagnosis, isn't it? You know if I'd come on looking, you know, like I put on a lot of weight or I look really tired, he might be like, "OK, well you look…", you know. So, those physical clues are there, aren't they still on the Zoom thing." – P05, 63F

One patient did find routine physical examination and regular in-person clinical assessment particularly reassuring, and this was her primary reason for preferring face-to-face consultations:

"You know, things get worse don't they, the longer you leave them… it would just- for him to sort of like review the tests and do examination and everything… it's just m- more reassuring." – P04, 56F

Interviewees stated that telemedicine consultations were more reliant on patients' self-care abilities and being able to identify a change in their clinical state and accurately describe worsening symptoms. One patient commented that telephone consultations were particularly reliant on self-described clinical status, and therefore open to a possible "mismatch" between the patient's and clinician's perceptions of their clinical status, whereas video allowed a visual assessment which may be able to detect this mismatch:

"Perhaps there might be a mismatch between them saying 'I'm absolutely fine, absolutely fine' and you may think you don't look perhaps, you know- don't look as well, perhaps, as you're saying." – P01, 57M

Most patients were confident that they were able to notice any deterioration in their cardiac status, and so did not see this as an issue:

"I'm very conscious of- very aware of my heart and my body. I know when something is going wrong I- I've lost count of the number of times when I've said

look this is happening, and this is wrong and I've been right. I don't just sit back and wait for someone to diagnose something." – P03, 70M

One patient remarked that she tended to access local care in case of acute deterioration and so she did not perceive much difference with telemedicine:

"Whenever I feel I'm getting worse, I- I always have the option of going to ER anyway."

– P07, 45F

Those that described being less confident in their ability to self-assess preferred in-person reviews by clinicians for routine heart failure monitoring:

"I think that sometimes that you- you could miss something yourself that- that they wouldn't." – P04, 56F

Some patients had their own home monitoring equipment such as sphygmomanometers, scales and oxygen saturation probes. One patient remarked that he found it more reassuring to self-monitor; he was more confident that home readings would be reliable and not subject to white-coat hypertension (the phenomenon of having elevated blood pressures in medical settings and normal blood pressures at home):

"I know pretty well where, my blood pressure, I expect it to be. And if it's different when I'm at the hospital, then I- that raises doubts for me because I'm now thinking is their equipment accurate or has my blood pressure become elevated by the fact that I've had to get up here and come to the traffic and so on and so forth, but sitting here in the calm with my own equipment, I'm very happy that the results I'm

getting are- even if they're not spot on, which is not critical in my view- but they are outlining a trend." – P08, 72M

Most patients had local tests (predominantly blood tests) organised, usually by their GP, to ensure appropriate guideline-directed routine monitoring was performed and that results were available for clinicians for telemedicine consultations. Some patients found this much more convenient as it was a much quicker process than getting tests at the hospital:

"They write to me and to my GP, I go and get a blood test at the GP, which is extremely convenient also, because it's in Woking where I am. It's a 5-minute exercise for me at the GP" – P08, 72M

One patient, who was very positive about the idea of having tests organised locally before telemedicine consultations, perceived that GPs were reluctant to perform these tests as it added to their workload:

"I have felt, um, some tests for going onto a new medication involving frequent blood tests were- the GP, in fairness, they did do it, but there was a little bit of a possible, 'but it is taking up <u>our</u> resources' … but it did, again, in this particular instance, slightly feel that they were- GP was doing me a favour."

– P01, 57M

Most patients stated that if they needed specialist tests such as echocardiography they needed to come to hospital for the test. One patient perceived that in-person appointments offered easier access to specialist tests:

"I know echo tests are probably expensive to run and they take quite a lot of time, but it is nice to know what the trend is…. I do enjoy finding out and keeping tabs on

that, which obviously I can't do [on the same visit] with telephone or video consultations."

– P03, 70M

If specialist tests were required for the consultation, there was a mix of opinions as to whether patients preferred to have tests and consultations done together or separately. Most responses were neutral, but some patients preferred having all required tests being done on the same day with an in-person appointment:

"So personally, for me in the future, if- yeah, I prefer, uh yeah, going into the clinic, having test results, tests and all and everything else done at the same time rather than just talk."

– P07, 45F

Another patient preferred having tests and consultations on separate days, as his long travel time to the hospital meant it would be challenging for him to have an echocardiogram early enough to have results ready in time for a morning clinic appointment:

"That's [getting an echocardiogram on the same day] obviously not always practical... you can't get everybody first thing in the morning and then chat- chat later on. So, I guess… it would still be better if- if the- the tests or whatever are separate from the- the consultation."

– P01, 57M

5.3.3 Theme 3: Communication and rapport

Similar to clinicians, patients found that telemedicine consultations changed how they communicated with clinicians, affecting rapport and consultation dynamics.

In-person consultations were sometimes seen as the gold-standard for communication, with some patients emphasising the importance of non-verbal communication:

> *"I think just being face-to-face and closer to someone you pick up more on certain nuances with communications, and body language, that sort of thing. And it's all part of communication, isn't it? And, being in a room, you see all that."*
>
> – P02, 65M

Many patients described communication in video consultations to be similar to in-person consultations, as it was still possible to make use of the same visual cues through a screen:

> *"In terms of communication, it's as good as being face to face because you- you talk, you listen. I think with the video it's quite good, obviously, that the doctor can at least see what you are looking like and may think 'oh, this person doesn't look as well as maybe when I last saw them', or they may… pick up on, I don't know, body language or something… "*
>
> – P01, 57M

Some patients perceived that the lack of these key visual cues impaired communication and detracted from the experience of telephone consultations:

> *"Telephone conversations are quite difficult to know quite what's going on at the other end, and I like to know how the… person is reacting to what I'm saying and*

I'm sure he wants to know how I'm reacting to what he's saying."

– P06, 75M

One aspect of communication negatively impacted by telephone consultations was visually relaying the results of investigations. Patients described how in face-to-face consultations, clinicians shared echocardiogram and radiology images with patients; this was not possible by telephone:

"One disadvantage of a telephone conversation is that [previously] very often I was showed- shown things, results of X-rays or- or echo tests or whatever. That was always- it was interesting to me." – P03, 70M

Similarly, some patients stated they were more comfortable discussing their condition and asking questions in-person:

"I was a barrister I- I used to spend my whole life interviewing people and cross-examining people and asking questions and there's nothing like being in the room with somebody. If you really want to know something, it's easier to find out by being there."

– P06, 75M

On the other hand, one patient stated that a benefit of telemedicine was that he was able to write down important information during the consultation to help him remember afterwards; he suggested the possibility of even recording telemedicine consultations but acknowledged there may be practical barriers to this:

"It was perhaps easier to write things down, make notes as we were going on a phone call. Uh, it would be interesting to be able to record the call and play it back

and pick up anything I might have missed…. That may not be very practical."

– P03, 70M

Patients gave mixed responses as to whether rapport was different by telemedicine, and how important it was. Some patients perceived a loss of rapport by telephone owing to the lack of visual communication:

"I find that [a difference in rapport by telephone]. I don't know if others would, but [I] do to a degree. Obviously, the subject of the phone call is generally about your health so knowing that beforehand does help to get that rapport going, but, again, being a visual thing as well, it [video consultation] helps a great deal."

– P02, 65M

One patient considered telephone consultations to be more "casual" and less like a formal consultation than in-person or video assessment:

"I think maybe the telephone… seems a little… more casual."

– P01, 57M

But they added that having more experience of a particular medium also influences how comfortable one is with that medium:

"I think also the more you do, in any sort of interaction, socially, medically, business, I think it becomes more- more natural or you feel more comfortable with it."

– P01, 57M

Another patient also stated that the ease of developing rapport by telemedicine was likely to be related to prior experience using video technology; he had used video conferencing

for several years and could not perceive any difference in clinical interaction compared with in-person appointments:

> *"No [there was no difference in communication or rapport], but only 'cause I'm used to it. My wife will not use this medium. She hates it. Absolutely loathes it…. I'm so used to conference calls, video conferencing and so on. I can understand why a lot of people might not like it, or feel uncomfortable… But from my point of view… it's just part of my business tools now."*
>
> – P08, 72M

Others, however, judged that even by telephone rapport was not significantly different, and one patient stated the impact of modality on rapport mattered less to him:

> *"It still is- it's the same, I guess, it's the same."*
>
> – P07, 45F

> *"Um, I don't think it really mattered, no. I wasn't- I didn't come away feeling short changed, as if I really missed anything."*
>
> – P03, 70M

Some patients perceived the rapport by video consultation as equivalent to in-person consultations, as visual communication was the key factor in developing rapport:

> *"It's pretty much the same, again it's all to do with seeing someone. I think the operative word there is seeing."* – P02, 65M

Unlike clinicians, however, patients did not express a specific preference for first appointments to be face to face, and most respondents thought that meeting someone for the first time by telemedicine was similar to in-person appointments:

"It [meeting new clinician by telemedicine] was fine. It's- it's something that all my business life, I suppose, happened to me all the time and so I- I didn't really think about it, it was OK."

– P03, 70M

One patient similarly stated that meeting new people by video was very natural for him as he did it regularly at work, but that others may feel differently:

"To me it makes absolutely no difference, but it does come back to the fact that I'm used to it. A lot of the calls lot of business calls I make are to people I've never met."

– P08, 72M

Similar to clinicians, most patients stated that sensitive topics such as breaking bad news were best discussed in-person so that patients could have adequate support:

"This is gonna sound quite dramatic, I think if it was like you've got six months to live, I'd probably rather do that face-to-face than over a Zoom call. I think that would be quite hard to hear that when you're on your own in the house, you know, and there's no support."

– P05, 63F

They added, however, that if telemedicine were to become the default and the clinician arranged a face-to-face appointment then they would assume that the reason must be that there was bad news:

"But then I'm guessing if he suddenly said to me you need to come to London I'd be 'oh my God I've only got six [months to live]'." – P05, 63F

5.3.4 Theme 4: Technology

Patients had generally positive experiences with the technology for telemedicine; telephone was familiar to all patients and straightforward, and patients who used video consultations via the Attend Anywhere platform were generally able to do so without issues.

Some patients were apprehensive before their first appointment using video technology as they were unfamiliar with the platform and concerned about potential difficulties in accessing it which could result in them missing their appointment:

> *"I was like 'oh God if it's like this could be really stressful' but actually it wasn't, it was- in some ways, it was easier than Zoom, it was like you were just in then that was it. So yeah, no it was fine, but I was a bit apprehensive, yeah…. I thought if I don't get this set up in time, they'll think I've not- like not turned up kinda thing. And then I'll miss out on my consultation. So, there was that level of panic…"*
>
> – P05, 63F

Despite this, patients found video consultations intuitive and easy-to-use:

> *"It was absolutely fine. Worked- worked first time, no delays getting in and I didn't have to download anything. So that was- it was part- perfectly fine, yeah."*
>
> – P01, 57M

One patient believed his prior experience with using video technology in other settings contributed to its ease of use, and supposed people who had never used video calling before may struggle:

"Other people might find it a bit of a nuisance, but then I worked with it for a long time so to me it's almost second nature…. I don't have a problem with that sort of thing, I'm pretty much mechanically minded. I can get on and do things so it's not a problem with that."

– P02, 65M

Most patients interviewed had prior experience of video calling outside of healthcare, often using platforms such as Zoom™ to connect with family and friends, particularly during the pandemic, and some patients had also used video platforms for work:

"I think we all make more use of video technology. My- my son and his family live in Abu Dhabi, so we frequently have Zoom or- or Teams calls with them…. We've had many a celebration of birthdays and so on with them over the last 15 months…. Zoom has helped enormously, and yeah, having the technology is terrific…. I used it for good few years before I retired…. it was very convenient to be able to hold video calls." – P07, 70M

Patients did not report technical disruptions during their video consultations, though one patient reported signal disruption in a telephone consultation:

"I guess it's the signal sometimes, see if it stutters or sometimes you lost- lose signal or sometimes it just cut off." – P07, 45F

5.3.5 Overall perceptions

As with clinicians, patients believed that the choice of consultation modality depended on the situation. The main downside of face-to-face consultations for patients was the time, expense and effort in travelling to hospital and waiting for an appointment, whereas the main advantage was the perception of a more thorough clinical assessment. Most patients

thought that a hybrid model with in-person and telemedicine clinics for different situations would be ideal for future care.

Communicating test results, for example, was generally perceived to be best done by telemedicine:

> *"But certainly, if it is just to go through the results, I would much prefer a remote thing because I don't- I can't see any particular, um, - a particular reason that there is a need to be face-to-face for something like that."*

– P01, 57M

Whereas, as reported above, patients tended to prefer in-person appointments when their symptoms deteriorated, and would also prefer in-person appointments if they were receiving bad news.

Video was perceived to be an overall improvement on telephone consultations with all patients who had used both modalities:

> *"So, I would say I preferred the video to the telephone, 'cause I quite like to see somebody."*

– P05, 63F

Some patients thought that telemedicine should be the default modality for them, and in-person appointments should be reserved for when physical assessment was required:

> *"Well, if there's no need for, uh, contact, physical contact, then obviously you don't really need to travel."* – P02, 65M

As stated earlier, some interviewed patients were more reassured by investigations than examination, and therefore some patients believed that in-person appointments should

be reserved for when specialist investigation was required, but otherwise telemedicine was preferable:

> *"Unless I am needing echocardiograms or ECGs or scans of any other sort, ultrasounds, or you name it, then this is perfect. I- I much prefer it. I'd far rather have this medium than- than having to keep coming to the hospital."*
>
> – P08, 72M

Others, however, preferred in-person assessment as the default as the reassurance of routine physical assessment outweighed the benefits of saving a journey:

> *"I would rather come in and see the consultant myself…. I- personally I don't mind travelling to go there."* – P04, 56F

One patient suggested alternating between telemedicine and face-to-face appointments:

> *"Maybe, come to the hospital once a year or once every two years, with video or telephone consultations in between… Yeah, I- I think I would like to be able to come to the hospital sometimes, see somebody and chat to somebody. I- I'm always very interested to know how it's progressing."* – P03, 70M

One patient commented on the potential environmental benefits of telemedicine from not having to make a journey to hospital:

> *"I haven't had to go outside the house get in the car, burn up a load of fossil fuels, warm up the- the country, get frustrated in the traffic…. it's saving the environment"*
>
> – P08, 72M

Patients also perceived that telemedicine would be more efficient for the NHS, and that this should also be a consideration in its use:

> *"I think it's going to save money for the NHS and free up resources, and I think that's a good thing…"* – P05, 63F

One patient, however, believed that the efficiency of telemedicine needed to be balanced against access to services, and he emphasised the importance of improving access:

> *"Obviously, there are issues about sort of connectivity and people who don't have access to digital communication… I think it's that balance of if it's more efficient for everybody, uh, then… encouraging people towards the most efficient way is- is better."*
>
> – P01, 57M

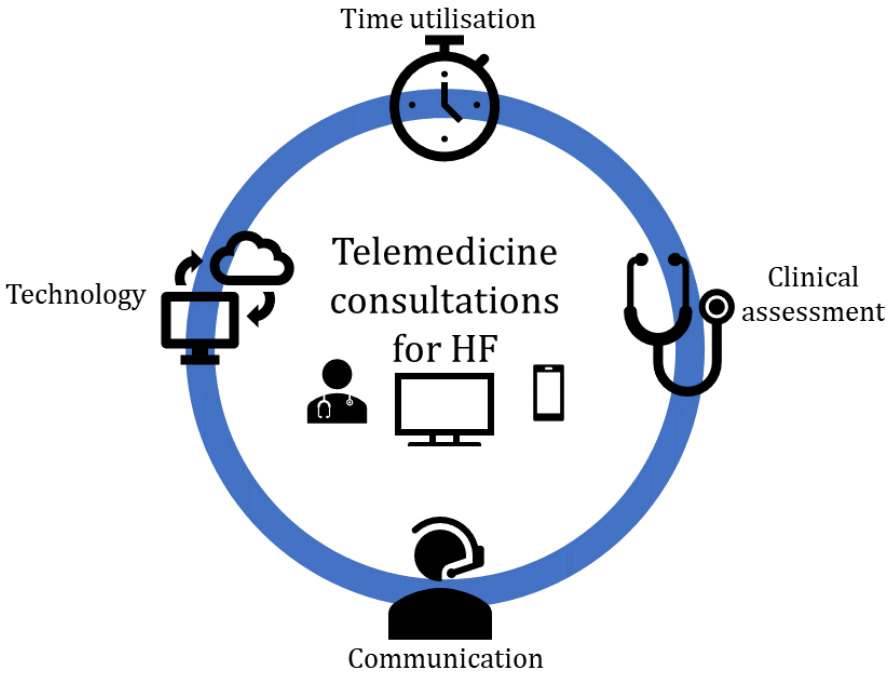


Figure 5.1 - Key themes of HF patients' experiences with telemedicine consultations

5.4 Discussion

5.4.1 Summary of key findings

4 key themes were identified in patients' experiences of telemedicine consultation: time utilisation, clinical assessment, communication and rapport, and technology (Figure 5.1). Patients described how telemedicine interviews saved them time by avoiding a journey (and associated expense) to hospital. The time waiting for a consultation was also shorter and patients were generally more comfortable waiting at home for a consultation than in a hospital waiting room.

With regards to clinical assessment, patients noted that clinicians were unable to perform physical examinations, but most patients were not troubled by this when they felt well and were content with history and imaging tests, and in some cases home monitoring equipment. Some patients believed clinical assessment was more reassuring in-person.

Communication in telemedicine consultations was limited by the loss of visual feedback and non-verbal cues; this was particularly true for telephone consultations, whereas video consultations allowed patients to make use of non-verbal cues. There was a mix of responses as to whether these changes in communication affected rapport, but patients generally perceived that breaking bad news was best done in-person.

Finally, with regards to technology, patients' experiences were mostly positive, with patients who used video consultation finding the platform intuitive and easy-to-use.

Patients perceived that both telemedicine and in-person consultations should play a role in delivery of HF care. Most patients thought that more "routine" clinical interactions such as delivering test results, and "check-ups" during periods of clinical stability could be provided by telemedicine, but some patients would in-person clinical assessment,

particularly if there were a deterioration in clinical status or if patients were less confident at self-assessment.

5.4.2 Comparison of clinician and patient perceptions

Patients and clinicians had similar experiences of telemedicine; and each of the 4 key themes emerging from patient interviews corresponded with themes arising from clinician interviews. Whereas clinicians had mixed opinions on whether telemedicine saved them time, patients were unequivocal that telemedicine consultations saved a significant amount of journey time and were more convenient. Both patients and clinicians emphasised the importance of non-verbal communication and visual cues for clinical assessment, however clinicians placed more emphasis on the effect this had on rapport; some patients even reported that telemedicine consultation did not change rapport at all. Clinicians unanimously thought that it was best to meet patients for the first time in-person rather than by telemedicine, but patients interviewed did not express a preference for this. Patients and clinicians agreed that breaking bad news was best done in person. Most clinicians raised the issue of lack of physical examination being a limitation to telemedicine, whereas patients had mixed opinions; some patients did not perceive physical examination to be a vital part of clinical assessment. Most clinicians interviewed experienced technical difficulties during video consultations and some perceived that patients would find video consultations technically challenging. Patients, on the other hand, tended to have good experiences with video consultation and did not encounter technical issues; this may simply reflect the fact that clinicians had performed a far higher number of consultations. Both patients and clinicians believed that telemedicine consultations may be more efficient. Clinicians identified journey time and expense as being a significant factor influencing patients' perceptions of telemedicine.

Whereas some clinicians perceived that many patients were not enthusiastic about telemedicine consultations and that patients had greater time-keeping expectations for telemedicine consultations, this was not borne out in patient interviews.

5.4.3 Comparison with prior research

5.4.3.1 Telemedicine in primary care

Telemedicine has been most widely evaluated in primary care. Thiyagarajan *et al.* performed a systematic review of clinician and patient experiences of video consultation in primary care in 2019.[79] Seven studies were identified, only one of which was a qualitative interview study (Powell *et al.* discussed below).

Powell *et al.*[80] conducted semi-structured interviews of 19 patients who had undergone primary care video consultations in the USA using a proprietary video platform. Patients reported benefits of reduced travel time, and not having to miss work or change attire, and also noted decreased wait times compared with face-to-face appointments; similar to the present study. With regards to hearing bad news, patients had mixed responses, with some preferring to receive bad news at home; in the present study, most patients and clinicians agreed bad news was best delivered in person.

Video consultations using the Attend Anywhere platform we used in our study have also been evaluated in primary care in the UK. Donaghy *et al.* used semi-structured interviews to evaluate clinician experiences of video consultations. 13 primary care clinicians and 21 patients who had used the Attend Anywhere video platform were interviewed.[130] Clinicians perceived video consultations were overall time neutral, with the exception of house visits, in keeping with our findings. Patients and clinicians also spoke of the advantages of picking up non-verbal cues by video which reduced miscommunication

and improved rapport compared with telephone. Similarly, primary care clinicians interviewed also reported that serious issues or delivering bad news would be more appropriate for face-to-face consultations, consistent with the present study. Patients reported convenience benefits from not having to travel or take a half day off work and generally had positive experiences of the consultation, similar to our findings.

Bjorndell and Premberg performed a similar study, evaluating 10 primary care physicians' experiences of telemedicine using semi-structured interviews.[81] Clinicians reported improved satisfaction from improved flexibility and being able to work from home which saved travel time. Some clinicians reported similar benefits in the present study. Clinicians also noted improved efficiency from "clicking" to start or end a consultation, rather than having to wait for patients to get dressed; clinicians in the present study reported similar improvements in efficiency. Finally, their study also reported that clinicians were able to guide patients through a form of examination, which although fell short of physical examination was nonetheless acceptable in many circumstances; these findings reflect clinician experiences of examination in the present study.

Hammersley *et al*. performed a study of primary care face-to-face, telephone and video consultations, analysing length of consultation, information exchange, consultation quality indicators and technical issues.[131] Both telephone and video consultations were found to be significantly shorter than face-to-face, in keeping with the perceptions of clinicians in the present study. There was significantly less information exchange in telemedicine consultations, with clinicians asking fewer questions on average and delivering less patient education. These findings were not noted by participants in the

present study. Occasional technical disruption necessitating change of modality of consultation was reported, consistent with our findings.

5.4.3.2 Telemedicine in other chronic conditions

Mair *et al*. used semi-structured interviews to evaluate 22 patients' experiences of telemedicine consultations in an outreach oncology clinic in Kansas, USA.[132] The mean age of patients was 67, and patients reported high satisfaction with telemedicine consultations, primarily driven by savings in time and effort to get to the hospital (an average 5h journey each way). Subjects highlighted that they were happy with telemedicine being used "just for monitoring" but that telemedicine consultations should not be intended to establish diagnoses or offer prognostic information, in keeping with our findings. Furthermore, subjects identified changes in the doctor-patient interaction, technological constraints and the absence of physical contact as barriers, similar to the present study. Of interest, patients reported that personal or embarrassing problems were less likely to be discussed by telemedicine, which was not reported in the present study.

The VOCAL study (Shaw *et al.*) evaluated telemedicine consultations for diabetes and cancer surgery at an acute trust in the UK using mixed methods including interviews.[133] Though policy-makers were enthusiastic, primarily owing to perceived efficiency benefits, implementing telemedicine consultations was found to be more complex and challenging than anticipated; in contrast, our organisation and clinicians were able to transition rapidly to telemedicine, likely owing to the absolute necessity resulting from Covid-19. Video consultations were perceived to be slightly shorter, primarily owing to more task-focused clinical assessment and less "chit-chat" in keeping with the perceptions of clinicians in the present study. Consultations tended to work better when

clinicians and patients knew each other, in keeping with the perceptions of clinicians in the present study. Some clinicians were unwilling to try telemedicine because they were "too busy" in contrast to the present study where all clinicians were required to and willing to use telemedicine. Telemedicine consultations were most frequently used for supplementary clinician-initiated encounters for patients undergoing a period of instability rather than as a replacement for in-person clinic appointments, in contrast with the present study whereby in-person clinics were able to be avoided entirely.

5.4.3.3 Telemedicine in HF

Telemedicine consultations for HF as a replacement for in-person consultations have had limited evaluation. Seuren *et al.* conducted an analysis of physical examinations by video for 7 highly selected patients with HF; strategies used by clinicians to aid remote clinical assessment, including using home monitoring equipment and limited video examinations restricted to assessing fluid retention, are similar to those used by clinicians in the present study .[134] Similarly, challenges in communicating examination and the limitations of the examination were consistent with opinions of clinicians in the present study. In contrast, the present study did not select patients for video consultation, and despite this, patients did not generally perceive a significant limitation to physical examination. Shaw *et al.* found that consultations with patients with long-term conditions (including 7 HF patients) could be frequently disrupted by breakdown of audio or visual feed or latency issues which sometimes resulted mishearing, missed information or conversational overlap, consistent with the perceptions of clinicians in the present study.[135]

5.4.4 Benefits and challenges of telemedicine in HF

Patients and clinicians in our study identified several benefits and challenges (summarised in Table 1) to telemedicine HF consultations compared with traditional in-person appointments.

	Benefits	**Challenges**
Face-to-face	• Better rapport • Physical examination • Easy access to same-day investigations	• Long travel times (and environmental impact of travelling) • Long waiting times • Longer consultations • Dedicated physical consultation space required
Telemedicine	• No travel necessary • Flexibility • Shorter consultations • Shorter wait for patients • Some visual assessment possible by video • No dedicated physical clinic rooms required	• More administrative time • Less rapport (particularly telephone) • Limited examination – more reliant on history • No access to same-day investigations • Need for personal computers for clinicians and high-quality internet • Need for private spaces

Table 5.1 - Benefits and challenges relating to telemedicine consultations as identified by interviewed clinicians and patients

Challenges identified by our study participants are similar to those identified by Greenhalgh *et al.* in a hermeneutic review of the literature of HF and telehealth, where

they reviewed 39 systematic reviews, 6 large trials and several empirical studies.[136] Greenhalgh *et al.* identified the following factors accounting for low staff uptake of telehealth prior to Covid-19:

- Absence of champions
- Dislike of new clinical routines (including increased workload)
- Dislike of new clinical interaction (i.e. prefers face-to-face encounters)
- Belief that relationships and therapeutic interactions will be compromised
- Perception that their clinical expertise is being marginalised
- Perception that there is no value for them in the new way of working
- Inability to use the technology.

In the present study clinicians expressed concerns regarding the increased administrative workload, the changing clinical interaction and its effects on clinical assessment and therapeutic relationships, perceptions that they could be "replaced by machines" and difficulty using the new technology. Champions were not necessary as telemedicine was used by necessity rather than choice, and clinicians did see the value in the new way of working, although the Covid-19 pandemic is likely to have altered the value equation significantly. When the risk of transmission from a hospital appointment (and associated travel) becomes much lower, the value equation may change again for some clinicians; other barriers may therefore need to be addressed to improve clinician experience and ensure a continued high uptake of telemedicine consultations. Perceptions of increased workload were partly driven by the extra time required to acquire results for investigations done outside the hospital (for example local blood

tests); technology solutions to allow GPs or patients to automatically share relevant health information with hospital IT systems thus have the potential to reduce hospital clinician workload. Other administrative issues identified by clinicians included not being able to prepare for which patients would be attending by video call or by telephone call; current local electronic health record schedules are unable to differentiate between video and telephone appointments and patients had the option of either without needing to inform the hospital in advance. When face-to-face appointments return in greater numbers this may pose a further challenge as clinicians may have a mix of in-person, video and telephone appointments in the same clinic. Clinicians expressed that they would prioritise in-person clinic patients which may result in increased delays for patients with telemedicine appointments. It may therefore be practical to separate face-to-face and telemedicine clinics, and within telemedicine clinics to ensure patient preference is recorded and known to clinicians before the clinic to assist with planning.

Improvements in video technology and home internet speed (for example planned expansion of the UK fibre-optic broadband network) may result in higher quality connections which may mitigate some of the concerns regarding the clinician interaction and communication. Difficulty in using the technology could be addressed by improved training for clinicians and dedicated helplines for technical difficulties; the benefits would have to be balanced against the potential costs to organisations.

Factors accounting for poor telehealth uptake in patients identified by Greenhalgh *et al.* included:

- Low motivation
- Preference for a face-to-face encounter

- Inability to use the technology
- Inability or unwillingness to take action in response to remote instructions
- Lack of confidence in own ability to use the technology or the service
- Fear that engaging with telehealth will lead to exclusion from a valued traditional service.

Patients we interviewed did not express low motivation, unwillingness to respond to remote instructions or fears that telehealth would lead to exclusion, but some did express preferences for a face-to-face encounter, difficulties using technology and lack of confidence in technology. Most patients interviewed stated that the technical difficulties they encountered were relatively minor and that the video technology was intuitive, but some patients still suggested helplines for dealing with technical difficulties would be helpful. Interviewed patients were sometimes unaware of certain functionalities within the video platform such as screen-sharing and the ability to invite guests; this could be addressed by information leaflets when patients are booked into a video appointment.

5.4.5 Discussion of methodology

5.4.5.1 Study design

Semi-structured interviews were used to provide a framework for data collection whilst providing opportunities for in-depth exploration of respondents' views. Semi-structured interviews are the most common form of interview used in healthcare research.[137] Nonetheless, there are some limitations to this approach which we will discuss here.

Firstly, only 8 clinicians and 8 patients with HF were interviewed; however, further recruitment was deemed unnecessary as clear themes had already emerged and

saturated. Although the sample size may appear small, meta-research of qualitative studies suggests this is in-fact a reasonable sample size, and that the majority of key themes emerge within the first 6 interviews.[138–140]

Interviewee perceptions of the interviewer, and the relationship of the interviewer to the study group may influence responses.[141] The interviewer (AS) was known to all staff interviewees; therefore, we cannot rule out that familiarity with the interviewer and purpose of the study biased responses. The interviewer was, however, conscious to ask questions without preconceptions in an open, neutral fashion and participants were encouraged to speak honestly. Patient interviewees were screened to ensure they had no prior medical interaction with the interviewer. To reduce the influence of any "power" dynamic, the interviewer introduced themselves as a "research doctor" rather than as a member of their heart failure team. Patients all participated in remote interviews from their own home which may also have lessened the impact of this. Interviews are also subject to "social desirability bias" whereby respondents may be more inclined to express views they think are more acceptable to the interviewer;[142] to mitigate this, care was taken by the interviewer not to express any personal opinions and to make clear to patients that the goal of the research was honest evaluation and service improvement.

Thematic analysis, as with all qualitative research, is subjective and subject to different interpretations of data. Our analysis, based on grounded theory coded statements made by respondents, and then iteratively compared transcripts to find similarities and differences between respondents' statements.[128] Two independent investigators agreed the emerging themes accurately reflected narrative data, one of whom (JPR) is an experienced researcher in qualitative methodology.

5.4.5.2 Study population

The Royal Brompton Hospital is a tertiary centre, and patients' and clinicians' experiences may not be representative of those in district general hospitals. All consultants interviewed are clinician-researchers which may have impacted on their perception of new technology. All clinician interviewees had performed a high volume of telemedicine consultations.

Patients were recruited by a text-message link to a survey. The response rate was just under 10%, and it is likely that respondents may have been more motivated or interested in research and more positive about technology than those who did not agree to take part in the study. It may also have excluded patients who are unable to use text-messages or who do not have access to the internet on their mobile phones. A strength of our study, however, is that unlike most telemedicine research pre-Covid-19, nearly all HF patients in the wider cohort had appointments by telemedicine, thus participants weren't selected based on their digital enthusiasm. The average age of patients interviewed in this study was 63 and the average age of HF patients seen in clinics at the Royal Brompton Hospital is 68, significantly younger than the national average age at diagnosis of HF of 77. Familiarity with and access to technology declines with increasing age,[88] and this cohort may therefore have been more digitally engaged than the wider HF population. As a tertiary centre, patients are also likely to live further away than at district general hospitals; for example, several interviewed patients reported a journey of over 2 hours to the hospital, and this may therefore influence patient and clinicians' perceptions of telemedicine consultations.

5.4.6 Significance and implications

Whilst the rapid transition to telemedicine consultations was "catalysed" by Covid-19, the NHS and other healthcare systems have previously recommended expanding telemedicine in order to help service over-burdened hospital outpatient departments. Our findings show that telemedicine is acceptable for many routine HF care when in-person appointments are not possible, and may even be favoured compared with face-to-face clinics in certain circumstances.

5.4.6.1 The modality of follow-up should depend on the situation

Both clinicians and patients believed that a "one-size fits all" policy was not appropriate, and the ideal modality of appointment was dependent on the clinical situation and purpose of the consultation. In general, relaying test results and routine "check-ups" are generally preferred to be done by telemedicine. Patients who are clinically stable and confident in self-assessment, and those who have access to home-monitoring equipment such as sphygmomanometers are ideal candidates for telemedicine follow-up. Patients who are less confident in their ability to self-monitor or self-assess or those in whom there may be a "mismatch" in their clinical status and self-reported symptoms are more appropriate to be seen in-person. New patients are preferably seen in-person in order to perform a baseline detailed clinical assessment, establish rapport and perform specialist investigations if required.

5.4.6.2 Impacts on the wider service

In Chapter 2, we demonstrated that in face-to-face clinics the median follow-up interval was more than 3 months following a deterioration in symptoms or change in therapy. The continued use of telemedicine in HF clinics after social distancing measures have been

relieved could free up significant capacity for in-person appointments, potentially facilitating shorter waiting times for patients.

In the Royal Brompton Hospital, face-to-face outpatient clinic activity is limited by physical clinic space. Increased use of telemedicine could therefore permit the expansion of existing clinics, or even the creation of new clinics provided that hospitals are able to staff them.

Although not reported by patients and clinicians in the present study, telemedicine may also facilitate multi-professional consultations involving clinicians in separate sites (for example primary care and hospital), and this should be explored in future programmes.

The environmental impacts of travelling to face-to-face appointments were reported in interviews. Patient and staff travel is estimated to account for approximately 10-17% of the NHS carbon footprint,[143,144] and thus replacing face-to-face appointments by telemedicine could have significant environmental benefits.

Some clinicians reported that a benefit of telemedicine consultations was that they were sometimes able to work from home. The NHS is estimated to have a shortage of nearly 94000 full-time-equivalent staff, with staff retention and "burnout" being a key issue.[145] Telemedicine could allow more flexible working, which may help address staff retention issues. Furthermore, staff shortages in primary care may impede the NHS's ambitions to deliver more care in the community. Thus, in the near-term while it may be challenging to discharge more stable patients to their GP, telemedicine clinics could continue to provide specialist care.

Clinicians reported increased reliance on local blood tests and imaging. It is therefore important to assess the impact of this on primary care resources. Clinical commissioning

groups (CCGs) often commission phlebotomy services to be mostly performed by hospitals, with GP phlebotomy services often given limited funding. Some GP practices even deprioritised non-essential local phlebotomy services in order to cope with increased pressures related to Covid-19.[146] Thus, the increased reliance on local phlebotomy services may result in additional financial pressures in GP surgeries or the need for "satellite" secondary care phlebotomy services, and may require review of commissioning. Demands on imaging services both locally and in hospital may also increase in the absence of regular physical examination, and it would be important to monitor this and research its impact.

Further research also should focus cost-benefit analyses of telemedicine consultation for HF care and outcome data for telemedicine strategies.

5.4.6.3 Recording consultations and privacy

The topic of recording consultations was raised by clinicians and patients, and multiple clinicians brought up concerns with privacy with patients using telemedicine at home or at work. As the proportion of telemedicine consultations performed by video increases, these concerns are likely to increase further. It is not possible to record video consultations by Attend Anywhere, or by hospital Voice-over-IP (VoIP) telephones, but third-party software may allow recording of both video and telephone consultations. For clinicians to record consultations they would need consent from patients and to ensure recordings were stored in accordance with United Kingdom General Data Processing Regulations (GDPR). Patients, however, do not require consent to record a consultation and are exempt from data protection principles if they process their own health data. This opens up the possibility of overt or covert recording by patients which though legal[147] may make clinicians feel uncomfortable and could change the clinician-patient

relationship; this needs to be balanced against the potential benefits for patients of being able to revisit consultations which could lead to greater recall.

Telemedicine consultations pose a unique challenge for clinicians compared with in-person appointments; whilst clinicians can control their own environment and ensure they conduct consultations in a confidential manner, it is not always possible to know who else is within audible range on the patient-end of a consultation. Patients should therefore be made aware that it is their responsibility to ensure that they are in a private place, and that they should inform the clinicians of anyone else who is able to hear the consultation. McKinstry *et al.* found that patients identified telemedicine consultation as both a risk and a solution for privacy; privacy concerns in face-to-face appointments mitigated by telemedicine included overheard conversations, receptionist triage, errors in identification and communal areas such as waiting rooms.[148]

5.5 Conclusion

We present a qualitative dataset of patient experiences of telemedicine consultations for HF. Patients had similar perceptions to clinicians of telemedicine consultations, and experienced significant benefits in terms of avoiding travelling to hospital but were generally more comfortable than clinicians with remote clinical assessment when they were clinically stable. Understanding these changes in consultation perceptions is essential for future delivery of care, in which telemedicine is likely to play a big role.

5.6 Appendix

5.6.1 Coding table

Overarching theme	Codes	Transcripts where code was applied
Time utilisation	Saving travel time to hospital	P01, P02, P03, P04, P05, P08
	Expense of journeys to hospital	P02, P08
	Not minding occasional journeys to hospital	P03, P04, P05, P06, P07
	Preferring waiting at home than in hospital	P01, P03, P06, P07, P08
	Not minding waiting if given adequate time	P01, P04
	Shorter waiting time by telemedicine	P01, P07, P08
	Perception that telemedicine is more efficient for NHS	P01, P05, P06
Clinical assessment	Need for awareness of own clinical state by telemedicine	P01, P02, P03, P04, P07
	Not being concerned by lack of examination	P01, P05, P06, P07, P08
	In-person assessment reassuring	P03, P04, P05
	Accessing tests through GP	P01, P02, P03, P05, P08
	Use of home monitoring equipment	P02, P08
	Access to specialist tests in hospital	P01, P03, P05, P07, P08
Communication and rapport	Importance of non-verbal/visual communication	P01, P02, P05, P06
	Communication by video similar to in-person	P01, P02, P07, P08
	Importance of being able to see clinician	P02, P06
	Easier to ask questions in-person	P03, P06, P07
	Communicating visual test results	P03, P07
	No loss of rapport by telemedicine	P01, P05, P07, P08
	Loss of rapport by telephone	P02, P06
	Rapport better by video than telephone	P03, P04, P06
	Bad news more appropriate to deliver in-person	P01, P02, P05, P06
	Happy to meet new people by telemedicine	P03, P04, P08
Technology	Video technology easy to use	P01, P02, P05, P08

	Initially apprehensive about using new technology	P01, P05
	Not experienced technical disruptions	P01, P02, P05, P08
	Being “used to” video technology	P01, P08

6 Designing an educational App for patients with heart failure

6.1 Introduction

As established in Chapter 1, patient education is a key component in the management of HF. Both NICE and ESC guidelines emphasise the importance of patient education and engagement, with the ESC recommending that education should cover the following areas:[1]

- Explanation about HF
- The trajectory of HF
- Medical treatment
- Self-care
- Living with HF

Several different methods exist for delivering education for HF patients. As demonstrated in Chapter 2, patient education is one of the most frequent actions performed in a HF clinic appointment, occurring in approximately 1/3 of appointments with long-term attenders. Sub-optimal patient education from consultations has previously been described in HF care; Barnes and colleagues conducted semi-structured interviews with 44 patients with HF who reported not being given enough information about their condition or being given complex information that they didn't understand.[83] A particularly interesting common theme was that clinicians avoided the use of the term "heart failure".

Another method of delivering patient education is through written materials; charitable organisations such as the British Heart Foundation and Pumping Marvellous have created

booklets for patient education in HF. Similarly, these written materials can now also be found on websites, often accompanied by pictures and animations.

As discussed in Chapter 1, written materials may pose challenges for patients with low literacy levels. Health literacy is the ability of people to understand and use information for the promotion and maintenance of good health. A 2015 study by Rowlands and colleagues sought to determine the threshold of literacy and numeracy skills required to understand representative health educational materials.[149] Sampled materials, which were agreed by independent experts as representative of those in everyday use, were assessed for literacy and numeracy complexity against the English National Qualifications Framework. 73% of written materials were judged to have a literacy rating at National Qualifications Framework Level 2 or above (equivalent to General Certificate of Secondary Education [GCSE] grades A* to C), and 60% were judged to have a numeracy rating at Level 1 or above (equivalent to GCSE grades D to G). This was then compared to a UK government literacy and numeracy assessment of nearly 6000 working-age adults representative of the wider population.[150] 61% of participants had literacy skills below Level 2 and numeracy skills below Level 1, suggesting the majority of the population had inadequate literacy and numeracy skills to make use of commonly used health materials. Poor literacy was associated with belonging to a minority ethnic group, being unemployed, low income, and living in more deprived areas.

Thus, other ways of communicating educational materials are needed to reach a wider share of the population. Experience-based co-design (EBCD, sometimes called experience-based design, EBD) is an approach to providing healthcare services that meet the needs and wants of service users. It involves gathering experiences of users through qualitative methodology and involving users in the design and implementation of the

service improvement process.[151] We aimed to explore HF patients' views on the shortcomings of traditional patient education methods, and co-design a smartphone App for teaching patients about HF.

6.2 Methods

Qualitative methodology was used to gather patients' experiences, needs and ideas for education. We used focus groups to gather a wide range of patient perspectives. Focus groups are defined as a group discussion whereby "the researcher is actively encouraging of, and attentive to, the group interaction".[152] The use of focus groups is an established methodology for exploring people's knowledge and experience in health care,[153] and are particularly useful for needs assessment and project evaluation.[154] Focus groups are differentiated from group interview by the interaction between participants, and using developing conversation as a source of knowledge.[155] Focus groups are a particularly helpful tool to gather insights from participants of a particular type who have collectively relevant knowledge and experiences.[156] The overarching question guiding the research was "Can digital technology be used to improve patient education in HF". Focus groups had 3 main aims: first, to define the problem; second, to propose a solution; and thirdly to develop the solution into a concept.

Cognitant Group™ were chosen as developers of the App, owing to their experience in developing a similar App for patients with rheumatoid arthritis in the UK. Development of the App was funded by a commercial agreement between Cognitant Group and Servier™, a pharmaceutical company.

The following section details the processes involved in developing a prototype educational App.

6.3 Focus groups

6.3.1 Heart Failure Patient Working Group

On 30th October 2019, the Heart Failure Patient Working Group was organised and hosted by Servier in Paris, France. 3 HF patients (from France, Lithuania and Portugal) and 2 HF patient advocates (from Ireland and Spain) participated alongside two investigators (MC and AS) in a focus group moderated by an external consultant. The meeting objectives were to:

- Gain insights on the HF patient journey from a patient perspective and identify key unmet needs;
- Understand gaps in meeting the needs of people living with HF, and their caregivers;
- Discuss what tools and solutions could address these gaps, and explore how Servier can work with patients to co-create priority solutions for patients with HF;
- Gain an overview of existing solutions for HF patients, and hear patient feedback on these solutions.

Participants were initially asked to reflect on the early stages of their journey with HF. They identified several challenging moments, including:

- Feelings of loneliness, depression and isolation
    - *"It was hard to admit that today is the reality; nothing will be the same again"*
- Uncertainty and worry about the future

- *"Knowing that you don't know what will happen tomorrow or in the next 5 hours"*

- Reluctance from healthcare professionals to use the term "heart failure"
  - *"We waited 4 years for HF to be mentioned to my mother, even though she had been on HF medication for 4 years"*

- Lack of support for self-care
  - *"It's not just about living well, but also how to manage problems"*

A number of challenges were also identified with regards to patient education. Participants noted that it was difficult to take in all the relevant information during a consultation, and additionally patients often forget what they want to say and which questions they want to ask. Participants also felt that the timing of information given was crucial, and that ideally information should be "prescribed" by clinicians so as to be individualised and relevant.

Participants were asked to rate the quality of educational materials they had access to on a scale of 0-10 (Figure 1). Of note, the average score for ease of reading was 5.5 out of 10.

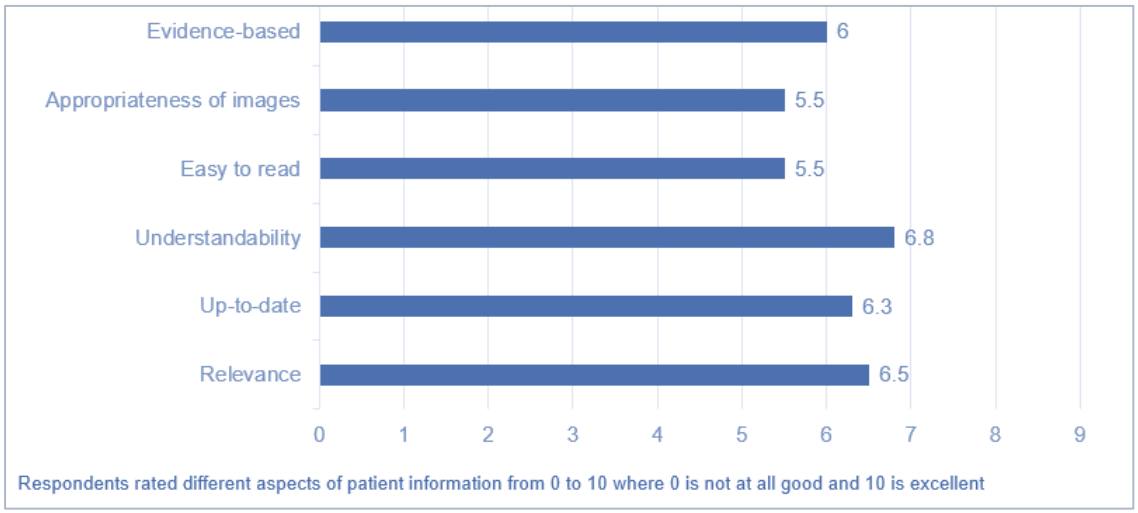


Figure 6.1 - Rating of available HF educational materials

Issues identified with patient educational materials included the difficulty in finding and accessing trusted resources, and the lack of organised peer support networks leading to patients searching for unmoderated forums such as Facebook™ groups. Clarity of materials was a key priority identified in discussion:

> *"There's absolutely no point in producing materials unless they are developed with patients [and] written in plain English"*

Participants defined good resources as those which were easy to read, clearly written and provide useful advice and practical information. Patients gave the following as examples of good educational resources:

- American Heart Association (https://www.heart.org/)
- Keep it Pumping (https://www.keepitpumping.com/)
- Heart Failure Matters (https://www.heartfailurematters.org/)
- Heartbeat Trust Ireland (http://heartbeat-trust.ie/)
- Pumping Marvellous (https://pumpingmarvellous.org/)
- Canadian Heart Attack and Stroke Foundation (https://www.heartandstroke.ca/)

Several solutions were proposed by participants for a new educational resource. These were:

- A HF "coach" – a virtual assistant that could support patient education with videos, animations and setting goals

- Newsletters or social media videos that shared practical advice and anecdotes for HF patients on regular basis
- A symptom-tracker which helped remind patients of which symptoms were most crucial to monitor
- Moderated peer-to-peer groups allowing discussing and sharing of experiences for HF patients

Participants emphasised that regardless of the means by which education is delivered, a key priority was to tailor the information to where the patient was in their journey.

The idea of a HF "coach" was chosen for further discussion. Following meetings between Cognitant Group, Servier and investigators, it was decided that this should be explored further.

6.3.2 Cardiovascular Lay Advisory Group

The proposal for developing an educational smartphone App was presented to the Royal Brompton Hospital "Cardiovascular Lay Advisory Group" on 3rd February 2020. The group was formed to assist with patient involvement in research in the hospital, and consists of volunteer patients treated for cardiovascular disease within the Trust. The Lay Advisory Group meets approximately every 3 months to review research proposals, provide feedback on patient literature and help provide a patient perspective on study design. Minutes of the meeting were recorded by the research communications co-ordinator of the hospital.

Patients from the Cardiovascular Lay Advisory Group gave the following verbatim feedback following the proposal for the concept of an Avatar-based educational App for HF:

- The group felt that the patient education project is a good one but that it's important that the language and content used is written in lay terms.
- The group also touched on the fact that the uptake and use of educational app will depend very much on people's first-time experience with it i.e. if it is difficult or hard to use the first time, patients won't use it anymore.
- The app also needs to be accessible so that hearing or visually impaired patients can use it.
- It was suggested that [the development team] should work closely with patient groups and charities such as the British Heart Foundation, Pumping Marvellous and Cardiomyopathy UK when putting together the content for the educational app.

6.3.3 Heart failure educational focus group

A further moderated focus group was held for patients with HF at the Royal Brompton Hospital on 14th February 2020 to explore their experiences with HF patient education and identify areas where education was lacking. 7 HF patients (4 male, 3 female) and 1 patient carer attended. The meeting was observed by 2 representatives from Cognitant Group: The Medical Writer and Chief Operating Officer. The mean age of patients was 70, ranging from 51 to 85. Participants were asked to share their experiences following the diagnosis of HF, and things they wished they knew. Participants were then asked to collaborate to design a curriculum of topics they thought would be most important in an educational App.

In an open group discussion, participants recalled the following experiences immediately after their diagnosis of HF:

- Feelings of shock and isolation
- Being overwhelmed by a “bombshell” diagnosis
- Impacts on quality of life
- Financial worries
- “Information overload” and difficulty assimilating information but having lots of questions
- Not knowing which information to trust or where to access support

Participants were asked about what they wished they had known following their HF diagnosis, and areas where they felt current educational programmes fell short. With regards to the diagnosis itself, participants highlighted the following priority areas of knowledge:

- Understanding what HF is
- Different types of HF and understanding ejection fraction
- The association with other forms of cardiovascular disease and impact on other organs
- A glossary of terminology related to HF

Participants also reported it would be helpful to better understand the tests used in HF such as echocardiography, and what the results meant. Some participants suggested that videos of tests would help reduce anxiety before experiencing the test for the first time.

Participants also highlighted that it was essential to deliver clear education about management, including:

- What the medicines are, how they work and the side effect profile
- How to manage side effects
- Interactions between medications
- Understanding the risk-benefit profile of different medications to help support shared decision making
- Different types of cardiac device and their indications
- Device procedures and recovery

Participants were asked about how HF education is best delivered. They reported that the key priorities were:

- Simple language that can be understood easily, and avoidance of technical jargon
- An example was the use of "kidney doctor" instead of "renal consultant"
- "A picture says a thousand words" – visual explanations (such as diagrams and videos) were easier to understand and more memorable than written text
- The need for a trusted portal for information – participants reported it was difficult to know from search engines which online information was trustworthy, and it was therefore important for their healthcare team to "signpost" them in the direction of trusted resources
- The need for personalised information given at the right time

Participants reported that their favourite resources were the British Heart Foundation, Pumping Marvellous and Cardiomyopathy UK.

They were then given a demonstration of an Avatar-based smartphone App used for rheumatoid arthritis, designed by Cognitant Group; this App would be used as a template for the HF App. Participants reported that the App was simple to use, and that the visuals were effective and made information easy to understand. Participants agreed that an Avatar-based App could be a useful tool for HF patient education.

Participants were asked to collaborate to design an ideal curriculum to be covered by an App for HF patient education. The curriculum is shown in Table 1.

Curriculum of topics for HF App
• **What is HF?**
– What does HF mean?
– Symptoms and impact on other body systems
– How to adapt to living with HF
• **Tests**
– What tests are needed and what do they entail?
– What do the results mean?
• **Lifestyle**
– Exercise
– Diet
– Sex and relationships
– Travel
• **Medications**
– Which medications and why?
– Side effects and managing side effects

– Staying up to date with the latest research
• **Device implants**
– Types of devices and indications
– Implantation and recovery
– Living with a device
• **Support**
– Reassurance
– "Mythbusting"
– Support groups/networks
– How family and carers can help
• **Self-monitoring**
– Signs of deterioration and improvement
• **Planning for the future**
– What happens if treatments don't work?
– Advanced care planning
– Genetics for inherited cardiomyopathies

Table 6.1 - Curriculum of topics to be covered by educational App for HF

6.4 Development of the App

Thus, participants of 3 focus groups agreed that there was a need for improved patient education in HF, that an Avatar-based App was a possible solution and finally a curriculum of topics for the App to address was made. An agreement was then reached to proceed with development of the App; initial funding would be provided by Servier, Cognitant Group would design the App alongside the study investigators.

The App was planned to be modular, allowing information to be "prescribed" in self-contained units so that it was individualised to patient needs. The prototype App was planned as an introductory module titled "Living with heart failure". The aim was to cover parts of the curriculum designed by patients that was most relevant to the initial diagnosis of HF. Thus, the following topics were chosen to be included in the first module:

- Explaining what HF is
- Purpose of HF medications
- Exercise and healthy eating
- Smoking and alcohol
- Sex and relationships
- Self-monitoring of HF symptoms
- When to call for help
- Signposts to trusted HF educational resources

Development of the prototype App occurred in 3 main phases: storyboarding, script writing and production. Unfortunately, owing to the Covid-19 pandemic, development of the App was significantly delayed.

Storyboarding commenced in August 2020. As patients had emphasised the importance of peer-to-peer education in focus groups, the Avatar was chosen to be a female patient expert in HF, aged in her mid-60s. A living room setting was picked as a background, with the idea that this may be more relaxing for viewers and appear less like a lecture. Figure 2 illustrates example scenes from the storyboard.

A script was then written to explain the topics in a simple way, using animations to help illustrate points. A key priority was that speech should be in plain, easy to understand language, although where appropriate, more complex words such as “cardiomyopathy” were used when accompanied by an explanation. A commonly used tool for measuring complexity of material is the Flesch reading-ease score, which scores text based on the length of sentences and number of syllables per word.[157] The proposed script had a Flesch reading-ease score of 68; scores between 60 and 70 are considered plain English which is easily understood by 13 to 15-year olds.

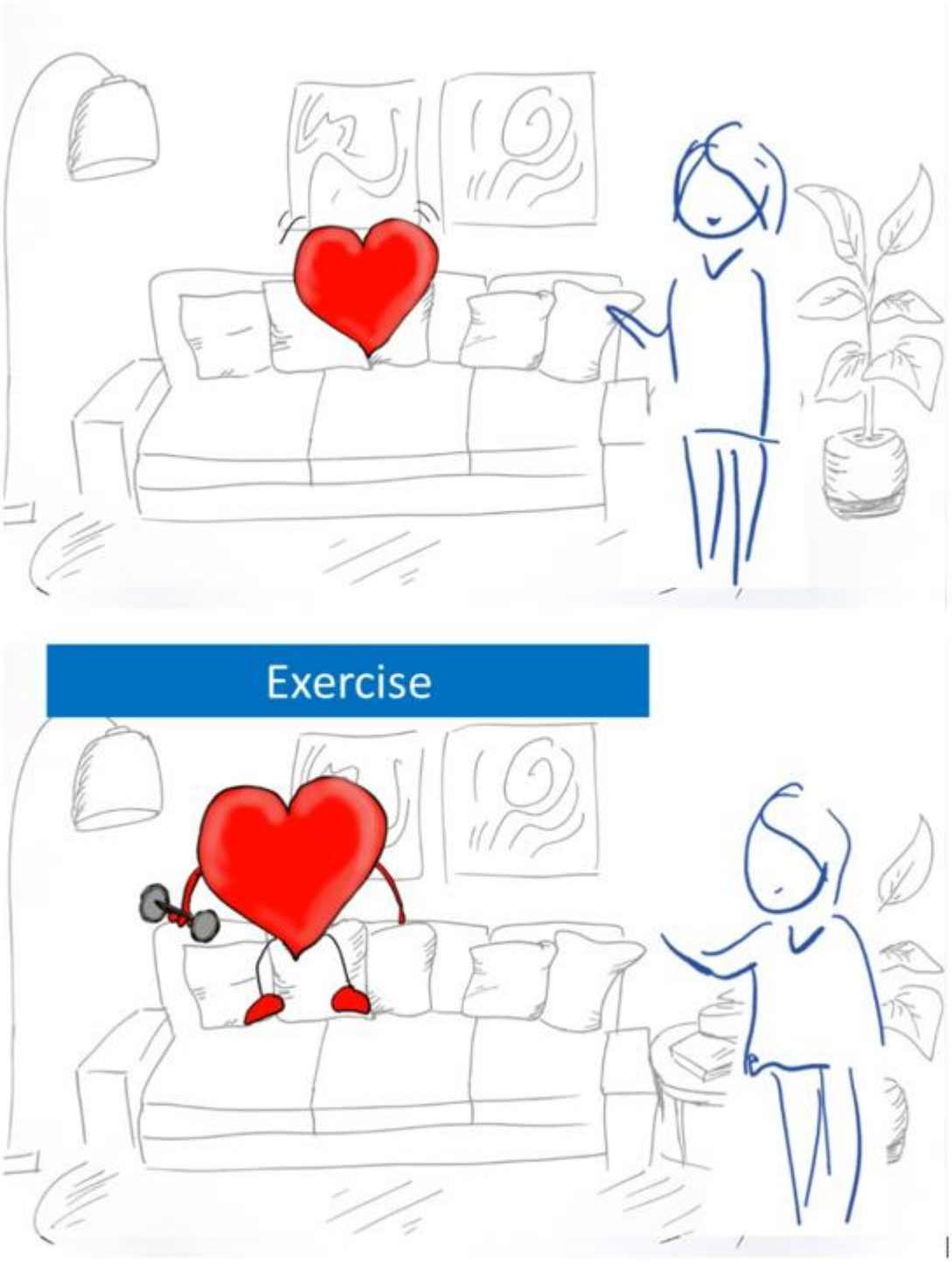


Figure 6.2 - Example scenes from storyboard for development of the App

Finally, the prototype App was produced. A voice actor was used in recording the script, and motion-capture technology was used to synchronise movements with voice so that Avatar facial and body movements seemed natural. Figure 3 shows screenshots from the

prototype App. A 3-dimensional environment was created such that the user could view the living room from different angles. Furthermore, a "virtual reality" functionality was added; users could place their smartphone inside a cardboard viewer (Figure 4) which converts two halves of the smartphone screen into a stereoscopic field of view.

Owing to delays in the development of the App, evaluation of the prototype is still ongoing.

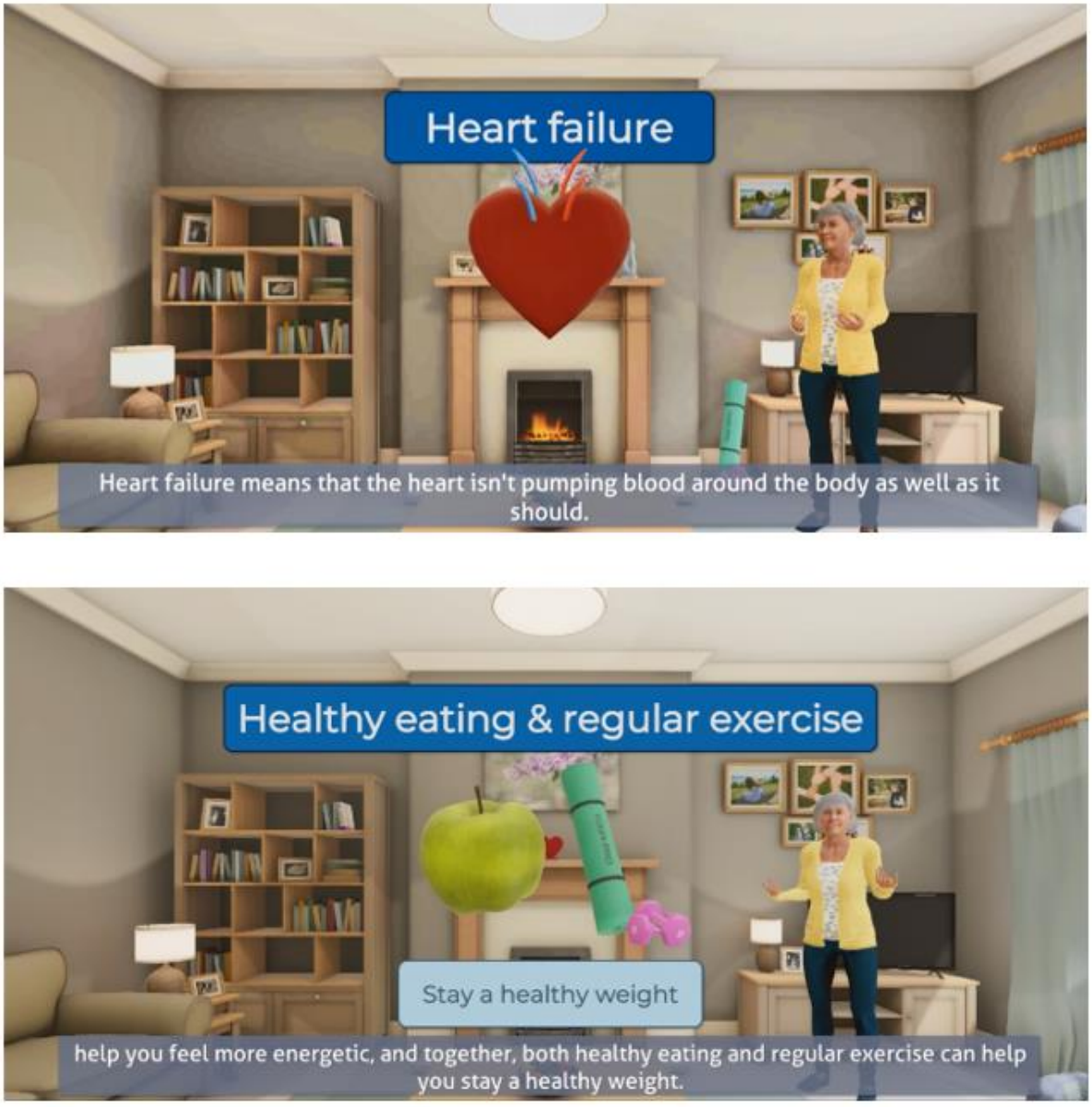


Figure 6.3 - Screenshots from prototype App

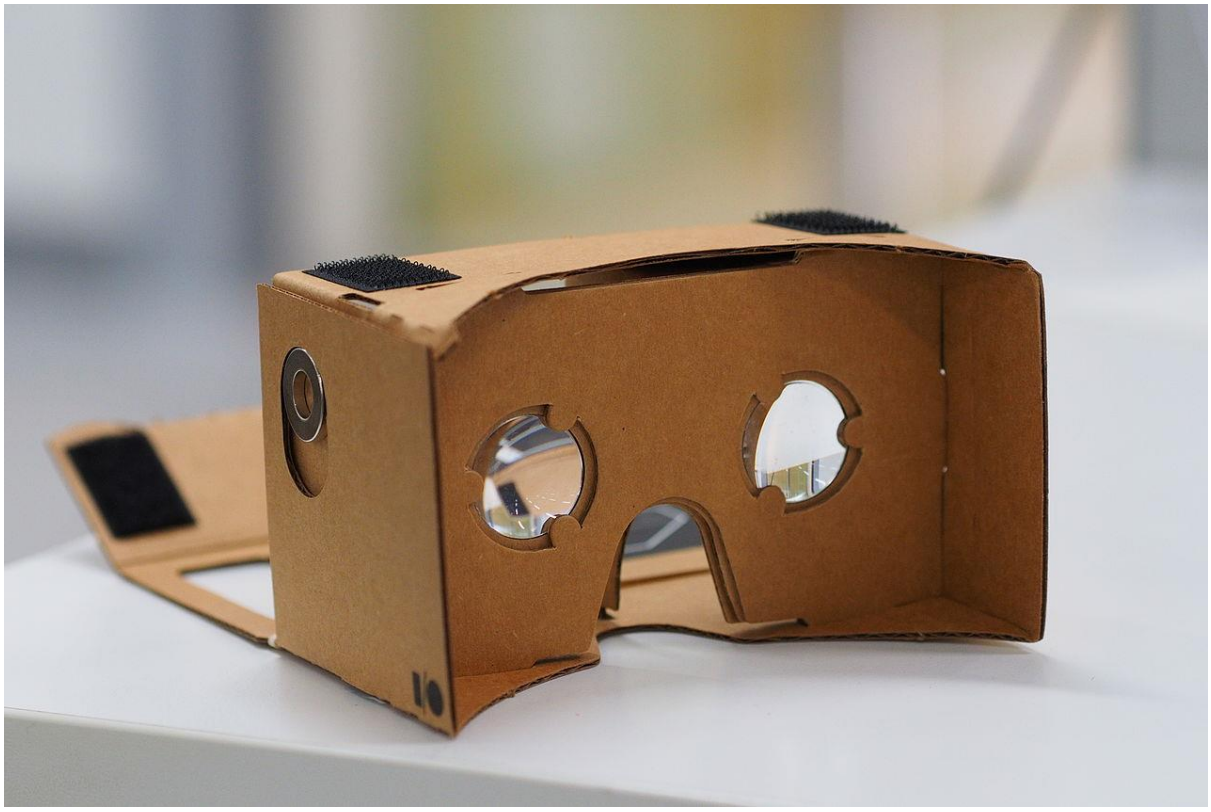


Figure 6.4 - Cardboard Virtual Reality viewer. Creative Commons licence

6.5 Discussion

We present a process for co-design of an educational smartphone App with HF patients. Through focus groups we identified key themes of patients' prior experiences with HF. Patients felt lonely, isolated and overwhelmed following a diagnosis of HF, and found it difficult to understand and retain patient education delivered in early consultations. Patients found it difficult to know which information to trust, and wanted personalised "prescribed information". The use of visual aids was considered crucial to assist in comprehension. Based on the needs and wants of patients in focus groups, we designed a prototype educational App for HF, designed to explain topics in plain English via a 3-dimensional Avatar and visual animations. The App was designed using experience-based co-design principles; HF patients were involved throughout its development.

6.5.1 Comparisons with other research

Participants in the present study identified shortcomings in how education had been delivered at the time of HF diagnosis. Patients reported not being given enough information, being given complex information they were not able to understand and the avoidance of the diagnosis of "heart failure" being used in communication in keeping with the aforementioned study by Barnes *et al*.[83]

Avatar-based Apps for patient education have been used in other chronic diseases such as cancer, diabetes, depression and surgical rehabilitation. Early evaluations of Avatar technologies have shown promise at improving patient education. An Avatar-based App providing education about ileostomies was trialled on 15 hospitalised patients with new stomas.[158] Ileostomy knowledge and self-efficacy scores significantly improved following use of the App in this single-arm study. Avatar-based educational Apps have also been shown to influence user behaviour and impact on quality of life. Andrade and colleagues

conducted an RCT of an Avatar-based behavioural intervention App for women with overactive bladder syndrome; the intervention was an Avatar coach whilst the control was listening to the programme with voice only.[159] 41 patients completed the study, and patients in the intervention group reported significant improvements in symptoms of incontinence. A systematic review by Wonggom and colleagues in 2019 identified 8 experimental studies evaluating Avatar-based technologies in chronic illnesses.[87] The technologies and methods reviewed were heterogeneous, making synthesis of studies challenging, however all 6 studies that measured disease-specific knowledge showed improvements with Avatar-based interventions.

During the development of the present App, a publication was released evaluating an Avatar-based educational App for HF patients in Australia.[160] 36 patients were randomised to either an Avatar-based intervention or usual care. At 90 days, intervention group participants had a greater increase in HF knowledge (measured by the Dutch Heart Failure Knowledge Scales) compared with controls (22% increase vs 4% increase, p=0.002).

6.5.2 Discussion of methodology

A key strength of focus groups is the production of data through social interaction.[161] Focus groups enable group discussion, allowing participants to better identify and clarify their views. Participants within a group are able to build on each other's ideas and better explore issues that are important to the group.[153] Furthermore, focus groups can encourage participation from those with lower literacy levels and those who are reluctant to be interviewed on their own.[153] There are, however, limitations to note. Firstly, group dynamics may shape participants' views and how they are expressed; individuals may dominate the discussion and attempt to influence the outcome, and thus careful

moderation is needed.[161] Furthermore, the "group effect" may lead to conformity and convergence of opinions.[162]

In the present study, moderation ensured all participants were engaged during discussions, and there was no confrontation. That independent groups agreed on key themes such as patient feelings following a diagnosis of HF and the educational needs support the validity of our findings.

6.5.3 Future work

Owing to delays in developing the App following the Covid-19 pandemic, the prototype App has not undergone a full evaluation. Evaluation will be primarily through qualitative methods and automated usage data. Participants of the heart failure educational focus group will be invited to participate in a repeat focus group following their experiences with the App. Group discussion will focus on acceptability and utility of the App as an educational resource. Patient feedback will then be used to guide the further development of the prototype, before distributing the App to the wider HF cohort at the Royal Brompton Hospital. The methods of further evaluation will then depend on the scope and funding of the project, but may include quantitative assessment of knowledge and self-efficacy in HF.

The impact of the App on clinicians' time should also be evaluated. Less time may be needed to deliver patient education if patients are "prescribed" access to an educational resource that can be used outside consultations. On the other hand, it is possible that prescription of the App and explanation of how to use it may also have unexpected time costs.

6.6 Conclusion

We present the process co-designing an Avatar-based educational App for patients with HF. Such an App may be a useful tool for improving patients' understanding and knowledge of HF, and may improve self-care behaviours. Further research will evaluate the acceptability of the prototype App to a cohort of HF patients at a specialist centre.

7 Discussion and clinical implications

7.1 Summary of findings

In Chapter 2, we demonstrated that HF patients at a specialist centre are seen a median of twice per year, but that for long-term attenders, deterioration in HF symptoms were recorded in only roughly 1 in 5 appointments, and therapy change occurred in roughly 1 in 3 appointments. Compared with research from other centres, it is possible that deterioration in symptoms and therapy change was more common in this tertiary centre, and thus in secondary care or community HF clinics, actions measured may be performed even less frequently. We identified themes of appointment which we hypothesised could be performed by telemedicine or by local clinicians: routine "check-up" appointments, planned medicine up-titration, and following up and communicating test results.

In Chapter 3, we measured the time patients spent in hospital on the day of an appointment in a specialist HF clinic. Patients spent a median of 103 minutes in hospital, the majority of which was spent waiting between activities. The median estimated total travel time was 90 minutes per patient. Patients arrived a median of 12 minutes before their first scheduled appointment, but despite this 84% of patients were seen later than their scheduled appointment time. Appointment schedules did not accurately reflect the time taken to cycle through patients, making such delays inevitable.

In Chapter 4 we interviewed clinicians who had participated in telemedicine consultations for HF. Five themes were apparent from clinicians' experiences of telemedicine consultations:

- Clinical assessment
- Communication and rapport
- Time utilisation

- Technology
- Choice and flexibility of consultation modality.

Clinicians perceived that without physical examination, clinical assessment relied more on history, test results and video examination, and for certain patients, clinicians could make use of home monitoring equipment. Clinicians found it more difficult to establish rapport by telemedicine, particularly by telephone, and believed that newly referred patients should be seen in-person if possible. Telemedicine consultations were perceived as more efficient, but clinicians stated that more administrative time and effort was involved in a telemedicine consultation compared with face-to-face. Most clinicians had encountered technical disruptions, and increased latency in some video consultations resulted in broken or interrupted conversation. Clinicians believed choice and flexibility with regards to consultation modality was essential to ensure individual needs were met.

In Chapter 5, patients were interviewed regarding their experiences of telemedicine consultations for HF care. Four similar themes were apparent from HF patient experiences:

- Time utilisation
- Clinical assessment
- Communication and rapport
- Technology

Patients reported that telemedicine consultations were more convenient and saved time travelling to hospital, but also perceived that the time spent waiting for consultations was reduced. Patients were generally not troubled by the inability to perform physical

examinations remotely, but some believed in-person assessments were more reassuring, particularly if there was a deterioration in clinical status, or patients were less confident with self-assessment. Patients generally believed communication was more effective by video than by telephone owing to the ability to make use of non-verbal information. Patients were generally content to meet new clinicians by telemedicine, but would prefer bad news to be given in-person. Finally, most patients had positive experiences with technology.

Finally, in Chapter 6, we presented the development process for an educational smartphone application (App) for patients with HF. Focus groups were used to understand patients' experiences with HF patient education and their unmet educational needs, and then a curriculum of key topics was designed. Co-design of an educational App may help with patient engagement and knowledge in HF, and further research is needed to test this hypothesis.

In this chapter we will first present data quantifying the effect of telemedicine consultations on follow-up frequency and the duration of consultation and waiting times. We will then discuss the implications of digital transformation of outpatient care.

7.2 The effect of telemedicine on follow-up frequency

A key issue not yet discussed is the impact of the switch to telemedicine on follow-up frequency and clinic capacity. If telemedicine appointments are needed more frequently than face-to-face appointments then this may place further strain on the system, offsetting perceived efficiency benefits. Thus, we performed retrospective analyses to ascertain whether follow-up frequency changed following the sudden switch to telemedicine appointments.

In the year prior to Covid-19 and the resultant shift to telemedicine by default (16th March 2019 to 15th March 2020) there were 2474 completed appointments with 1296 unique patients across consultant and nurse-led HF clinics. From 16th March 2020 to 15th March 2021 there were 2797 completed appointments with 1253 unique patients (Figure 1). Thus, slightly fewer unique patients were seen, but more appointments were attended following the shift to telemedicine. The increase in appointments was primarily driven by a 50% increase in the number of patients seen in nurse-led clinics. The number of weekly nurse-led clinics increased from 2 to 3 the week prior to the shift to telemedicine in order to increase clinic capacity.

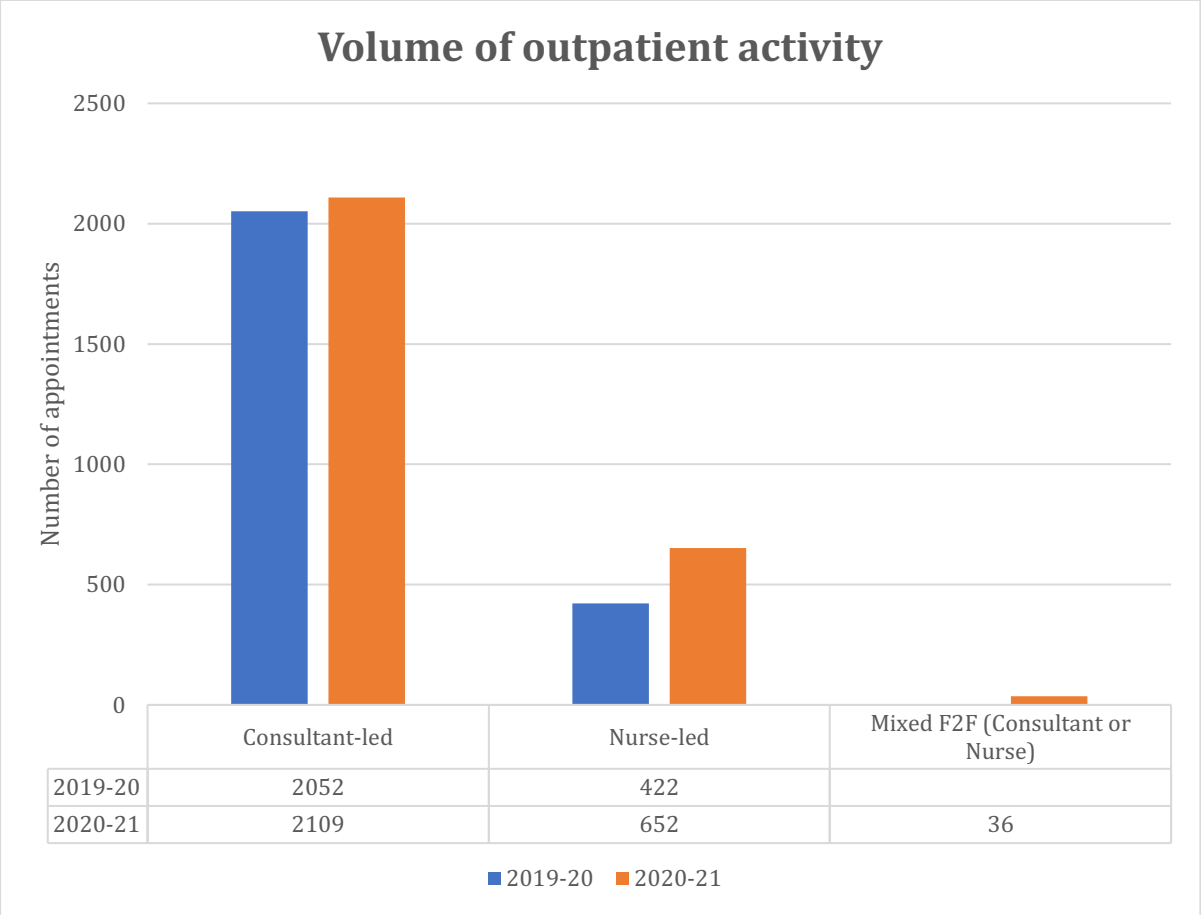
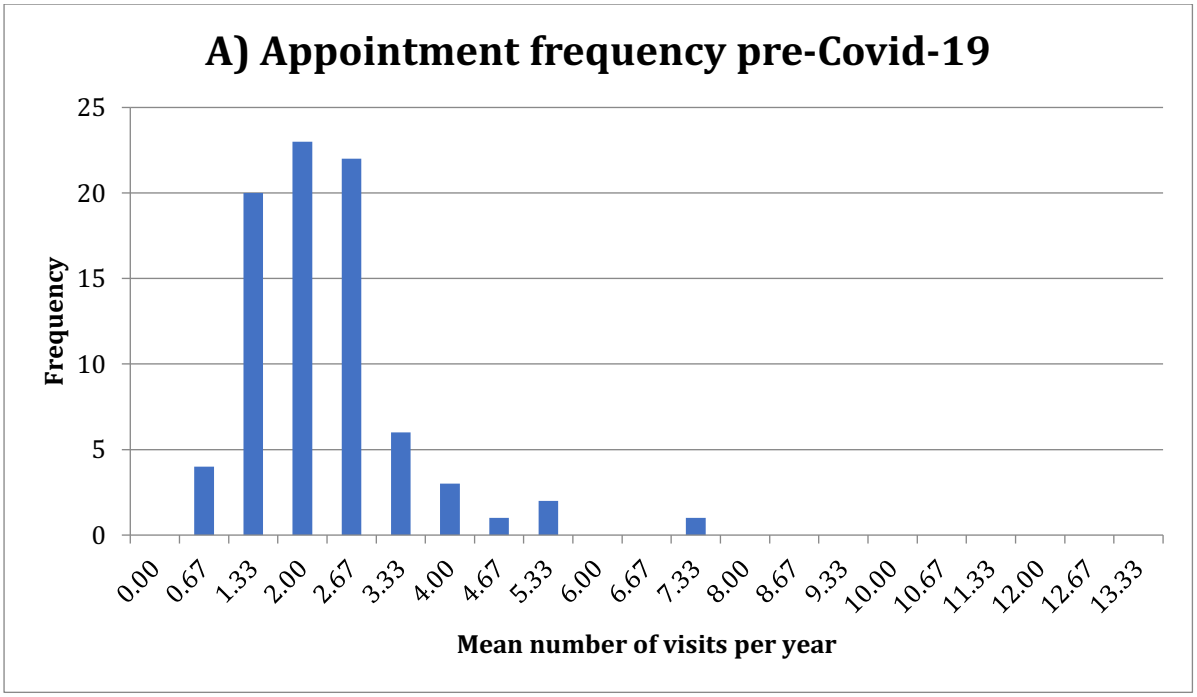


Figure 7.1 - Number of attended appointments across HF clinics in 2019-20 and 2020-21. Mixed F2F was the pooled consultant and nurse face-to-face clinic for exceptional circumstances during Covid-19 precautions

To examine the patterns of follow-up further, we conducted a further analysis of the long-term attender cohort to see how their appointment frequency changed. The number of HF appointments attended by members of the cohort was counted over an 18-month period from 16th March 2020 to 15th September 2021. Of the 100 patients in the long-term attender cohort, 14 were deceased as of 15th September 2021 and 4 had been discharged from the clinic. The remaining 82 patients had 295 appointments in HF clinics over an 18-month period following the switch to telemedicine by default (2.39 appointments per patient per year, SD 1.08), compared with 516 appointments in the 3-year period between 1st Jan 2017 and 31st December 2019 (2.10 appointments per patient per year, SD 2.64). This difference was not statistically significant (p=0.226 Wilcoxon Signed-Rank test for paired samples). Figure 2 shows histograms of appointment frequencies pre- and post-Covid-19 for the remaining 82 patients. Of note, the histogram post-Covid-19 demonstrates a greater positive skew and right tail; in other words, the majority of patients appear to be seen slightly less frequently post-Covid-19, but some patients are seen far more frequently.



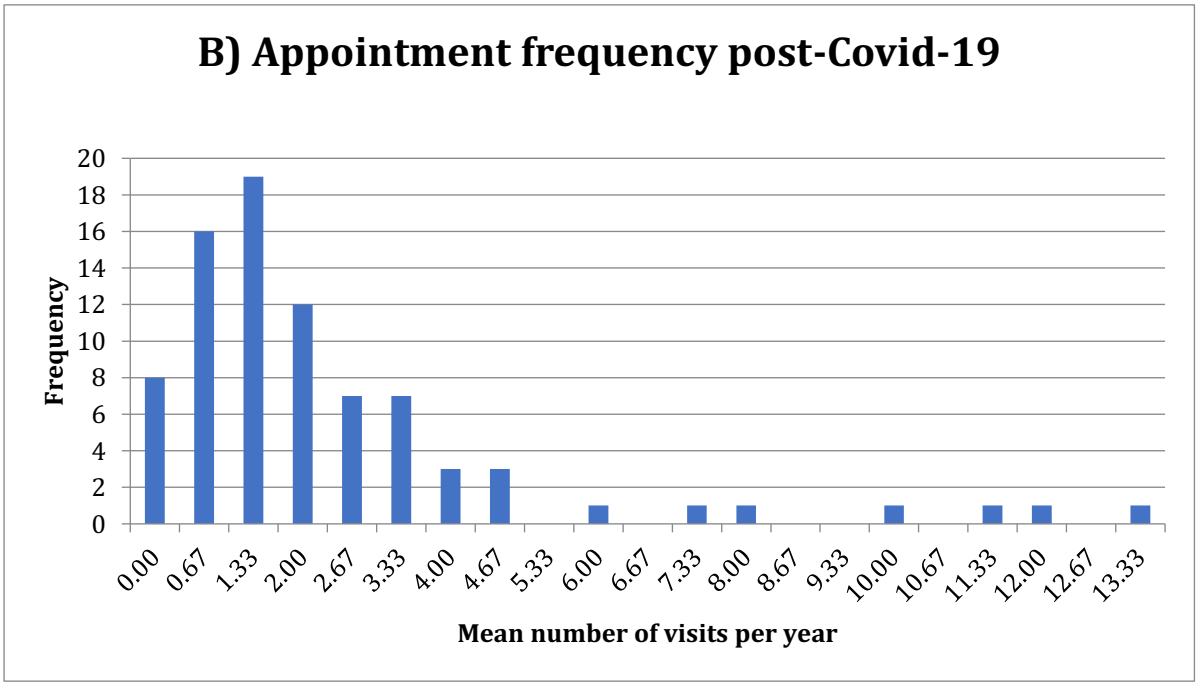


Figure 7.2 - Histograms of mean appointment frequencies A) in a 3-year period between 1st January 2017 and 31st December 2019, and B) in an 18-month period between 16th March 2020 and 15th September 2021. Histogram bins have been matched to aid visual comparison

A few explanations are possible for this observation. This may reflect a cultural shift to a "one-size fits all" approach of in-person appointments approximately twice a year, to a more nuanced approach where more telemedicine clinic resources are diverted to patients with the greatest need. Similarly, this may be a result of the extra nurse-led clinic, with the increased capacity being primarily used for a select group of patients who may be considered a priority for admissions avoidance. Finally, the effect may be due to patient and clinician anxiety around remote follow-up where patients are less clinically stable or less able to self-manage; patients and clinicians may agree on more frequent follow-up if they feel telemedicine consultations are less reassuring for these patients, particularly as during the Covid-19 pandemic it was more challenging for patients to visit their GP. For other patients, telemedicine follow-up was possible less than 6-monthly.

7.3 The effect of telemedicine on the duration of appointments and waiting times

Anonymised video consultation data were extracted from the Attend Anywhere platform for consultant-led HF clinics. Data included the clinician seeing the patient, the duration of the consultation and the duration patients were waiting in the "waiting area" before being connected. It was not possible to collect data from telephone consultations. 687 video consultations were conducted on the platform between 29th September 2020 and 28th September 2021. The median consultation duration was 12.0 minutes (IQR 7.1 – 17.6 minutes). Consultations conducted by consultant were a median of 10.2 minutes (IQR 6.5 – 14.8), which was shorter than registrars (median 14.7 minutes, IQR 7.9 – 19.3 minutes, $p<0.001$) and "SHO" (junior training level) doctors (median 13.1 minutes, IQR 9.3 – 20.1 minutes). This is shown in Figure 7.3.

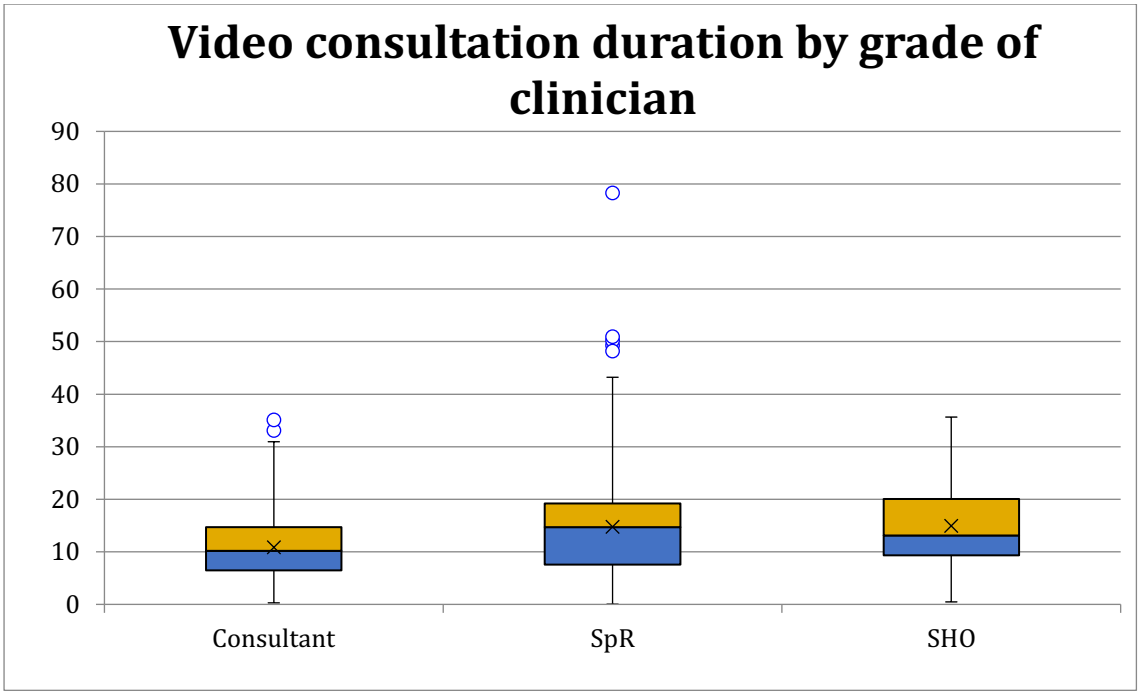


Figure 7.3 - Box and whisker plot of consultation duration by grade of clinician seeing patient. Boxes represent medians and quartiles. Whiskers represent the range excluding outliers, dots represent outliers (> 3rd quartile plus 1.5 x IQR of the 1st and 3rd quartiles). X represents the mean. SpR = Specialty registrar (middle-grade training doctor). SHO = Senior House Officer (junior-grade training doctor)

The median consultation duration for in-person appointments was 20 minutes in the earlier time-and-motion studies. Consultations by video were significantly shorter ($p<0.001$, Mann-Whitney U test).

Patients on Attend Anywhere were seen a median of 17.3 minutes after arriving in the virtual waiting room (IQR 6.1 – 33.8 minutes). A direct comparison of waiting time with face-to-face clinics is challenging, as patient data are not recorded in the Attend Anywhere system, and thus scheduled appointment times were unknown; it is therefore not possible to ascertain whether or not patients were seen late relative to their scheduled appointment time, particularly as patients were instructed to log on to the platform before their scheduled time. In the earlier time-and-motion studies,

consultations took place a median of 23 minutes after their scheduled time (IQR 6 – 74 minutes) and a median of 63 minutes after arrival to the hospital (IQR 34 – 94 minutes), however many of these patients had investigations prior to being seen by clinicians. A retrospective analysis was conducted of time-and-motion study data, including only patients who had no pre-booked investigations on the day of their appointment. 40 Patients who did not have pre-booked investigations were seen a median of 48 minutes after arriving at the hospital (IQR 26.5 – 70 minutes). Thus, patients spent significantly less time waiting in the video consultation waiting area than patients spent waiting in hospital before an in-person consultation ($p<0.001$, Figure 7.4). This is in keeping with patient perceptions of video appointments in Chapter 5.

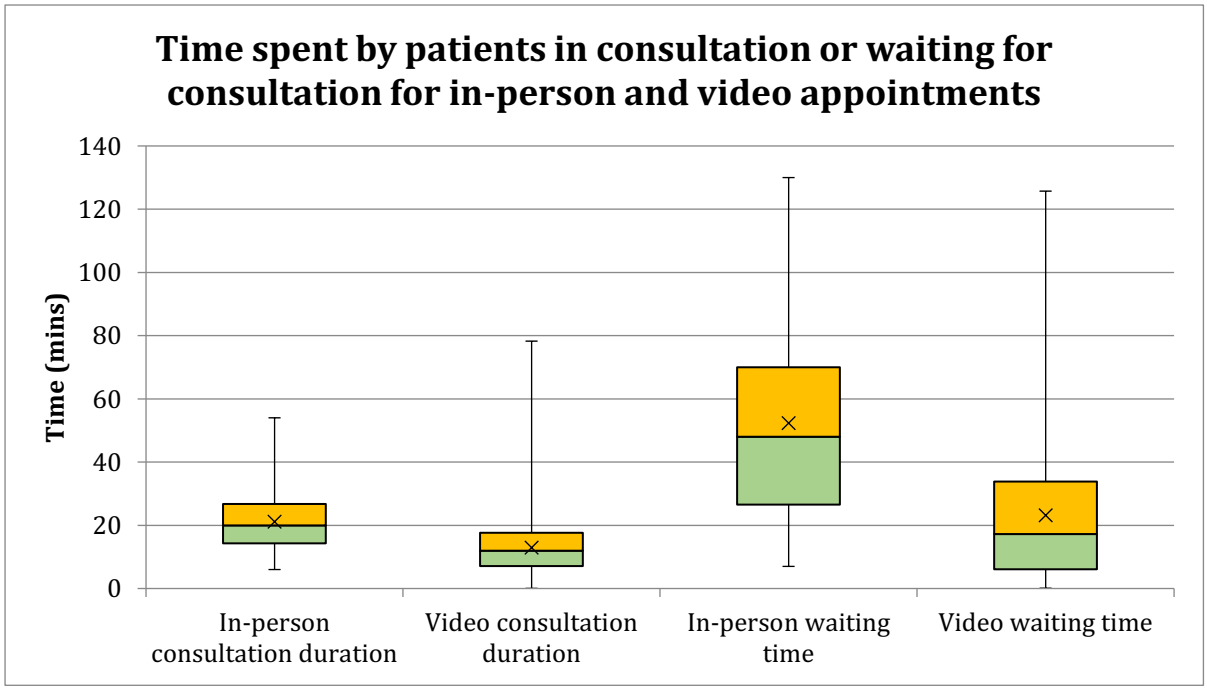


Figure 7.4 - Box and whisker plot of consultation duration and waiting time by whether appointment was in-person or video Boxes represent medians and quartiles, whiskers represent the range, and X represents the mean.

7.4 Transforming outpatient care in HF

> *"There is enormous inertia—a tyranny of the status quo—in private and especially governmental arrangements. Only a crisis—actual or perceived—produces real change."*
>
> — Milton Friedman, Nobel Prize-winning Economist

Inertia is the natural tendency of objects to resist changes to their state of motion, but this term can also refer to systems or organisations that are resistant to change. Professor Sir Chris Ham, then director of The King's Fund, wrote in 2012 that inertia was the biggest threat faced by the NHS, as a result of its size and complexity.[163] Similarly, in 2017, NHS England's Medical Director for Acute Care, Professor Keith Willett, wrote that the NHS was "still based on its original 1940s design", that inertia in healthcare systems can be "truly harmful" and that the old "if it's not broke, don't fix it" approach was no longer realistic.[164] Indeed, as was outlined in the introduction, the delivery of outpatient care has barely changed since its inception in the 17th Century.

In January 2020, all HF clinic appointments at the Royal Brompton were face-to-face, but by the end of March 2020, nearly all appointments were delivered by telemedicine. This was an extraordinary change in the provision of care, and was likely only possible out of absolute necessity. The Covid-19 pandemic meant that for the first time in the history of outpatients it was not possible to deliver the traditional model of care for a sustained period of time, thus adaptation was essential. Although this rapid transformation was born out of acute necessity, this thesis argues that change was necessary for the long-term sustainable delivery of outpatient care. It remains to be seen, however, to what extent these changes will be sustained in a post-pandemic landscape. Here we propose a

"hybrid" model of care using both in-person and telemedicine appointments, based on our findings so far.

7.4.1 "Digital by default"

Most patients preferred telemedicine for "routine" appointments, particularly if they did not have any change in symptoms or were confident in self-assessment. Given that in the vast majority of appointments, patients' symptoms had not deteriorated since the previous appointment, telemedicine should therefore be assumed to be the default consultation modality. Telemedicine allows patients to save long journeys to hospital, and potentially allows for a timelier running of clinic with fewer delays.

However, as we identified from patient and clinician experiences, flexibility is crucial as neither patients nor clinicians appreciate a "one-size fits all" policy. Certain circumstances may favour face-to-face appointments including:

- Patient and clinician preference; particular consideration should be given to patients who do not have access to high-speed internet, or the technologies required for a video consultation such as a webcam. Clinicians may also identify certain patients who are more appropriately assessed in-person
- Deterioration in symptoms prompting need for more thorough clinical assessment; in-person assessment can include a physical examination as well as same-day investigations such as blood tests, ECG, echocardiography and device monitoring
- Discussing sensitive topics such as breaking bad news

- Meeting patients for the first time; clinicians tended to prefer developing a rapport in person, and newly referred patients frequently underwent investigations which could be combined with their first visit.

The British Cardiovascular Society (BCS) published similar recommendations in August 2020 following the first wave of Covid-19.[165] They suggested that telemedicine should "become the norm… for patients who do not require a face to face attendance", and that visits to hospital should occur "only when necessary… at the right time in the right environment".

7.4.2 Improving clinic responsiveness

One of the key drivers for transforming outpatient care was the fact that current pressures meant that outpatient services were no longer able to meet the demands placed on them. NICE guidance recommends that patients with suspected HF undergo specialist assessments within 6 weeks, or within 2 weeks if their NT-proBNP level is greater than 2000ng/L.[7] Data from the performance and analytics team at the Royal Brompton Hospital show that for patients referred to the HF clinic who attended between 1st April 2019 and 31st March 2020, the median time between referral and appointment was 9 weeks. Thus, pre-Covid-19, HF clinics at the Royal Brompton Hospital did not have capacity to meet national waiting time targets.

A key factor limiting capacity is physical clinic space; clinic rooms are fully occupied throughout the week, preventing expansion of clinics at this hospital. Clinic capacity may therefore be increased if some clinic sessions could be conducted by telemedicine, as telemedicine consultations do not require a dedicated clinic room. On its own, however, this may not be sufficient, as staff resources may also limit clinic expansion. Assuming staff resources stay the same, clinics may only be expanded if:

- Existing HF clinical staff have capacity to see more patients in their work schedule
- Clinicians are able to save time elsewhere, thus increasing their time available to see new patients

With regards to the former, the HF nursing team at the Royal Brompton Hospital was able to expand from 2 to 3 clinics with the same number of staff, however this may only have been possible owing to less HF inpatient work because of Covid-19. A review of work schedules would be required to see whether clinicians had any spare capacity to increase clinic delivery, but such a move may not prove popular with clinicians.

With regards to the latter, clinicians reported that telemedicine consultations were more "efficient", and video consultation data suggest that consultations were indeed shorter, and thus telemedicine consultations have the potential to save clinicians time and increase their capacity to see patients. However, they also reported that more time was spent performing administrative tasks, which we are unable to quantify. Thus, a possible solution is to reduce the administrative workload of clinicians. This is discussed in more detail in the section "Barriers and enables to change" below.

7.4.3 Flexible follow-up

If clinic capacity were to remain unchanged, then responsiveness may still be improved by reducing the number of "unnecessary" appointments. Patients with HF have variable disease trajectories, but typically patients undergo periods of relative stability, and episodes of acute deterioration which may precipitate functional decline or death;[1,166,167] this is illustrated in Figure 3.

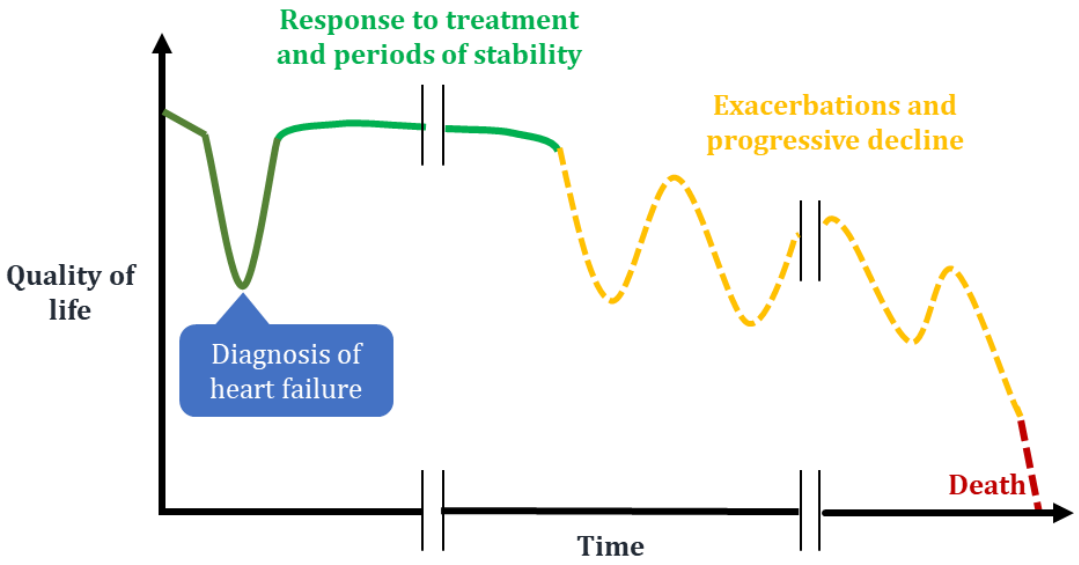


Figure 7.5 - Modelled typical trajectory of patients with HF.[166,167] Adapted and redrawn from Goodlin SJ[166] with permission. Copyright © 2009 American College of Cardiology Foundation.

Clinic resources could therefore be diverted to more complex patients by seeing some existing patients less frequently. However, this would be a significant cultural shift, and would mark a break away from established practice. National, European and American guidelines recommend regular follow-up for patients with HF,[1,7,52] but where follow-up is performed is a much-debated area.

For patients hospitalised with HF, who are at high risk of death or rehospitalisation, randomised controlled trials (RCTs) have shown clear benefit for early specialist review; a systematic review and meta-analysis of 29 RCTs found that follow-up by a specialist MDT was associated with a 25% reduction in mortality rate and a 26% reduction in hospitalisation rate.[168]

The ESC Heart Failure Association Standards for Delivering HF care recommend specialist follow-up for patients requiring escalation of medical therapy, consideration of device therapy or assessment for transplantation,[169] but for other patients the benefits of

in-person specialist HF clinics is unknown. Evidence from a Danish randomised control trial suggests that selected stable patients could be followed up in primary care without ongoing specialist input. The NorthStar trial randomised 921 clinically stable patients (defined as being on optimal medical therapy with no change in drug doses, symptoms or physical examination signs for two consecutive visits) to either extended HF clinic follow-up or discharge to GP.[170] There was no significant difference in the primary endpoint of cardiovascular admission or death from any cause, and the study population had a median age of 69, similar to the long-term attender cohort reported in the present thesis. Thus, for clinically stable well-optimised patients, HF specialist care may not provide an additional morbidity or mortality benefit. Nonetheless, the ESC Standards for Delivering HF care recommend at least annual review by specialist teams to ensure ongoing adherence to disease management programmes and to maximise opportunities for realising advances in care where appropriate.[169]

Clinic responsiveness could also be improved by rationalising new referrals. As demonstrated in Chapter 2, the majority of patients referred for HF assessment at the Royal Brompton had been investigated with echocardiography and natriuretic peptides, yet only 1/3 went on to be diagnosed with HF. It is possible that some of these appointments could be avoided by triaging of referrals, or facilitating clinician-to-clinician discussion without an appointment; further research is needed to evaluate this.

The challenge is thus to for clinics to improve their responsiveness to see patients newly referred with HF and patients recently discharged from hospital sooner, whilst continuing to monitor "stable" patients for deterioration and opportunities to improve care.

7.5 Recommendations

We therefore propose that the intensity of follow-up should be more carefully tailored to where patients are on their HF trajectory, with particular focus on new diagnoses and deteriorating patients. Patients newly diagnosed with HF should have intensive follow-up to investigate the aetiology of their HF, optimise therapy, and provide education for self-care. Patients with deteriorating symptoms should have prompt follow-up in order to intervene before hospitalisation is required.

To enable new referrals and at-risk patients to be seen more promptly without a significant increase in clinic capacity, clinically stable patients already optimised on HF therapy would need to be seen less frequently. The long-term attender cohort study in Chapter 2 demonstrated that 41% of patients in the cohort had no documented worsening in HF symptoms throughout the 3-year follow-up period, and so can reasonably be considered "stable" and in less need of regular follow-up. Such patients could be followed up in primary care, although this may further stretch GP services.

7.5.1 Patient-initiated follow-up

Alternatively, Patient Initiated Follow-up (PIFU) may be considered in order to keep patients under specialist care. Patients may be given certain criteria for initiating a follow-up appointment such as deterioration in symptoms, self-monitoring status, or change in medication, with an annual "back-up" appointment.[106] This may mean appointments are appropriately timed to patients' needs, but the effects on service, patient satisfaction and clinical outcomes of PIFU in HF are unknown.

PIFU has been most widely evaluated in breast cancer, inflammatory bowel disease and rheumatoid arthritis follow-up. Hewlett *et al.* conducted an RCT randomising 209

patients with rheumatoid arthritis to a "shared care" group (where no routine hospital appointment was booked, but rapid access to clinic was available on request) or usual care (where patients received routine planned follow-up appointments).[171] Patients in the intervention group had less pain at 24 months, and used fewer resources (calculated at £208 per patient in the intervention group vs £313 per patient in usual care). A follow-up study revealed that patients in the shared care group had 38% fewer appointments over 6 years.[172] A similar RCT was conducted by Robinson *et al.* for patients with ulcerative colitis. 203 patients were randomised to self-management and PIFU or planned follow-up appointments.[173] Patients in the intervention group had significantly fewer visits to hospital (0.9 vs 2.9 visits per year) and relapses were treated earlier. A cluster RCT involving 19 sites was performed by Kennedy and colleagues to evaluate self-management and PIFU compared with usual care.[174] Patients in the intervention arm had fewer hospital outpatient visits (1.9 per patient per year vs 3.0), and reported high satisfaction in interviews. Patients reported that flexible open access to clinic appointments better suited their lifestyle.

Thus, in chronic illnesses such as rheumatoid arthritis and inflammatory bowel disease, PIFU resulted in fewer hospital appointments, whilst maintaining high satisfaction with services, often owing to patients being able to rapidly access services when they were required. This should be further studied for HF patients.

7.5.2 Improved monitoring

Reduced follow-up frequency for stable patients and PIFU requires both patients and clinicians to be confident that clinical status is being monitored, either by patients themselves or remotely by clinicians, so that deterioration may be picked up and acted upon early. As discussed in Chapter 1, self-monitoring interventions have so far shown

only marginal benefits, and it is not clear which components of self-monitoring are most useful. Smartphone Apps such as the one developed and described in Chapter 6 have the potential to improve self-monitoring by providing easy-to-understand explanations of how to self-monitor and when to seek help, but further evaluation is needed.

Remote monitoring may play an important role in supporting outpatient management of patients. As discussed in Chapter 1, CardioMEMS is a pulmonary artery pressure monitoring device which has so far shown impressive results in reducing hospitalisation in HF patients with NYHA III symptoms who have recently been hospitalised,[53] and a more recent trial has shown probable benefit in a broader range of patients who have not been hospitalised.[54] The effectiveness of CardioMEMS was recently also evaluated in European settings; this open-label study showed that in the first 100 implantations, the annualised HF hospitalisation rate after 12 months was 82% lower than the previous 12 months.[175] The Royal Brompton Hospital is one of the participating sites in this study, and recruited 10 patients. Thus, this centre has experience in remote monitoring with implantable pulmonary artery pressure monitors. Device and implantation costs are likely to be high, and NICE will assess the cost-effectiveness of CardioMEMS for UK HF patients. If approved for use, this may be an important part of the menu for remote patient care.

Wearable technologies may also be useful in supporting remote management for HF patients.[176] Activity monitors, which contain accelerometers that measure motion, have high validity at measuring step counts;[177] low step counts are an independent poor prognostic indicator in HF patients,[178,179] though as yet the prospective use of activity monitors to guide management or risk stratification is unstudied. Whilst exercise therapy is recommended for patients with HF,[1,52] the lack of facilities and availability of trained

staff limits its wider uptake in HF patients.[180] Activity monitors have been suggested to support remote delivery of exercise therapy.[181] A small sub-study of the Teledi@log RCT demonstrated a proof of concept for telephone-directed exercise therapy using activity monitors; patients' measured step counts increased from a baseline mean of 5899 steps per day to 7890 steps per day after a year, and 20% of patients in the study had HF.[182] Mobile Apps have been developed to integrate with wearable devices with the aim of supporting exercise therapy by providing patients with exercise goals and training programmes;[183] if proven to improve outcomes such as functional capacity and symptoms, these may also be important components of remote care for HF.

The degree to which patients are able to use these technologies will depend on their engagement with technology and digital literacy. Devices such as CardioMEMS require relatively little engagement, as all that is required of patients is to lie on a "pillow" (transmission device) daily for pulmonary artery pressure readings to be sent to the clinician. Clinicians then contact patients if any readings are concerning or if there are any recommended therapy changes. Apps and wearables, however, are likely to require a higher level of digital engagement as they require use of a smartphone, and monitoring is self-directed.

7.5.3 The digital menu

We have therefore argued that follow-up intensity should be tailored to the clinical stability of patients, and monitoring technologies tailored to patients' needs and abilities to engage with technologies or self-monitor. Figure 4 shows a "menu" of options for the follow-up and monitoring of HF patients based on categorising patients by their clinical stability and digital engagement.

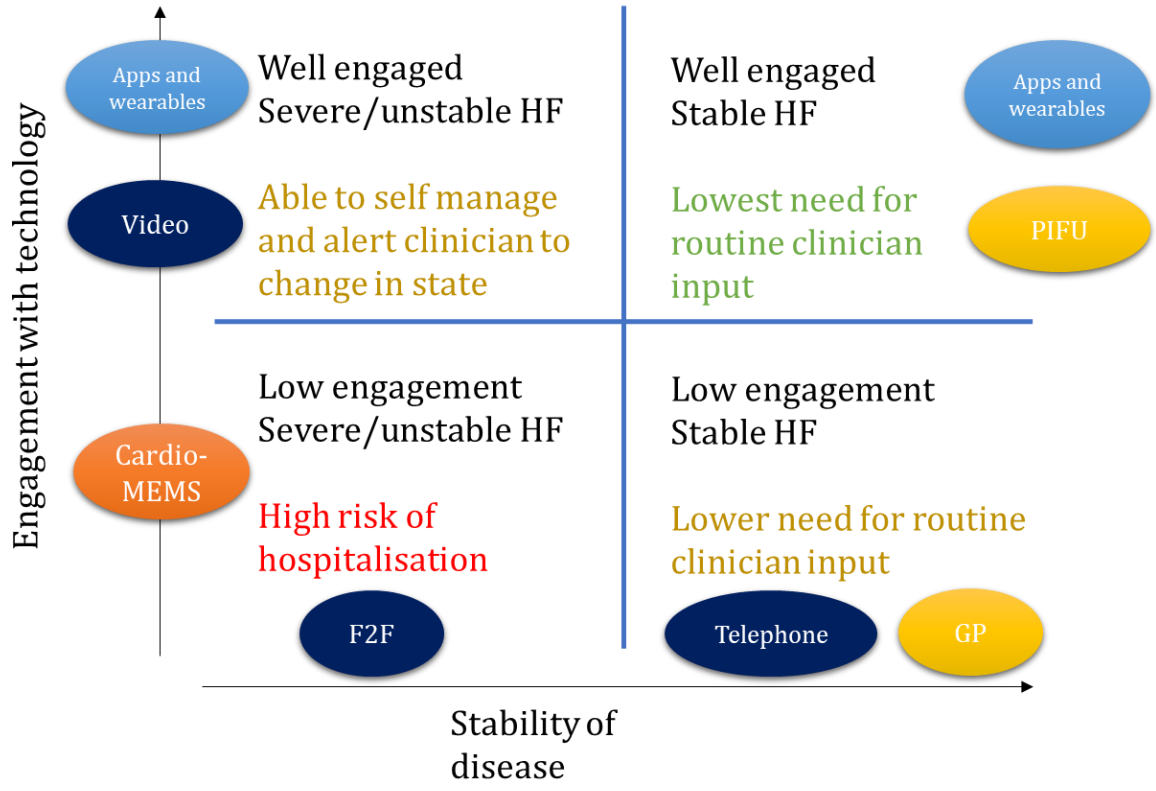


Figure 7.6 - "Menu" of options for the follow-up and monitoring of patients with HF. F2F = face-to-face. PIFU = Patient-initiated follow-up

Patients whose HF syndrome is severe or unstable are most likely to benefit from intensive follow-up and monitoring. Certain patients, particularly those considered at high risk of hospitalisation, may be suitable for CardioMEMS which requires relatively little engagement with technology. Patients more engaged with technology have more options available to them in terms of monitoring and follow-up modality; well-engaged patients may be able to self-monitor with Apps and wearables, and may be able to use video technology for follow-up. Patients who have stable disease but are less well engaged with technology may be appropriate for telephone follow-up, or even local follow-up with their GP.

7.6 Barriers and enablers to change

The European e-Health action plan and ESC e-Health working group identified several barriers to the widespread implementation of digital technologies, and the ESC e-Health working group also proposed broad solutions to some of these issues (Table 7.1).

	Barriers[184]	Solutions[88]
Stakeholder resistance to adopt digital care	• Lack of awareness of, and confidence among patients, citizens and healthcare professionals • Regional differences in accessing ICT services, including limited access in deprived areas.	• Patient digital health education programs • Redesign contemporary workflow models
Legal, ethical and technical barriers	• Lack of inter-operability between digital solutions • Lack of legal clarity for health and wellbeing mobile applications and the lack of transparency regarding the utilisation of data collected by such applications	• Assure interoperability of digital health services • European-wide digital health certification programs • Assure compliance to digital health directives
Lack of reimbursement	• High start-up costs • Inadequate or fragmented legal frameworks for reimbursement • Limited large-scale evidence of cost-effectiveness	• Encourage economical evaluations of digital health-based care • Inform health insurance industry and policy makers • Stimulate digital health-related knowledge and experience sharing

Table 7.1 - Barriers and solutions to the large-scale deployment of digital health-based care in cardiology

Many of these barriers have already been overcome as a result of the Covid-19 pandemic. Improvements in technology are generally associated with significant upfront costs for equipment, training and software licenses, but many organisations, including the Royal Brompton Hospital, have already made substantial investments during the Covid-19 pandemic, thus enabling the use of telemedicine consultations. Similarly, the lack of confidence in using video technology would likely have been a significant barrier to widespread adoption of telemedicine, but as established from patient and clinician interviews, users rapidly adapted to the technology, with some patients becoming more confident from needing to use video technology to communicate with friends and relatives because of social distancing requirements.

One key barrier not yet addressed is the lack of interoperability between digital solutions. In order to safely deliver care remotely, HF patients should have access to monitoring tests such as blood tests and ECGs. Clinicians interviewed identified significant time costs from trying to obtain results from locally performed tests. Current hospital electronic health record (EHR) systems do not integrate with community care EHRs, meaning that extra effort is required to obtain records, for example by contacting GP practices, and in some cases, tests are duplicated. Newer EHRs promise better integration with local systems, and NHS England is investing in programmes to enable easier sharing of data between organisations.[185] Furthermore, as of 1st April 2020, the NHS Standard Contract requires organisations to enable clinical data to be accessible to other providers as structured information through open interfaces.[186] The Royal Brompton Hospital has begun the process of transitioning to a new EHR, but whether seamless integration of clinical data with local systems is achievable remains to be seen.

Indeed, EHRs have had a history of over-promising and under-delivering. Whilst the transition to "paperless" working was touted as a much-needed efficiency improvement in clinical medicine, a survey of US primary care physicians revealed that 74% reported that EHRs increased their workload, and 68% reported that EHRs resulted in time being taken away from patient care.[187] A time and motion study across 4 American outpatient clinics found that 49% of clinician time was spent on administrative tasks and using EHRs.[188] This may be because EHRs are often procured on the basis of their functionality for billing, rather than on clinician user experience.[189]

It is therefore important to ensure stakeholders' interests are aligned when adopting a new EHR. Healthcare professionals' time is a valuable resource which clearly needs to be factored into health economic decisions, particularly if staffing is a limiting factor for improving service delivery. EHRs need to save rather than create work for clinicians and support staff, and smart use of EHRs may even address some of the problems identified in this thesis. For example, in Chapter 3 we demonstrated that patients' appointment times did not consider how far they needed to travel into the hospital. A decision-support tool integrated into an EHR could alert an administrator to book patients who lived far away into later appointments in order to improve their experience and reduce the chance they would attend late. Similarly, investigations could be better co-ordinated to ensure a reasonable interval between appointments on a given day, to reduce the chance of delays and ensure that clinicians have the information they need before the appointment starts.

7.7 Future research

Digital transformation in HF clinics is still in its infancy, and the full impact of change is yet to be seen. Further research should focus on the following areas:

7.7.1 The impact on the use of investigations

Some clinicians reported being more reliant on objective data in the absence of physical examinations. It would be important to measure changes in behaviour for requesting investigations as this will impact the demand on resources such as echocardiography. Furthermore, it is highly likely that fewer blood tests are requested in hospital for patients who have telemedicine appointments, but whether this results in a higher demand for local blood tests should be investigated.

7.7.2 Cost-benefit analyses of telemedicine

During the Covid-19 pandemic, the video consultation platform used in the present study, Attend Anywhere, was made freely available to trusts through an agreement with NHS England. Once this agreement expires, an additional subscription cost may be required for ongoing use of the platform. This must be balanced against the possible cost savings in terms of physical clinic space, clinic support staff and patient transport. An additional consideration for NHS trusts is how tariffs for telemedicine appointments will compare to face-to-face appointments in the long-term.

7.7.3 Repeat time-and-motion studies

We hypothesise that changes to clinic scheduling, co-ordination of investigations and increased use of telemedicine will save patients time and reduce clinic delays once a hybrid clinic is possible. This should be measured using time-and-motion studies with similar methodologies to the present thesis.

7.7.4 Evaluation of the educational smartphone App

The educational avatar-based smartphone App should be evaluated following a wider rollout to HF patients. Key areas of study should include user experience, and the effect of App use on knowledge of HF, self-care, and use of HF services.

7.7.5 Health outcomes

Finally, objective data on health outcomes should be collected to ensure telemedicine consultations are not associated with adverse outcomes. Long-term hospitalisation and mortality data are needed to reassure patients and clinicians that telemedicine is a safe alternative to face-to-face consultations for delivering HF care.

Other metrics may provide an indication on whether telemedicine and more flexible follow-up (such PIFU) has had an effect on the responsiveness of the clinic, such as the time from referral to first appointment for new patients, or the time taken to achieve optimal medical therapy following up-titration. We hypothesise that more flexible, tailored follow-up may permit seeing new patients and optimising medical therapy sooner.

7.8 Conclusions

The traditional model of HF outpatient care, with regular face-to-face specialist appointments, was inadequate to meet the needs of 21st century HF patients. Appointments frequently involved few clinical actions, but necessitated long journeys and waits for patients. A rapid shift to telemedicine appointments following the Covid-19 pandemic was generally well received by clinicians and patients, but a hybrid of face-to-face and telemedicine appointments should be used long-term. A smartphone App, co-

designed with patients, may be a useful tool to address the shortcomings in HF patient education.

Telemedicine and redesign of outpatient services, including changes to scheduling, co-ordination of investigations and appointments, EHRs and improvements in remote monitoring can improve patient and clinician experience, improve efficiency and rationalise limited resources, thus adding value to outpatient HF care.

8 References

1. McDonagh TA, Metra M, Adamo M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. *Eur Heart J* 2021; 42: 3599–3726.

2. National Cardiac Audit Programme. *National Heart Failure Audit*, https://www.hqip.org.uk/wp-content/uploads/2021/10/NHFA-Domain-Report_2021_FINAL.pdf (2021, accessed 30 August 2002).

3. Conrad N, Judge A, Tran J, et al. Temporal trends and patterns in heart failure incidence: a population-based study of 4 million individuals. *The Lancet* 2018; 391: 572–580.

4. Taylor CJ, Ordóñez-Mena JM, Roalfe AK, et al. Trends in survival after a diagnosis of heart failure in the United Kingdom 2000-2017: population based cohort study. *BMJ* 2019; l223.

5. Bottle A, Kim D, Aylin P, et al. Routes to diagnosis of heart failure: observational study using linked data in England. *Heart* 2018; 104: 600–605.

6. NICE. *Resource impact report: Chronic heart failure in adults: diagnosis and management (NG106)*, https://www.nice.org.uk/guidance/ng106/resources/resource-impact-report-pdf-6537494413 (2018, accessed 30 August 2022).

7. NICE. *Chronic heart failure in adults: diagnosis and management,* https://www.nice.org.uk/guidance/ng106 (2018, accessed 30 August 2022).

8. Malik A, Brito D, Vaqar S, et al. Congestive Heart Failure. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing, http://www.ncbi.nlm.nih.gov/books/NBK430873/ (2022, accessed 30 August 2022).

9. CONSENSUS Trial Study Group. Effects of enalapril on mortality in severe congestive heart failure. Results of the Cooperative North Scandinavian Enalapril Survival Study (CONSENSUS). *N Engl J Med* 1987; 316: 1429–1435.

10. SOLVD Investigators, Yusuf S, Pitt B, et al. Effect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. *N Engl J Med* 1991; 325: 293–302.

11. Granger CB, McMurray JJ, Yusuf S, et al. Effects of candesartan in patients with chronic heart failure and reduced left-ventricular systolic function intolerant to angiotensin-converting-enzyme inhibitors: the CHARM-Alternative trial. *The Lancet* 2003; 362: 772–776.

12. CIBIS-II Investigators. The Cardiac Insufficiency Bisoprolol Study II (CIBIS-II): a randomised trial. *The Lancet* 1999; 353: 9–13.

13. MERIT-HF Investigators. Effect of metoprolol CR/XL in chronic heart failure: Metoprolol CR/XL Randomised Intervention Trial in-Congestive Heart Failure (MERIT-HF). *The Lancet* 1999; 353: 2001–2007.

14. Packer M, Coats AJS, Fowler MB, et al. Effect of Carvedilol on Survival in Severe Chronic Heart Failure. *N Engl J Med* 2001; 344: 1651–1658.

15. Pitt B, Zannad F, Remme WJ, et al. The Effect of Spironolactone on Morbidity and Mortality in Patients with Severe Heart Failure. *N Engl J Med* 1999; 341: 709–717.

16. Zannad F, McMurray JJV, Krum H, et al. Eplerenone in Patients with Systolic Heart Failure and Mild Symptoms. *N Engl J Med* 2011; 364: 11–21.

17. Burnett H, Earley A, Voors AA, et al. Thirty Years of Evidence on the Efficacy of Drug Treatments for Chronic Heart Failure With Reduced Ejection Fraction: A Network Meta-Analysis. *Circ Heart Fail* 2017; 10: e003529.

18. McMurray JJV, Packer M, Desai AS, et al. Angiotensin–Neprilysin Inhibition versus Enalapril in Heart Failure. *N Engl J Med* 2014; 371: 993–1004.

19. McMurray JJV, Solomon SD, Inzucchi SE, et al. Dapagliflozin in Patients with Heart Failure and Reduced Ejection Fraction. *N Engl J Med* 2019; 381: 1995–2008.

20. Packer M, Anker SD, Butler J, et al. Cardiovascular and Renal Outcomes with Empagliflozin in Heart Failure. *N Engl J Med* 2020; 383: 1413–1424.

21. Swedberg K, Komajda M, Böhm M, et al. Ivabradine and outcomes in chronic heart failure (SHIFT): a randomised placebo-controlled study. *The Lancet* 2010; 376: 875–885.

22. Digitalis Investigation Group. The Effect of Digoxin on Mortality and Morbidity in Patients with Heart Failure. *N Engl J Med* 1997; 336: 525–533.

23. Armstrong PW, Pieske B, Anstrom KJ, et al. Vericiguat in Patients with Heart Failure and Reduced Ejection Fraction. *N Engl J Med* 2020; 382: 1883–1893.

24. McMurray JJV, Adamopoulos S, Anker SD, et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. *Eur Heart J* 2012; 33: 1787–1847.

25. Anker SD, Butler J, Filippatos G, et al. Empagliflozin in Heart Failure with a Preserved Ejection Fraction. *N Engl J Med* 2021; 385: 1451–1461.

26. Solomon SD, McMurray JJV, Anand IS, et al. Angiotensin-Neprilysin Inhibition in Heart Failure with Preserved Ejection Fraction. *N Engl J Med* 2019; 381: 1609–1620.

27. Solomon SD, Vaduganathan M, L. Claggett B, et al. Sacubitril/Valsartan Across the Spectrum of Ejection Fraction in Heart Failure. *Circulation* 2020; 141: 352–361.

28. Solomon SD, Claggett B, Lewis EF, et al. Influence of ejection fraction on outcomes and efficacy of spironolactone in patients with heart failure with preserved ejection fraction. *Eur Heart J* 2016; 37: 455–462.

29. Cleland JGF, Bunting KV, Flather MD, et al. Beta-blockers for heart failure with reduced, mid-range, and preserved ejection fraction: an individual patient-level analysis of double-blind randomized trials. *Eur Heart J* 2018; 39: 26–35.

30. Lund LH, Claggett B, Liu J, et al. Heart failure with mid-range ejection fraction in CHARM: characteristics, outcomes and effect of candesartan across the entire ejection fraction spectrum. *Eur J Heart Fail* 2018; 20: 1230–1239.

31. Edelmann F, Gelbrich G, Düngen H-D, et al. Exercise training improves exercise capacity and diastolic function in patients with heart failure with preserved ejection fraction: results of the Ex-DHF (Exercise training in Diastolic Heart Failure) pilot study. *J Am Coll Cardiol* 2011; 58: 1780–1791.

32. Taylor RS, Walker S, Smart NA, et al. Impact of Exercise Rehabilitation on Exercise Capacity and Quality-of-Life in Heart Failure. *J Am Coll Cardiol* 2019; 73: 1430–1443.

33. Long L, Mordi IR, Bridges C, et al. Exercise-based cardiac rehabilitation for adults with heart failure. *Cochrane Database Syst Rev* 2019; 1: CD003331.

34. Bardy GH, Lee KL, Mark DB, et al. Amiodarone or an implantable cardioverter-defibrillator for congestive heart failure. *N Engl J Med* 2005; 352: 225–237.

35. Moss AJ, Zareba W, Hall WJ, et al. Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. *N Engl J Med* 2002; 346: 877–883.

36. Cleland JGF, Daubert J-C, Erdmann E, et al. The effect of cardiac resynchronization on morbidity and mortality in heart failure. *N Engl J Med* 2005; 352: 1539–1549.

37. Bristow MR, Saxon LA, Boehmer J, et al. Cardiac-resynchronization therapy with or without an implantable defibrillator in advanced chronic heart failure. *N Engl J Med* 2004; 350: 2140–2150.

38. Bottle A, Faitna P, Aylin PP, et al. Five-year outcomes following left ventricular assist device implantation in England. *Open Heart* 2021; 8: e001658.

39. Clark A, Gardner R, McDonagh T (eds). *Oxford textbook of heart failure*. Second edition. New York: Oxford University Press, 2021.

40. Cowie MR, Harper AR, Singhal A. Monitoring. In: Clark AL, Gardner RS, McDonagh TA, et al. (eds) *Oxford Textbook of Heart Failure*. Oxford University Press, pp. 819–832.

41. Zhang J, Goode KM, Cuddihy PE, et al. Predicting hospitalization due to worsening heart failure using daily weight measurement: analysis of the Trans-European Network-Home-Care Management System (TEN-HMS) study. *Eur J Heart Fail* 2009; 11: 420–427.

42. Lewin J, Ledwidge M, O'Loughlin C, et al. Clinical deterioration in established heart failure: what is the value of BNP and weight gain in aiding diagnosis? *Eur J Heart Fail* 2005; 7: 953–957.

43. Schiff GD, Fung S, Speroff T, et al. Decompensated heart failure: symptoms, patterns of onset, and contributing factors. *Am J Med* 2003; 114: 625–630.

44. Jonkman NH, Westland H, Groenwold RHH, et al. What Are Effective Program Characteristics of Self-Management Interventions in Patients With Heart Failure? An Individual Patient Data Meta-analysis. *J Card Fail* 2016; 22: 861–871.

45. Strömberg A. The crucial role of patient education in heart failure. *Eur J Heart Fail* 2005; 7: 363–369.

46. Cajita MI, Cajita TR, Han H-R. Health Literacy and Heart Failure: A Systematic Review. *J Cardiovasc Nurs* 2016; 31: 121–130.

47. Fabbri M, Murad MH, Wennberg AM, et al. Health Literacy and Outcomes Among Patients With Heart Failure: A Systematic Review and Meta-Analysis. *JACC Heart Fail* 2020; 8: 451–460.

48. Hibbard J, Gilburt H. *Supporting people to manage their health: An introduction to patient activation*, https://www.kingsfund.org.uk/sites/default/files/field/field_publication_file/su

pporting-people-manage-health-patient-activation-may14.pdf (2014, accessed 30 August 2002).

49. Pumping Marvellous. *Monitoring your symptoms,* https://www.pumpingmarvellous.org/heart-failure-guide/monitoring-your-heart-failure-symptoms/ (accessed 30 August 2022).

50. Inglis SC, Clark RA, Dierckx R, et al. Structured telephone support or non-invasive telemonitoring for patients with heart failure. *Cochrane Database Syst Rev* 2015; CD007228.

51. Pandor A, Gomersall T, Stevens JW, et al. Remote monitoring after recent hospital discharge in patients with heart failure: a systematic review and network meta-analysis. *Heart Br Card Soc* 2013; 99: 1717–1726.

52. Heidenreich PA, Bozkurt B, Aguilar D, et al. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation* 2022; 145: e895–e1032.

53. Abraham WT, Adamson PB, Bourge RC, et al. Wireless pulmonary artery haemodynamic monitoring in chronic heart failure: a randomised controlled trial. *The Lancet* 2011; 377: 658–666.

54. Lindenfeld J, Zile MR, Desai AS, et al. Haemodynamic-guided management of heart failure (GUIDE-HF): a randomised controlled trial. *Lancet Lond Engl* 2021; 398: 991–1001.

55. Morton G, Masters J, Cowburn PJ. Multidisciplinary team approach to heart failure management. *Heart Br Card Soc* 2018; 104: 1376–1382.

56. Van Spall HGC, Rahman T, Mytton O, et al. Comparative effectiveness of transitional care services in patients discharged from the hospital with heart failure: a systematic review and network meta-analysis. *Eur J Heart Fail* 2017; 19: 1427–1443.

57. Takeda A, Martin N, Taylor RS, et al. Disease management interventions for heart failure. *Cochrane Database Syst Rev* 2019; 1: CD002752.

58. Loudon IS. Historical importance of outpatients. *BMJ* 1978; 1: 974–977.

59. Bridges R. An Account of the Casualty Department. *Charity Organ Rev* 1890; 6: 309–319.

60. Policy Navigator. *National Insurance Act 1911*, https://navigator.health.org.uk/theme/national-insurance-act-1911 (accessed 30 August 2022).

61. Policy Navigator. *Lord Dawson's Interim report on the future provision of medical and allied services 1920,* https://navigator.health.org.uk/theme/lord-dawsons-interim-report-future-provision-medical-and-allied-services-1920 (accessed 30 August 2022).

62. Policy Navigator. *National Health Service Act 1946*, https://navigator.health.org.uk/theme/national-health-service-act-1946 (accessed 30 August 2022).

63. Consultative Council on Medical and Allied Services (Ministry of Health GB. *The Dawson report,* https://archive.kingsfund.org.uk/concern/published_works/000018795?locale=it#?cv=0&xywh=-2958,0,7177,1838 (accessed 30 August 2022).

64. NHS Digital. *Hospital Outpatient Activity 2019-20*, https://digital.nhs.uk/data-and-information/publications/statistical/hospital-outpatient-activity/2019-20 (accessed 30 August 2022).

65. UK Government. *NHS Constitution for England*, https://www.gov.uk/government/publications/the-nhs-constitution-for-england (accessed 30 August 2022).

66. Porter ME. What is value in health care? *N Engl J Med* 2010; 363: 2477–2481.

67. Centre for Evidence-Based Medicine (CEBM), University of Oxford. *Defining value-based healthcare in the NHS*, https://www.cebm.ox.ac.uk/resources/reports/defining-value-based-healthcare-in-the-nhs (2019, accessed 30 August 2022).

68. The BMJ. *Too much medicine*, https://www.bmj.com/too-much-medicine (accessed 30 August 2022).

69. Academy of Medical Royal Colleges*. Choosing Wisely,* https://www.aomrc.org.uk/choosing-wisely/ (accessed 30 August 2022).

70. GIRFT. *Getting It Right First Time – GIRFT*, https://www.gettingitrightfirsttime.co.uk/ (accessed 30 August 2022).

71. RCP London. *Outpatients: the future – adding value through sustainability*, https://www.rcplondon.ac.uk/projects/outputs/outpatients-future-adding-value-through-sustainability (2018, accessed 2 August 2022).

72. The NHS Long Term Plan. *NHS Long Term Plan*, https://www.longtermplan.nhs.uk/publication/nhs-long-term-plan/ (2019, accessed 30 August 2022).

73. Health Education England. *The Topol Review: Preparing the healthcare workforce to deliver the digital future,* https://topol.hee.nhs.uk/ (accessed 30 August 2022).

74. WHO Global Observatory for eHealth. *Telemedicine: opportunities and developments in Member States: report on the second global survey on eHealth*. World Health Organization, https://apps.who.int/iris/handle/10665/44497 (2010, accessed 30 August 2022).

75. Aronson SH. The Lancet on the telephone 1876-1975. *Med Hist* 1977; 21: 69–87.

76. Hashiguchi, T. *Bringing health care to the patient: An overview of the use of telemedicine in OECD countries.* OECD Health Working Papers, No. 116, OECD Publishing, Paris, https://doi.org/10.1787/8e56ede7-en

77. The Nuffield Trust. *QualityWatch: The remote care revolution during Covid-19*, https://www.nuffieldtrust.org.uk/files/2020-12/QWAS/digital-and-remote-care-in-covid-19.html# (2020, accessed 2 August 2022).

78. Castle-Clarke, Sophie. *What will new technology mean for the NHS and its patients?: Four big technological trends*. UK: The Health Foundation, 2018.

79. Thiyagarajan A, Grant C, Griffiths F, et al. Exploring patients' and clinicians' experiences of video consultations in primary care: a systematic scoping review. *BJGP Open* 2020; 4: bjgpopen20X101020.

80. Powell RE, Henstenburg JM, Cooper G, et al. Patient Perceptions of Telehealth Primary Care Video Visits. *Ann Fam Med* 2017; 15: 225–229.

81. Björndell C, Premberg Å. Physicians' experiences of video consultation with patients at a public virtual primary care clinic: a qualitative interview study. *Scand J Prim Health Care* 2021; 39: 67–76.

82. Sørensen K, Pelikan JM, Röthlin F, et al. Health literacy in Europe: comparative results of the European health literacy survey (HLS-EU). *Eur J Public Health* 2015; 25: 1053–1058.

83. Barnes S, Gott M, Payne S, et al. Communication in heart failure: perspectives from older people and primary care professionals. *Health Soc Care Community* 2006; 14: 482–490.

84. Office for National Statistics. *Internet access – households and individuals, Great Britain,* https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2019 (accessed 3 September 2022).

85. Food and Drug Administration. *Device Software Functions Including Mobile Medical Applications*, https://www.fda.gov/medical-devices/digital-health-center-excellence/device-software-functions-including-mobile-medical-applications (2020, accessed 3 September 2022).

86. Mortara A, Vaira L, Palmieri V, et al. Would You Prescribe Mobile Health Apps for Heart Failure Self-care? An Integrated Review of Commercially Available Mobile Technology for Heart Failure Patients. *Card Fail Rev* 2020; 6: e13.

87. Wonggom P, Kourbelis C, Newman P, et al. Effectiveness of avatar-based technology in patient education for improving chronic disease knowledge and self-care behavior: a systematic review. *JBI Database Syst Rev Implement Rep* 2019; 17: 1101–1129.

88. Frederix I, Caiani EG, Dendale P, et al. ESC e-Cardiology Working Group Position Paper: Overcoming challenges in digital health implementation in cardiovascular medicine. *Eur J Prev Cardiol* 2019; 26: 1166–1177.

89. American Library Association. *Digital Literacy,* https://literacy.ala.org/digital-literacy/ (accessed 3 September 2022).

90. Lloyds Bank. *UK Consumer Digital Index 2019*.

91. WHO. *WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020,* https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed 3 September 2022).

92. UK Government. *Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand, 16 March 2020*, https://www.gov.uk/government/publications/impact-of-non-pharmaceutical-interventions-npis-to-reduce-covid-19-mortality-and-healthcare-demand-16-march-2020 (accessed 3 September 2022).

93. UK Government. *Prime Minister's statement on coronavirus (COVID-19): 16 March 2020*, https://www.gov.uk/government/speeches/pm-statement-on-coronavirus-16-march-2020 (accessed 3 September 2022).

94. UK Government. *Prime Minister's statement on coronavirus (COVID-19): 23 March 2020*, https://www.gov.uk/government/speeches/pm-address-to-the-nation-on-coronavirus-23-march-2020 (accessed 3 September 2022).

95. UK Government. S*taying at home and away from others (social distancing)*, https://www.gov.uk/government/publications/full-guidance-on-staying-at-home-and-away-from-others (2020, accessed 3 September 2022).

96. NHS Digital. *Appointments in General Practice*, https://digital.nhs.uk/data-and-information/publications/statistical/appointments-in-general-practice (accessed 4 September 2022).

97. Hauptman PJ, Rich MW, Heidenreich PA, et al. The Heart Failure Clinic: A Consensus Statement of the Heart Failure Society of America. *J Card Fail* 2008; 14: 801–815.

98. Guha K, Allen CJ, Chawla S, et al. Audit of a tertiary heart failure outpatient service to assess compliance with NICE guidelines. *Clin Med* 2016; 16: 407–411.

99. Crespo-Leiro MG, Anker SD, Maggioni AP, et al. European Society of Cardiology Heart Failure Long-Term Registry (ESC-HF-LT): 1-year follow-up outcomes and differences across regions. *Eur J Heart Fail* 2016; 18: 613–625.

100. Allen LA, Tang F, Jones P, et al. Signs, symptoms, and treatment patterns across serial ambulatory cardiology visits in patients with heart failure: insights from the NCDR PINNACLE® registry. *BMC Cardiovasc Disord* 2018; 18: 80.

101. Maggioni AP, Dahlström U, Filippatos G, et al. EUR *Observational* Research Programme: regional differences and 1-year follow-up results of the Heart Failure Pilot Survey (ESC-HF Pilot). *Eur J Heart Fail* 2013; 15: 808–817.

102. Hebert K, Macedo FYB, Trahan P, et al. Routine Serial Echocardiography in Systolic Heart Failure: Is It Time for the Heart Failure Guidelines to Change?: serial echocardiography in heart failure. *Congest Heart Fail* 2011; 17: 84–88.

103. Patel MR, White RD, Abbara S, et al. 2013 ACCF/ACR/ASE/ASNC/SCCT/SCMR Appropriate Utilization of Cardiovascular Imaging in Heart Failure. *J Am Coll Cardiol* 2013; 61: 2207–2231.

104. Čelutkienė J, Spoletini I, Coats AJS, et al. Left ventricular function monitoring in heart failure. *Eur Heart J Suppl J Eur Soc Cardiol* 2019; 21: M17–M19.

105. Zheng A, Cowan E, Mach L, et al. Characteristics and outcomes of patients with suspected heart failure referred in line with National Institute for Health and Care Excellence guidance. *Heart* 2020; 106: 1579–1585.

106. NHS England. *Patient initiated follow-up*, https://www.england.nhs.uk/outpatient-transformation-programme/patient-initiated-follow-up-giving-patients-greater-control-over-their-hospital-follow-up-care/ (accessed 19 September 2022).

107. Taylor FW. *The Principles of Scientific Management*. New York, London: Harper & Brothers, 1911.

108. Baumgart A, Neuhauser D. Frank and Lillian Gilbreth: scientific management in the operating room. *Qual Saf Health Care* 2009; 18: 413–415.

109. Lopetegui M, Yen P-Y, Lai A, et al. Time Motion Studies in Healthcare: What are we talking about? *J Biomed Inform* 2014; 0: 292–299.

110. Alamo ST, Wagner GJ, Ouma J, et al. Strategies for Optimizing Clinic Efficiency in a Community-Based Antiretroviral Treatment Programme in Uganda. *AIDS Behav* 2013; 17: 274–283.

111. Wagenaar BH, Gimbel S, Hoek R, et al. Wait and consult times for primary healthcare services in central Mozambique: a time-motion study. *Glob Health Action* 2016; 9: 31980.

112. Olwanda E, Shen J, Kahn JG, et al. Comparison of patient flow and provider efficiency of two delivery strategies for HPV-based cervical cancer screening in Western Kenya: a time and motion study. *Glob Health Action* 2018; 11: 1451455.

113. Mamlin JJ, Baker DH. Combined Time-Motion and Work Sampling Study in a General Medicine Clinic. *Med Care* 1973; 11: 449–456.

114. Ho ETL. Improving waiting time and operational clinic flow in a tertiary diabetes center. *BMJ Qual Improv Rep* 2014; 2: u201918.w1006.

115. Drayton Jackson M, Bartman T, McGinniss J, et al. Optimizing patient flow in a multidisciplinary haemophilia clinic using quality improvement methodology. *Haemophilia* 2019; hae.13768.

116. Shinder GA, Paradis PE, Posman M, et al. Patient and work flow and costs associated with staff time and facility usage at a comprehensive cancer centre in Quebec, Canada – a time and motion study. *BMC Health Serv Res* 2012; 12: 370.

117. Seiler A, Biundo E, Di Bacco M, et al. Clinic Time Required for Remote and In-Person Management of Patients With Cardiac Devices: Time and Motion Workflow Evaluation*. JMIR Cardio.* 2021 Oct 15;5(2):e27720. doi: 10.2196/27720.

118. Heart Rhythm Society. *2015 HRS Expert Consensus Statement on Remote Interrogation and Monitoring for Cardiovascular Electronic Implantable Devices*, https://www.hrsonline.org/guidance/clinical-resources/2015-hrs-expert-consensus-statement-remote-interrogation-and-monitoring-cardiovascular-electronic (accessed 19 September 2022).

119. Jun JB, Jacobson SH, Swisher JR. Application of discrete-event simulation in health care clinics: A survey. *J Oper Res Soc* 1999; 50: 109–123.

120. White MJB, Pike MC. Appointment Systems in Out-patients Clinics and the Effect of Patients' Unpunctuality. *Med Care* 1964; 2: 133–145.

121. Cayirli T, Yang KK, Quek SA. A Universal Appointment Rule in the Presence of No-Shows and Walk-Ins. *Prod Oper Manag* 2012; 21: 682–697.

122. Williams KA, Chambers CG, Dada M, et al. Patient punctuality and clinic performance: observations from an academic-based private practice pain centre: a prospective quality improvement study. *BMJ Open* 2014; 4: e004679.

123. Parkinson C. (19 Nov 1955). Parkinson's Law. *The Economist*, https://www.economist.com/news/1955/11/19/parkinsons-law (accessed 19 September 2022).

124. Chambers CG, Dada M, Elnahal S, et al. Changes to physician processing times in response to clinic congestion and patient punctuality: a retrospective study. *BMJ Open* 2016; 6: e011730.

125. DiCicco-Bloom B, Crabtree BF. The qualitative research interview. *Med Educ* 2006; 40: 314–321.

126. Corbin J, Strauss A. *Basics of Qualitative Research (3rd ed.): Techniques and Procedures for Developing Grounded Theory*. 2455 Teller Road, Thousand Oaks California 91320 United States: SAGE Publications, Inc. Epub ahead of print 2008. DOI: 10.4135/9781452230153.

127. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; 3: 77–101.

128. Charmaz K. *Constructing grounded theory*. London ; Thousand Oaks, Calif: Sage Publications, 2006.

129. Glaser BG, Strauss AL. *The discovery of grounded theory: strategies for qualitative research*. 5. paperback print. New Brunswick: Aldine Transaction, 2010.

130. Donaghy E, Atherton H, Hammersley V, et al. Acceptability, benefits, and challenges of video consulting: a qualitative study in primary care. *Br J Gen Pract J R Coll Gen Pract* 2019; 69: e586–e594.

131. Hammersley V, Donaghy E, Parker R, et al. Comparing the content and quality of video, telephone, and face-to-face consultations: a non-randomised, quasi-experimental, exploratory study in UK primary care. *Br J Gen Pract* 2019; 69: e595–e604.

132. Mair F, Whitten P, May C, et al. Patients' perceptions of a telemedicine specialty clinic. *J Telemed Telecare* 2000; 6: 36–40.

133. Shaw S, Wherton J, Vijayaraghavan S, et al. *Advantages and limitations of virtual online consultations in a NHS acute trust: the VOCAL mixed-methods study*. Southampton (UK): NIHR Journals Library,

http://www.ncbi.nlm.nih.gov/books/NBK507677/ (2018, accessed 2 August 2022).

134. Seuren LM, Wherton J, Greenhalgh T, et al. Physical Examinations via Video for Patients With Heart Failure: Qualitative Study Using Conversation Analysis. *J Med Internet Res* 2020; 22: e16694.

135. Shaw SE, Seuren LM, Wherton J, et al. Video Consultations Between Patients and Clinicians in Diabetes, Cancer, and Heart Failure Services: Linguistic Ethnographic Study of Video-Mediated Interaction. *J Med Internet Res* 2020; 22: e18378.

136. Greenhalgh T, A'Court C, Shaw S. Understanding heart failure; explaining telehealth - a hermeneutic systematic review. *BMC Cardiovasc Disord* 2017; 17: 156.

137. DeJonckheere M, Vaughn LM. Semistructured interviewing in primary care research: a balance of relationship and rigour. *Fam Med Community Health* 2019; 7: e000057.

138. Guest G, Bunce A, Johnson L. How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. *Field Methods* 2006; 18: 59–82.

139. Namey E, Guest G, McKenna K, et al. Evaluating Bang for the Buck: A Cost-Effectiveness Comparison Between Individual Interviews and Focus Groups Based on Thematic Saturation Levels. *Am J Eval* 2016; 37: 425–440.

140. Galvin R. How many interviews are enough? Do qualitative interviews in building energy consumption research produce reliable knowledge? *J Build Eng* 2015; 1: 2–12.

141. Denscombe M. *The good research guide: for small-scale social research projects*. Maidenhead, England: McGraw-Hill/Open University Press, http://www.dawsonera.com/abstract/9780335241408 (2010, accessed 2 August 2022).

142. Graeff TR. Response Bias. In: Kempf-Leonard K (ed) *Encyclopedia of Social Measurement*. New York: Elsevier, pp. 411–418.

143. Tennison I, Roschnik S, Ashby B, et al. Health care's response to climate change: a carbon footprint assessment of the NHS in England. *Lancet Planet Health* 2021; 5: e84–e92.

144. The King's Fund. *Sustainable services,* https://www.kingsfund.org.uk/projects/time-think-differently/trends-sustainable-services (accessed 19 September 2022).

145. The King's Fund. *NHS workforce: our position,* https://www.kingsfund.org.uk/projects/positions/nhs-workforce (accessed 19 September 2022).

146. BMA, RCGP. *COVID-19 Pandemic Recovery Workload Prioritisation Guidance*, https://www.bma.org.uk/media/4386/bma-rcgp-covid-workload-prioritisation-aug-2021.pdf (accessed 19 September 2022).

147. BMA. *Patients recording consultations*, https://www.bma.org.uk/advice-and-support/ethics/confidentiality-and-health-records/patients-recording-consultations (accessed 19 September 2022).

148. McKinstry B, Watson P, Pinnock H, et al. Telephone consulting in primary care: a triangulated qualitative study of patients and providers. *Br J Gen Pract J R Coll Gen Pract* 2009; 59: e209-218.

149. Rowlands G, Protheroe J, Winkley J, et al. A mismatch between population health literacy and the complexity of health information: an observational study. *Br J Gen Pract* 2015; 65: e379–e386.

150. UK Government. *2011 skills for life survey*, https://www.gov.uk/government/publications/2011-skills-for-life-survey (accessed 19 September 2022).

151. NHS Improvement Hub. *Experience Based Design Using Patient and Staff Experience to Design Better Healthcare Services; Guide and Tools*, https://www.england.nhs.uk/improvement-hub/publication/experience-based-

design-using-patient-and-staff-experience-to-design-better-healthcare-services-guide-and-tools/ (accessed 19 September 2022).

152. Barbour R, Kitzinger J. *Developing Focus Group Research*. 6 Bonhill Street, London England EC2A 4PU United Kingdom: SAGE Publications Ltd. Epub ahead of print 1999. DOI: 10.4135/9781849208857.

153. Kitzinger J. Qualitative Research: Introducing focus groups. *BMJ* 1995; 311: 299–302.

154. Leung F-H, Savithiri R. Spotlight on focus groups. *Can Fam Physician* 2009; 55: 218–219.

155. Flick U. *An introduction to qualitative research*. 4th ed. Los Angeles: Sage Publications, 2009.

156. Pope C, Mays N (eds). *Qualitative research in health care*. Fourth edition. Hoboken: Wiley-Blackwell, 2020.

157. Flesch R. A new readability yardstick. *J Appl Psychol* 1948; 32: 221–233.

158. Bedra M, Wick E, Brotman D, et al. Avatar-based interactive ileostomy education in hospitalized patients. *Stud Health Technol Inform* 2013; 190: 83–85.

159. Andrade AD, Anam R, Karanam C, et al. An overactive bladder online self-management program with embedded avatars: a randomized controlled trial of efficacy. *Urology* 2015; 85: 561–567.

160. Wonggom P, Nolan P, Clark RA, et al. Effectiveness of an avatar educational application for improving heart failure patients' knowledge and self-care behaviors: A pragmatic randomized controlled trial. *J Adv Nurs* 2020; 76: 2401–2415.

161. Holloway. *Qualitative Research in Nursing and Healthcare, 4th Edition*. 4th edition. Chichester, West Sussex, UK ; Ames, Iowa: Wiley-Blackwell, 2016.

162. Carey MA, Smith MW. Capturing the Group Effect in Focus Groups: A Special Concern in Analysis. *Qual Health Res* 1994; 4: 123–127.

163. BMJ. Chris Ham. *Inertia rather than privatisation is the biggest threat facing the NHS*, https://blogs.bmj.com/bmj/2012/02/21/chris-ham-inertia-rather-than-privatisation-is-the-biggest-threat-facing-the-nhs/ (2012, accessed 19 September 2022).

164. NHS England. *We must help our NHS adapt in order to keep it healthy*, https://www.england.nhs.uk/blog/keith-willett-4/ (accessed 19 September 2022).

165. British Cardiovascular Society Working Group. *The Future of Cardiology*, https://www.britishcardiovascularsociety.org/__data/assets/pdf_file/0010/21142/BCS-Future-of-Cardiology-17-Aug-2020.pdf (2020, accessed 4 September 2022).

166. Goodlin SJ. Palliative Care in Congestive Heart Failure. *J Am Coll Cardiol* 2009; 54: 386–396.

167. McIlvennan CK, Allen LA. Palliative care in patients with heart failure. *BMJ* 2016; i1010.

168. McAlister FA, Stewart S, Ferrua S, et al. Multidisciplinary strategies for the management of heart failure patients at high risk for admission. *J Am Coll Cardiol* 2004; 44: 810–819.

169. McDonagh TA, Blue L, Clark AL, et al. European Society of Cardiology Heart Failure Association Standards for delivering heart failure care. *Eur J Heart Fail* 2011; 13: 235–241.

170. Schou M, Gustafsson F, Videbaek L, et al. Extended heart failure clinic follow-up in low-risk patients: a randomized clinical trial (NorthStar). *Eur Heart J* 2013; 34: 432–442.

171. Hewlett S, Mitchell K, Haynes J, et al. Patient-initiated hospital follow-up for rheumatoid arthritis. *Rheumatol Oxf Engl* 2000; 39: 990–997.

172. Hewlett S, Kirwan J, Pollock J, et al. Patient initiated outpatient follow up in rheumatoid arthritis: six year randomised controlled trial. *BMJ* 2005; 330: 171.

173. Robinson A, Thompson DG, Wilkin D, et al. Guided self-management and patient-directed follow-up of ulcerative colitis: a randomised trial. *Lancet Lond Engl* 2001; 358: 976–981.

174. Kennedy A, Nelson E, Reeves D, et al. A randomised controlled trial to assess the impact of a package comprising a patient-orientated, evidence-based self-help guidebook and patient-centred consultations on disease management and satisfaction in inflammatory bowel disease. *Health Technol Assess*; 7. Epub ahead of print October 2003. DOI: 10.3310/hta7280.

175. Cowie MR, Flett A, Cowburn P, et al. Real-world evidence in a national health service: results of the UK CardioMEMS HF System Post-Market Study. *ESC Heart Fail* 2022; 9: 48–56.

176. Singhal A, Cowie MR. The Role of Wearables in Heart Failure. *Curr Heart Fail Rep* 2020; 17: 125–132.

177. Kooiman TJM, Dontje ML, Sprenger SR, et al. Reliability and validity of ten consumer activity trackers. *BMC Sports Sci Med Rehabil* 2015; 7: 24.

178. Loprinzi PD. The effects of free-living physical activity on mortality after congestive heart failure diagnosis. *Int J Cardiol* 2016; 203: 598–599.

179. Izawa KP, Watanabe S, Oka K, et al. Usefulness of step counts to predict mortality in Japanese patients with heart failure. *Am J Cardiol* 2013; 111: 1767–1771.

180. Piepoli MF, Conraads V, Corrà U, et al. Exercise training in heart failure: from theory to practice. A consensus document of the Heart Failure Association and the European Association for Cardiovascular Prevention and Rehabilitation. *Eur J Heart Fail* 2011; 13: 347–357.

181. Alharbi M, Straiton N, Gallagher R. Harnessing the Potential of Wearable Activity Trackers for Heart Failure Self-Care. *Curr Heart Fail Rep* 2017; 14: 23–29.

182. Thorup C, Hansen J, Grønkjær M, et al. Cardiac Patients' Walking Activity Determined by a Step Counter in Cardiac Telerehabilitation: Data From the

Intervention Arm of a Randomized Controlled Trial. *J Med Internet Res* 2016; 18: e69.

183. Beatty AL, Magnusson SL, Fortney JC, et al. VA FitHeart, a Mobile App for Cardiac Rehabilitation: Usability Study. *JMIR Hum Factors* 2018; 5: e3.

184. Cowie MR, Bax J, Bruining N, et al. e-Health: a position statement of the European Society of Cardiology. *Eur Heart J* 2016; 37: 63–66.

185. NHS England. *Joining up health and care data*, https://www.england.nhs.uk/digitaltechnology/connecteddigitalsystems/health-and-care-data/joining-up-health-and-care-data/ (accessed 19 September 2022).

186. NHS England. *Interoperability,* https://www.england.nhs.uk/digitaltechnology/connecteddigitalsystems/interoperability/ (accessed 19 September 2022).

187. EHR National Symposium. *EHR Poll Results,* http://med.stanford.edu/ehr (accessed 19 September 2022).

188. Sinsky C, Colligan L, Li L, et al. Allocation of Physician Time in Ambulatory Practice: A Time and Motion Study in 4 Specialties. *Ann Intern Med* 2016; 165: 753–760.

189. Tutty MA, Carlasare LE, Lloyd S, et al. The complex case of EHRs: examining the factors impacting the EHR user experience. *J Am Med Inform Assoc JAMIA* 2019; 26: 673–677.

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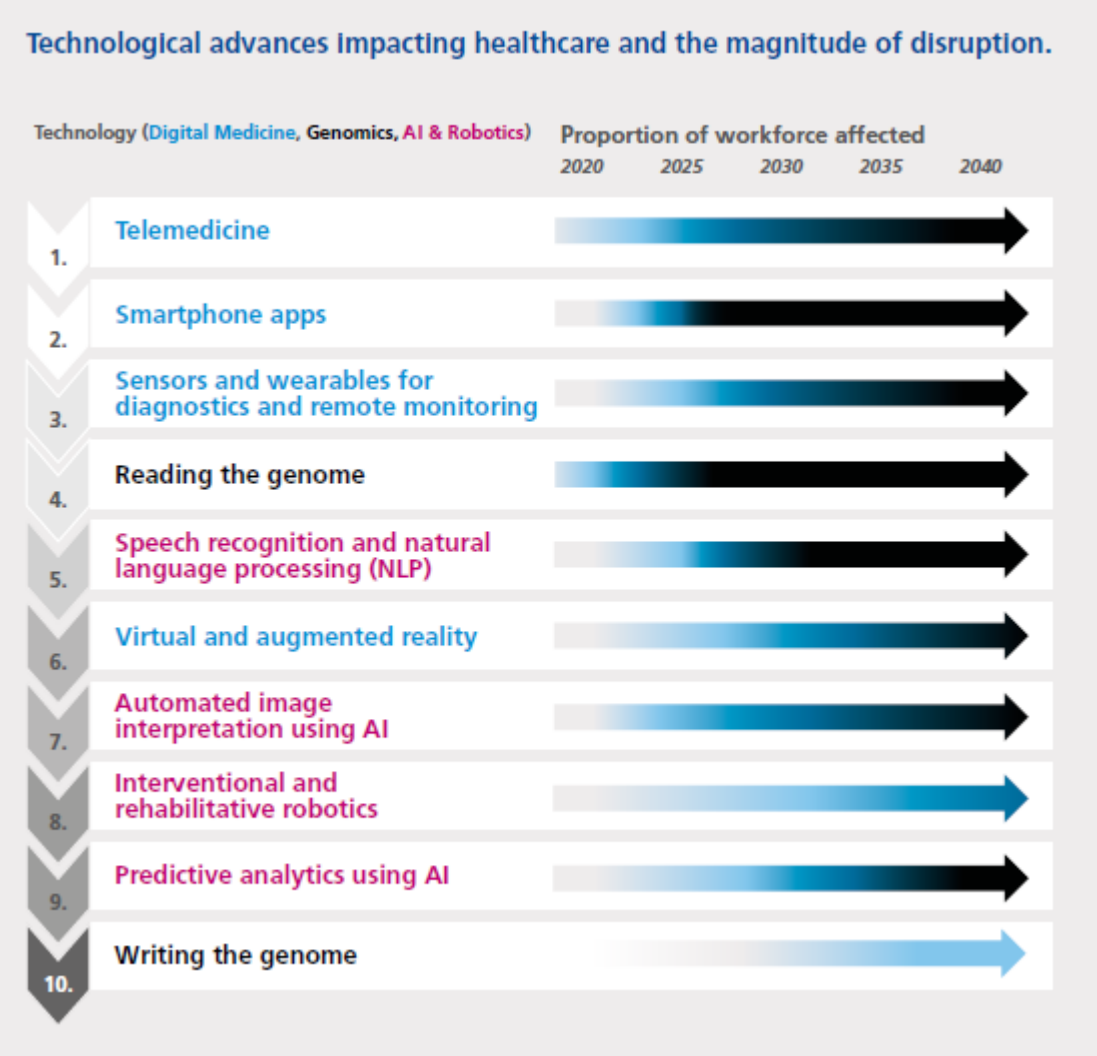

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