AN EVALUATION OF CASUALTY BEHAVIOUR DURING CHEMICAL, BIOLOGICAL, RADIOLOGICAL AND NUCLEAR INCIDENTS REQUIRING MASS DECONTAMINATION

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DECLARATION OF ORIGINALITY

I hereby declare that the entire work presented in this Thesis has been personally carried out. Where sources of information or the work of others have been used, they are fully cited and referenced and/or appropriate acknowledgement is given.

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ABSTRACT

Understanding human behaviour during emergencies is crucial, especially incidents involving chemical, biological, radiological, or nuclear (CBRN) materials requiring mass decontamination. This knowledge will help responders effectively engage with casualties. However, there is limited research on casualty behaviour's during mass decontamination, with current studies focusing mainly on technical aspects.

This research addresses this challenge, utilising a mixed-methods approach, including a critical literature review, qualitative and quantitative methods with real-world data, expert opinions, and a public visualization experiment.

The literature review identified cognitive behavioural, social-psychological, and cultural aspects of casualty response during mass decontamination, highlighting two significant gaps: the need for holistic examination of casualty behaviour during Hazmat/CBRN incidents and incorporating insights from actual events rather than controlled simulations or hypothetical scenarios.

Qualitative research of real-world incidents led to a behavioural model of casualty behaviour, validated through a survey of 118 evacuees from a Hazmat fire. This informed the development of mass decontamination scenarios to study how long casualties stay at the scene. Quantitative research, involving 1096 participants provided reliable data on the duration casualties are willing await decontamination, identifying average waiting times of 141 minutes and 30 seconds, highlighting the impact of external factors and emergency services' communication and response times.

The thesis concludes with expert-verified recommendations:

1. Increase the utilization of Interim Decontamination to enhance response times and flexibility.
2. Direct deployment of Mass Decontamination Units to hospitals, improving accessibility and efficiency.
3. Create a model for mass decontamination response based on leaver rates identified in the thesis.
4. Enhance public awareness of Hazmat/CBRN risks and Mass Decontamination capabilities.
5. Provide training for frontline responders on human behaviour and effective communication strategies for Mass Decontamination.

The novelty, rigour, and impact of the research highlights the need for effective engagement with casualties, impacting guidance, training, and future resourcing.

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My PhD journey has been a long one. Undertaking it as I have part-time whilst balancing my career and family life has been a challenge. Three children, six job roles and a global pandemic has added to the already sizable challenge of undertaking a PhD. However, I have been lucky enough to have received great support throughout.

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'For wisdom will come into your heart, and knowledge will be pleasant to your soul.' – Proverbs 2:10"

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Chapter 1 – Casualty Behaviour During Hazmat/CBRN Incidents Introduction

1.1 Introduction

The UK's National Risk Register identifies that the threat of a Chemical, Biological, Radiological or Nuclear (CBRN) incident occurring in the UK remains high and that this threat continues to grow with incidents such as the assassination of the former Russian agent Alexander Litvinenko's in November 2006 and the 2018 attack on Sergei Skripal and his daughter, Yulia Skripal, in Salisbury (see Figure 1) highlighting the threat of such incidents.

Figure 1 Response to the 2018 Novichok attack in Salisbury



Should such an emergency occur on a larger scale the impacts to the UK could be catastrophic. As a result, the National Risk Register identifies the government's commitment to continue to reduce the vulnerability of the UK to CBRN attacks.

A crucial element in preparing for such an incident is to understand how members of the public are likely to behave during such a CBRN emergency as this is vital in the planning and preparation of responses for such eventualities due to the need for: correct strategies, appropriate tactics, adequate resourcing and training of those tasked with managing such occurrences (Kuligowski, 2016). If we are better able to understand how members of the public behave during emergencies, in relation to their decision making and willingness to co-operate with emergency responders, including during emergencies such as a Hazmat/CBRN incident, we are better able to prepare the emergency services to respond.

However, prior to understanding people's behaviour during emergencies, we first must understand what is meant by the term 'emergency'. Although it can be defined in different ways, the definition widely accepted among the emergency services, and the one that will be used throughout this Thesis is: "(a) an event or situation which threatens serious damage to human welfare in a place in the United Kingdom, (b) an event or situation which threatens serious damage to the environment of a place in the United Kingdom, or (c) war, or terrorism, which threatens serious damage to the security of the United Kingdom."(Fire and Rescue Service Act, 2004) This Thesis will also understand major emergencies as any scenario during which the local response is overwhelmed and requires additional resources and support to resolve (Johns Hopkins and the International Federation of Red Cross and Red Crescent Societies, 2008).

One such area during an emergency where the behaviours of individuals will be critical is when decontamination activities are required following an incident involving a hazardous substance, most crucially should this be a CBRN emergency (Carter *et al*, 2015b).

Emergency decontamination may be required for a multitude of reasons which can be broadly categorized into two camps: i) Hazardous Materials (Hazmat) incidents, and ii) Chemical, Biological, Radiological, Nuclear (CBRN) Incidents (Joint Emergency Services Interoperability Principles, 2016b). Such classification is dependent on the circumstances of the incidents: an accidental chemical release would be a Hazmat incident, whereas a deliberate release for terrorist or criminal purposes of the same substance would be a CBRN incident (Joint Emergency Services Interoperability Principles, 2016b). This differentiation is to highlight the additional risks associated with a deliberate attack such as secondary devices or the presence of the perpetrator, and will also have implications for the Police and Security Services response to deliberate attacks. In both cases, should there be a danger to life or health, decontamination in some form will be required.

1.2 Thesis Overview

This Thesis aims to demonstrate how management of casualty behaviour can enhance the mass decontamination response. It is essential to understand this, as the ability of responders to effectively manage such incidents will largely depend on their capacity to engage with those affected efficiently.

The research explores human behaviour during such emergencies, conducting a literature review to delve into mass decontamination and its relationship with human behaviour.

The Thesis subsequently further explores this area by seeking current insights and perspectives from Fire and Rescue Service (FRS) personnel active in this domain.

Having explored the importance of human behaviour, the research will proceed to identify specific behaviours and their drivers during acute emergency situations. Notably however, the absence of mass decontamination incidents in the UK poses a major challenge. To further inform mass decontamination operations in the absence of any real such events that have occurred, the research will leverage another acute emergency incident: the 2017 Grenfell Tower fire. Transcripts of interviews conducted during the public inquiry following the fire will be utilised to reveal critical behavioural drivers. The insights gleaned from the Grenfell incident transcripts, along with additional literature on human behaviour during acute emergencies, will pave the way for the development of a hypothesized model of behaviours.

To validate this model, this research again relies on another acute emergency incident due to the absence of actual mass decontamination events. The chosen incident is the Ocado Fire, this was a large fire which occurred in February 2019 at the Ocado distribution centre in Andover and which was accompanied by an evacuation necessitated by the risks associated with fire impinging on an ammonia tank at the facility. A survey of evacuees will be employed to validate the model through path analysis. Consequently, the validated model will be able to reinforce the findings from the review of the Grenfell Fire transcripts.

Based on these findings, the research will then develop a visualisation experiment with which to explore the role of casualty behaviours directly relating to the willingness of

casualties to remain at the scene of a Hazmat/CBRN incident and undergo decontamination.

There is a genuine risk of casualties leaving the scene of a Hazmat/CBRN incident before undergoing decontamination. This concern, combined with the current absence of research on how long casualties would be willing to wait for decontamination, highlights a critical omission in planning assumptions.

Consequently, this Thesis will attempt to understand the likelihood that casualties remain at the scene of a Hazmat/CBRN incident and undergo decontamination and how emergency response efforts can influence them based upon the earlier findings of the Thesis. The research conducted up to this point will have examined the impact of behaviour in Hazmat/CBRN incidents requiring mass decontamination, especially the willingness of casualties to wait and cooperate.

Therefore, this Thesis will look to determine the duration casualties are willing to wait and the factors that influence this decision, with a particular focus on both the emergency service response times and communications.

Current planning assumes that casualties will remain at the scene, enforced by cordons organised by the police. Such planning is seriously flawed, failing to consider the limited availability of equipped police officers and the potential negative impact on cooperation, such as hostile behaviours towards officers and refusal to follow instructions which such enforcement tactics would have.

It is imperative to understand how casualties can be convinced to remain and undergo decontamination willingly. Establishing valid assumptions about waiting times and

leaver rates which are currently missing from any planning assumptions, but which are essential for effective planning to occur.

Hence, the research presented in this Thesis will underscore the importance of both understanding the factors influencing casualties to stay at the scene of a Hazmat/CBRN incident requiring mass decontamination and of determining how long they are willing to wait. This information will be pivotal in shaping future planning for such incidents.

The implications of these findings will be invaluable for informing future planning regarding mass decontamination strategies and capabilities in the UK. Currently, these strategies and resource allocations rely heavily on technical judgments with limited consideration of the role of human behaviour in influencing desired outcomes. This is a major weakness in the UK's preparation for such an incident and this Thesis will attempt to rectify this by providing crucial insights into how human behaviour will impact the ability of the UK emergency services to effectively deliver mass decontamination should it be required.

1.3 Aims and Objectives

The aim of this PhD research is to understand how casualties are likely to behave during a Hazmat/CBRN incident requiring mass decontamination.

By understanding what such behaviours are likely to be, recommendations can be made to inform planning for such incidents including the strategies chosen to provide capabilities for mass decontamination, resourcing levels, responder training and public awareness and information campaigns.

Chapter 1 –

This Chapter looks to provide an introduction to the PhD, elucidating the rationale behind the Thesis's development and outlining the intended aims and objectives it seeks to achieve.

Chapter 2 – This Chapter establishes the context for Mass Decontamination operations in the UK, detailing their governance, the legal framework, planning, and operational aspects.

Chapter 3 – The aim of Chapter 3 is to analyse existing literature on casualty behaviours in Hazmat/CBRN and mass decontamination incidents, with the goal of identifying knowledge gaps and establishing a foundational understanding to address the PhD's research objectives.

Chapter 4 – This Chapter will provide a methodological overview of the Thesis.

Chapter 5 – The aim of Chapter 5 is to engage with emergency responders experienced and trained in mass decontamination response in order to:

- Catalogue responder perceptions of casualty's behaviours during mass decontamination incidents.
- Catalogue how responders believe they would impact these behaviours.
- Catalogue how prepared responders feel about dealing with these behaviours.

All of these aims are with a view to informing future modelling, resourcing and planning for mass decontamination incidents.

Chapter 6 – The aim of Chapter 6 is to utilise transcripts of those involved in the Grenfell Tower fire to:

- Catalogue and describe factors that affected the way in which those involved in the Grenfell Tower Fire behaved.

The aim of this Chapter will then help to inform further understanding of casualty behaviours during a mass decontamination incidents.

Chapter 7 – This Chapter aims to utilise the real-life experiences of those involved in a major evacuation to understand how trust and anxiety interact with risk perceptions and co-operation and how these factors are influenced by the rational and irrational decision-making pathways.

- Develop a psychological model of what influences casualty behaviours.
- Validate this model in a real-world incident involving hazardous materials.

Chapter 8 – This Chapter looks to engage with Hazmat/CBRN and mass decontamination experts, aiming to:

- Create a list of variables which will influence casualty willingness to stay at the scene of a CRBN incident and undergo decontamination.

- Develop a range of scenarios which can subsequently be used to investigate the amount of time that casualties will be willing to remain at the scene and their willingness to undergo decontamination.

Chapter 9 – This Chapter uses the previously developed scenarios to engage respondents in a visualisation experiment in order to:

- Determine how long casualties will be willing to wait at the scene of a Hazmat/CBRN incident and how willing they would be to undergo decontamination.
- Determine how the roll of communications by emergency responders influences casualties' willingness to wait at the scene of a Hazmat/CBRN incident and undergo decontamination.

Chapter 10 – This Chapter will reflect on the use of the mixed methods approach for understanding human behaviour during mass decontamination incidents and will set out implications for future research in this field.

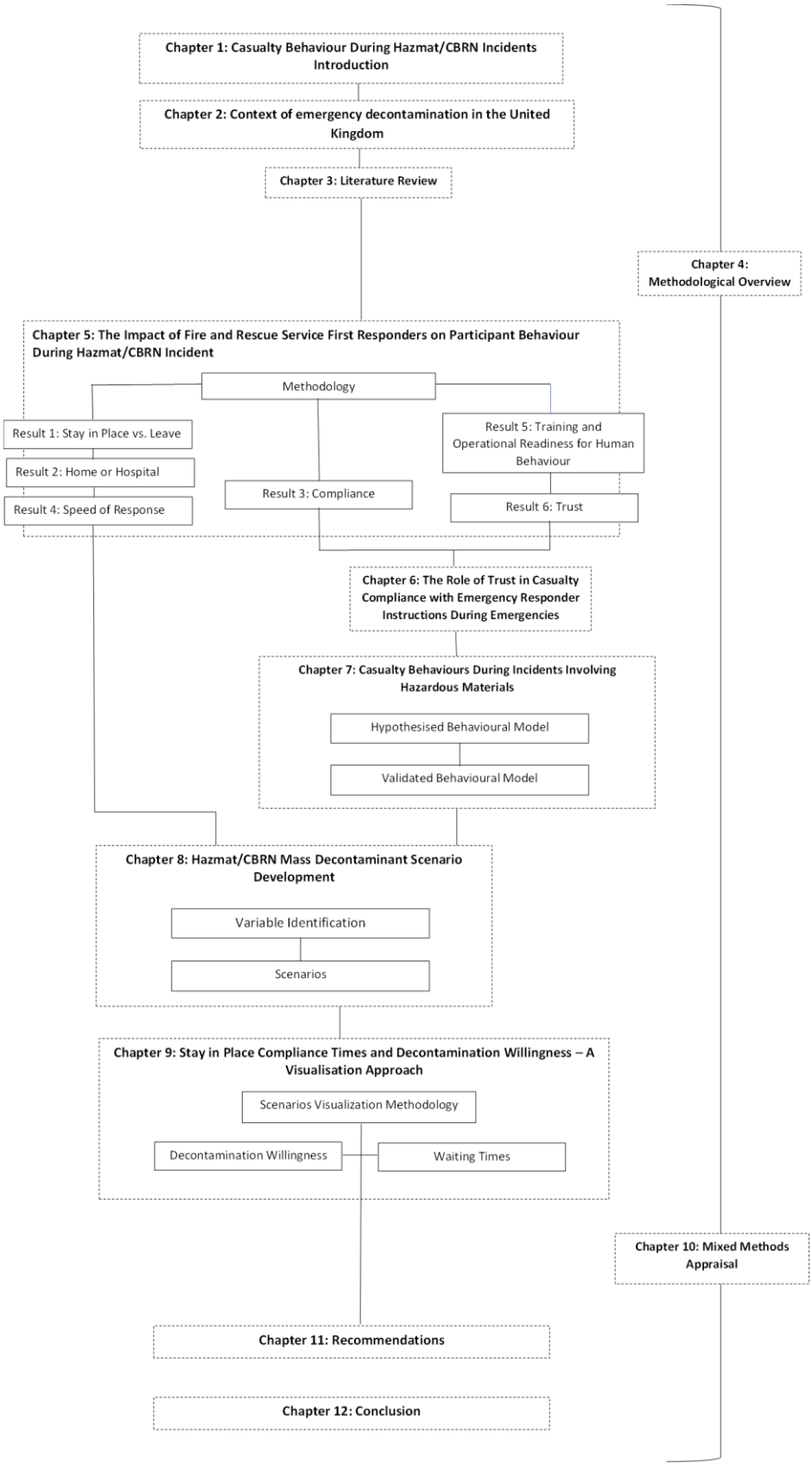
Chapter 11 – This Chapter will present a set of recommendations to guide future planning, resource allocation, and training strategies for Mass Decontamination response and validate these findings with experts in the UK CBRN/Mass Decontamination field.

The end user of these recommendations is to be emergency planners for mass decontamination response across the Home Officer and National Resilience in order to

inform mass decontamination strategies, resourcing and training requirements for responders.

Chapter 12 – This Chapter provides the conclusion of the Thesis providing a concise summary of the key points and findings presented within. It looks to restate and reinforce the main argument of the Thesis highlighting the most important findings and results and how this will contribute to the field of study.

Figure 2 Thesis Overview



Chapter 2 – Context of Emergency Decontamination in the United Kingdom

This Chapter outlines the context in which decontamination occurs in the United Kingdom. In particular, this Chapter begins with a descript of decontamination. This is followed by a section outlining how a mass decontamination operation at a Hazmat/CBRN event is conducted, including the main actors and their roles.

- Explain the Legal Framework for a mass decontamination response and the New Dimensions programme.
- Explain how modelling of Mass Decontamination Operations has been used to shape responses.
- Explain the significance of casualty behaviour at a Mass Decontamination Operation.

2.1 What is Decontamination?

Decontamination refers to any process by which something is made clean of any unwanted material that is attached to it which may be either harmful to health or to the environment (National Operational Guidance, 2022a) and is of critical importance to a Hazmat/CBRN emergency. As such, decontamination may occur in order to remove hazardous materials from equipment (e.g., from Personal Protective Equipment of FRS personnel who have operated in a contaminated environment), or it may refer to the removal of contaminants from a member of the public who has been exposed to a hazardous material (National Operational Guidance, 2022a).

During an incident requiring decontamination, it is crucial that all hazardous materials are removed from individuals and equipment in order to mitigate any potentially harmful effects they may have on a person's health (National Operational Guidance, 2022a).

In the UK, the overall, responsibility for decontaminating members of the public lies with the Department of Health with FRS' tasked with carrying out decontamination on its behalf (National Operational Guidance, 2022b). This arrangement is primarily due to the levels of Personal Protective equipment available to all front-line FRS responders, namely fire kit and gloves and most importantly self-contained breathing apparatus.

Decontamination is a structured operation delivered in the UK by the FRS who are the primary responding agency when dealing with decontamination (The Fire and Rescue Services (Emergencies) (England) Order, 2007).

Further to this, the ability of the FRS to utilise and deliver large supplies of water is also a crucial factor in determining their lead in decontamination. A decision on the need to perform decontamination operations will be taken by the Ambulance Service, in consultation with the FRS and the Police (National Operational Guidance, 2022c; Joint Emergency Services Interoperability Principles, 2016a; Joint Emergency Services Interoperability Principles, 2016b).

The arrangements in place within the UK would see the FRS undertaking the decontamination of ambulant casualties (i.e., those casualties able to walk) on behalf of the Ambulance Service, an arrangement which came into place as part of the New

Dimension programme (Joint Emergency Services Interoperability Principles, 2016b) in the early 2000s.

2.2 Construction of a Mass Decontamination Operation at a Hazmat/CBRN Incident

Should a Hazmat or CBRN event that requires mass decontamination occur, then the responsible FRS would first seek to establish a series of cordons at such an event. These cordons are areas designated to all personnel and denote the level of risk of exposure of the contaminant to anyone within that area. In effect, the cordons set the basis for all other actions of the emergency services and set up of facilities at the incident scene by denoting where different personnel and operations can happen based upon the levels of personal protective equipment (PPE) and decontamination arrangements which are required (Joint Emergency Services Interoperability Principles, 2016b; National Operational Guidance, 2022d).

The cordons establish three categories of zones at a Hazmat/CBRN incident based on the level of risk present in each area: hot, warm and cold zones (Joint Emergency Services Interoperability Principles, 2016b). Each zone will be designated by the FRS Incident Commander based upon an assessment of risk and are therefore scaled according to each individual operation.

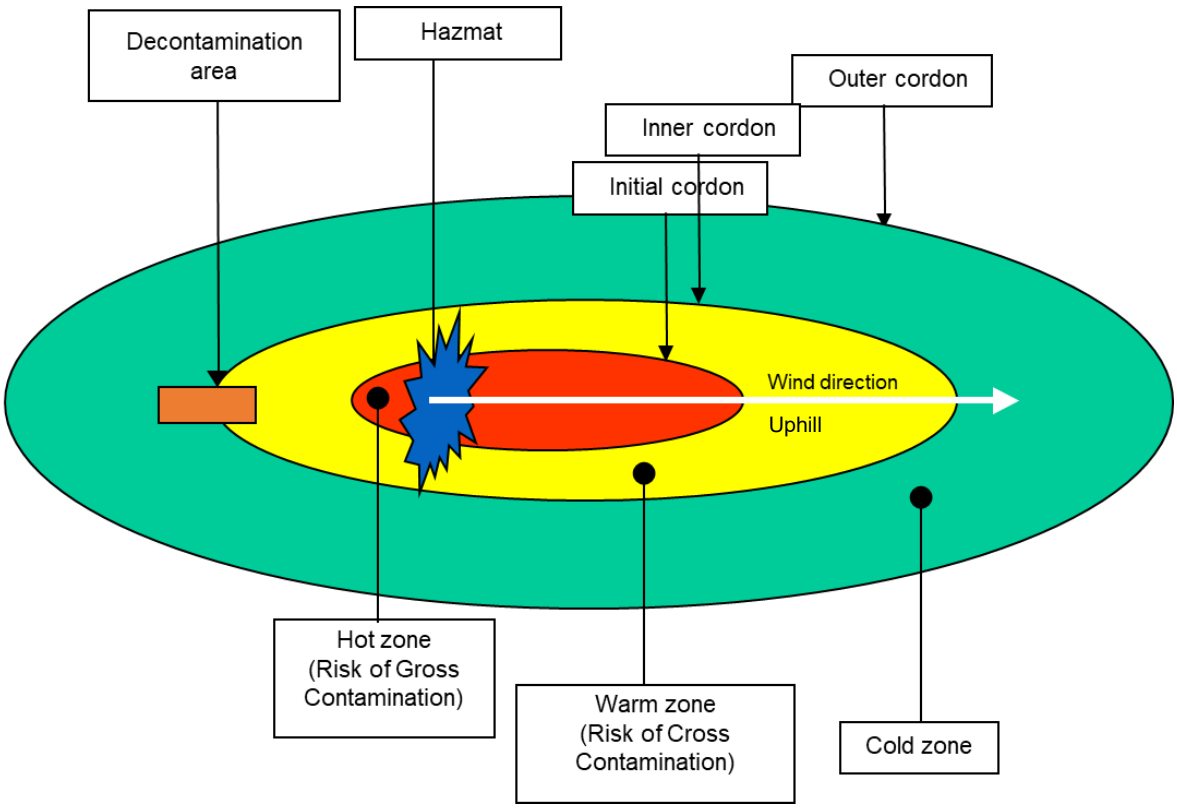
The three categories are detailed below with Figure 3 showing how these three zones would be used at a Hazmat/CBRN incident where decontamination was required.

The hot zone refers to the area in which the hazardous material is located and the area around this, which is considered likely to cause any individual in it, who does not have appropriate PPE (e.g., structural fire kit, self-contained breathing apparatus), to become contaminated or exposed to the material[1]. The warm zone is subsequently formed around the hot zone and creates a buffer between the risk area and the cold zone. Finally, the cold zone surrounds the warm zone and is considered a 'clean' area, i.e. no hazardous material should be in the cold zone, and thus responders will be able to operate safely in this area.

All decontamination activity takes place within the warm zone. This allows for casualties to be removed from the immediate risk area within the hot zone without contaminating the clean cold zone (Joint Emergency Services Interoperability Principles, 2016b). FRS' would look to move ambulant casualties away from the hot zone as soon as possible and conduct rescues of any non-ambulant casualties moving both into the warm zone in order to carry out decontamination. If practical, decontamination should occur in a direction which is located both up-hill and up-wind of the incident, as this reduces the risk of the contaminant spreading to these areas (National Operational Guidance, 2022e).

[1] Exposure refers to when a harmful substance enters the body through a route, for example, inhalation, ingestion, absorption, or injection or when the body is irradiated. Contamination occurs when a substance adheres to or is deposited on people, equipment, or the environment, thereby creating a risk of exposure and possible injury or harm. Note contamination does not automatically lead to exposure but may do.

Figure 3 Hazard Zones at a Hazmat/CBRN Incident



Several decontamination methods may be employed by the FRS that can be classified into 'Firefighter' and 'Public' Decontamination categories (National Operational Guidance, 2022f; National Operational Guidance, 2022g). Within the context of this Thesis, only Public Decontamination operations will be considered since in contrast, fire crews are trained, prepared for and highly familiar with all aspects of Firefighter Decontamination. Furthermore, the vast majority of Firefighter Decontamination will be the decontamination of Personal Protective Equipment (PPE) rather than any exposure of the Firefighter. As such, their behaviour within Firefighter Decontamination routines should be very predictable and standard. Public Decontamination, however, can be achieved through several different approaches and will be highly dependent upon the behaviours of those being decontaminated.

Ambulant casualties may be decontaminated through one of three stages: Initial Operational Response (IOR), Interim Decontamination and Mass Decontamination as part of Specialist Operational Response (SOR).

Non-ambulant casualties, be that as a result of a hazardous material, injury from any explosion or accident that has occurred, or due to a pre-existing condition, would be triaged by the Ambulance Services Hazardous Area Response Team (HART) to determine who could pass through mass decontamination, who would require clinical decontamination by the Ambulance service and who requires immediate medical intervention prior to decontamination occurring (Joint Emergency Services Interoperability Principles, 2016b).

These non-ambulant casualties would be removed from the hot zone by the FRS and decontaminated in the Warm Zone by the Ambulance Service Specialist Operational Response Team (SORT) (Joint Emergency Services Interoperability Principles, 2016b).

Upon arrival at the scene and as an immediate action, responders can begin implementing an Initial Operational Response (IOR) for ambulant casualties which has been recently introduced into the UK FRS through the 'Joint Emergency Services Interoperability Programme' (JESIP) (Joint Emergency Services Interoperability Principles, 2016a). The IOR was introduced to acknowledge the need for first responder crews to be able to recognise and take action in the event of casualties requiring decontamination, prior to the later arrival of specialist assets to undertake mass decontamination activities. Prior to the instigation of the IOR, the operating policy and training for the first arriving response to a Hazmat or CBRN incident requiring decontamination was to stand-off and 'wait for the specialists' (Home Office, 2015).

However, recent scientific insight into the potential impacts of hazardous materials to health (Chilcott, 2013), alongside lessons learned from exercises and the few real incidents which have occurred (Carter *et al.,* 2012; Carter *et al.,* 2013c), have highlighted the need for first responding crews to be able to actively help casualties in the very earliest stages of an incident. It was therefore acknowledged that a more operationally directed flexible approach would be required, particularly with the aforementioned scientific evidence (Chilcott, 2013) now pointing to how removal of casualties from a highly contaminated area and removing their outer layer of clothing within the first 15 minutes can significantly contribute to the saving of lives (Chilcott, 2013). IOR has therefore been developed around this time frame and in a manner which allows these goals to be achieved without putting first responders at undue risk of exposure.

IOR can be performed as either dry or wet decontamination based on the contaminant. Dry decontamination is the preferred method for all non-caustic agents and involves using a dry absorbent material to either soak up or brush off any contaminants. Wet decontamination utilises any source of available clean water, including fire service hoses and water supplies, or buckets of water from a nearby water source and is the preferred method for all caustic agents (Home Office, 2015).

Whilst technically a simple process, IOR is useful in quickly removing contaminants from a casualty (Chilcott *et al.,* 2019). The process of IOR includes first responders positioning themselves in a place of relative safety, which has not been contaminated and is unlikely to become contaminated. It is from here that responders will look to instruct casualties to move to a safer area, which is also free from contamination.

Depending on the contaminant, casualties will then be provided some form of towel or tissue to wipe and dust down their bodies to remove any contaminants (dry) or they will be provided with water to wash any contaminants away (wet). Casualties will then be instructed to remove or cut their outer clothing, taking care to not remove any items over their face. For modesty purposes casualties will be provided with an orange poncho to wear before they begin the next stage of decontamination. Next, because this location will be contaminated by their clothing, they will then be instructed to move away from this location. This signals the end of the IOR process and from here more comprehensive decontamination procedures will be instigated as required and this will be discussed in more detail below. (Home Office, 2015).

Although a simple process it can be a huge benefit before the arrival of specialist units. However, even more so than mass decontamination operations with all other resources that are available for the management of crowds, effective IOR will be highly dependent upon the behaviours of those whom first responders engage with (Long *et al.,* 2020).

The second stage of decontamination is interim decontamination. Once sufficient resources are available, Interim Decontamination may be set up by crews and involves a more structured and thorough process of delivering wet decontamination to ambulant casualties. Interim decontamination utilises general fire service equipment carried on all frontline fire appliances, such as hoses and ladders with methods varying depending on different FRS' equipment and procedures (Home Office, 2015). Some examples are shown below in Figure 4.

Figure 4 Interim Decontamination Methods







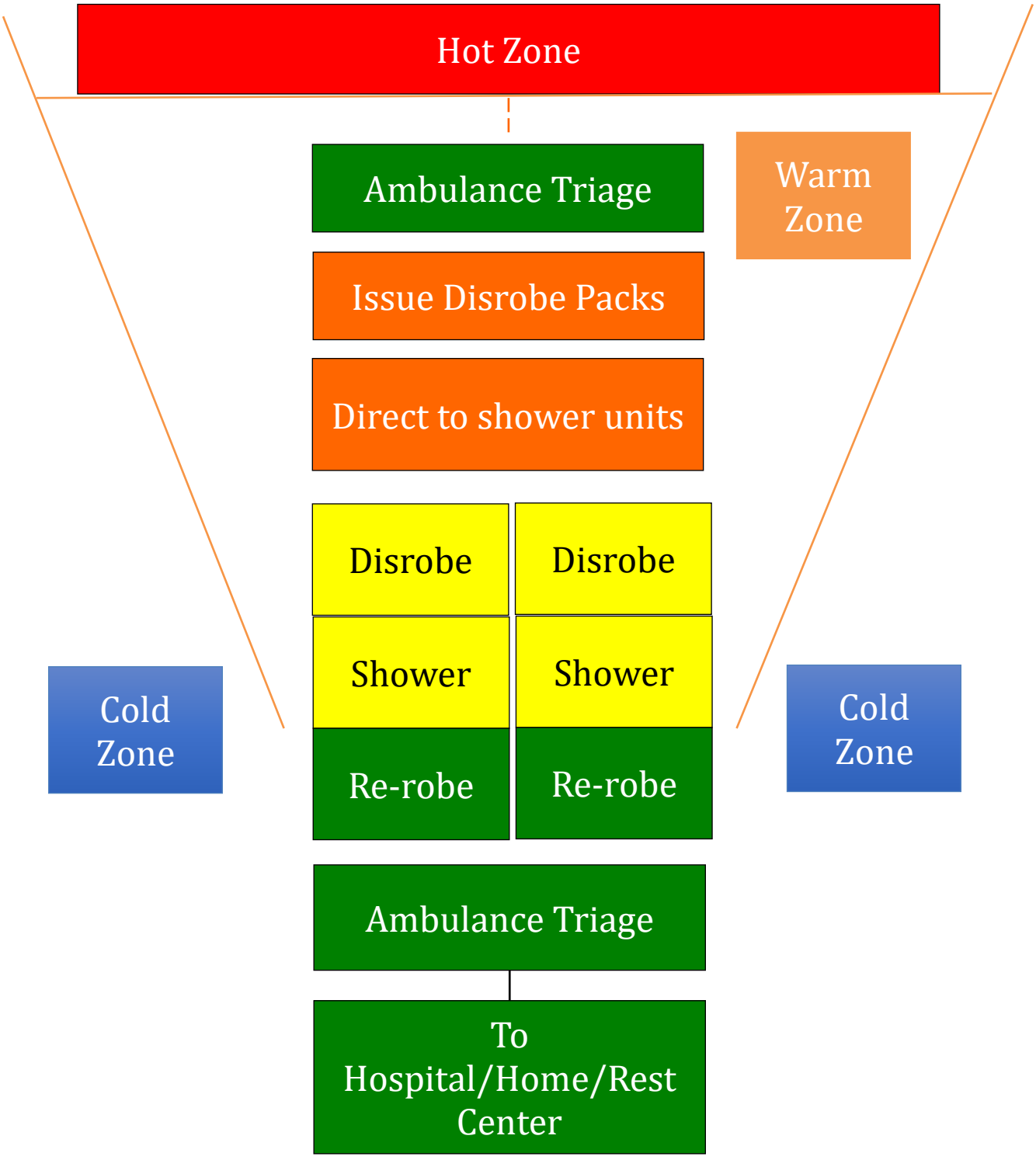
Both IOR and Interim decontamination are currently seen as providing a stopgap measure to reduce the exposure risk to casualties whilst allowing sufficient time to enable the arrival and construction of mass decontamination facilities (Home Office, 2015; Chilcott *et al.,* 2019). Based on both the situation and a risk assessment carried out between the emergency services on scene, it will be decided whether IOR or interim decontamination may be considered sufficient or whether a full mass decontamination setup is required (Home Office, 2015; National Operational Guidance, 2022c).

It is also worth noting that should an incident be considered by the Police as deliberate then the Police would hold overall authority of the scene (Joint Emergency Services Interoperability Principles, 2016b). They may look to implement (if they were not already doing so) and maintain an inner cordon around the hot and warm zones, with a view of maintaining evidence and potentially apprehending any perpetuators (Joint Emergency Services Interoperability Principles, 2016b). It is also likely that the Police would wish to perform information gathering tasks with victims post decontamination (Joint Emergency Services Interoperability Principles, 2016b), which again raises the

importance of considering behaviours in regard to compliance with emergency services but the specifics of which in this instance fall outside the purview of this Thesis.

The final stage of decontamination is Mass Decontamination. Mass decontamination refers to an organised process of utilising specialist assets known as 'Mass Decontamination Units' (MDU). Although the word 'mass' conjures ideas of large numbers of casualties, it actually refers to the resources used, and the setup performed rather than a particular number of casualties. In fact, mass decontamination may be used for just a few people, but it has the ability to cope with much larger crowds, if necessary (Joint Emergency Services Interoperability Principles, 2016b). The Mass Decontamination setup from the MDU's involves the construction of a number of self-contained units, which function as part of a formally set process in order to systematically decontaminate members of the public. The structure of this can be viewed in Figure 5.

Figure 5 Mass Decontamination Process Layout



Ambulant casualties will be asked by emergency responders to move out of the hot zone at the earliest possible time and will ideally already be in the warm zone as the Mass Decontamination structure is constructed ready to begin decontamination (National Operational Guidance, 2022h). Within the warm zone casualties will firstly be triaged by the Ambulance Service and ambulant casualties will be required to remove their clothes and don disrobe packs (if not already undertaken during IOR or Interim Decontamination). Disrobe packs[2] are provided to casualties in order to provide them with warmth and preserve their dignity whilst construction of the mass decontamination showering units is being undertaken.

Once the units are ready, casualties will be directed to the first of three units (Joint Emergency Services Interoperability Principles, 2016b). The first of these units is the disrobe section where casualties will remove the clothing donned from the disrobe pack before proceeding into the second section - the showering unit. Once completed in the shower, casualties will enter the final section of the unit which is the re-robe section. Here, they will be provided with a re-robe pack of green clothing to identify their status as being decontaminated (Joint Emergency Services Interoperability Principles, 2016b). Upon exiting the mass decontamination structure, they will be in the cold zone and considered 'free from any contaminant (Joint Emergency Services Interoperability Principles, 2016b). Finally, casualties will again be triaged by the Ambulance Service and either sent to hospital, sent home or onto a rest centre depending on the wider situation (Joint Emergency Services Interoperability Principles, 2016b). It is worth noting that, should it be required, the middle lane of the mass decontamination unit can

[2] Disrobe packs consist of nitril gloves, face wipe, large plastic bag, dust mask, seat belt cutter for cutting away clothing, small plastic bag for valuable items, orange thermal poncho, identity wrist band to correspond with valuable bag, shoes and socks, cable ties to secure plastic bags.

be configured to allow clinical decontamination of non-ambulant casualties to occur. However, this will be instead of any ambulant casualty decontamination and therefore will impact the speed at which casualties can be decontaminated due to needing to await the arrival of another mass decontamination unit to deliver decontamination for ambulant casualties.

Whilst responders are present to guide casualties through the process, the process is controlled by an automated flow control system utilising green and red lights to indicate to casualties when they are to enter, move on or exit the various sections of the unit and are intended to ensure an efficient rate of decontamination occurs.

2.3 New Dimensions

At the turn of the millennium there was an increased focus on emergency planning (Kapucu, 2009) as governments across the world including the UK, recognised limitations in their preparedness, highlighted by the terrorist attacks in New York on September 11th 2001. This recognised the need that in order to meet the challenges presented by many of the disaster hazards facing them in the 21st century, it was imperative that the right resources (e.g., equipment, trained personnel or other resources) be mobilised to an affected area in a timely and effective manner (Dillon, 2014). The planning of such an undertaking is a complex task given the uncertainty surrounding disasters which can occur in any number of incident combinations potentially occurring simultaneously at several disparate locations (Bergström and Frykmer, 2016).

To meet this challenge of disaster planning, the UK undertook a programme of resilience building across the nation, through the introduction of the New Dimensions Capabilities Programme. This particular Programme was introduced in 2004 to construct "a robust infrastructure' capable of 'rapidly, effectively and flexibly' dealing with the 'consequences of civil devastation and widespread disaster" (UK Government, 2018).

Originally, co-ordinated by the Civil Contingencies Secretariat in the Cabinet Office, the Capabilities Programme consisted of 17 capability work streams, one of which, New Dimensions, focussed on the role of the FRS (Cabinet Office, 2018). In the UK, the FRS has always occupied a crucial role in providing a response to large-scale disasters (Civil Contingencies Act, 2004; Fire and Rescue Service Act, 2004) largely due to its structure that allows for the rapid mobilization of large numbers of trained responders who are equipped materially and skills-wise to intervene in a wide array of operations. Such operations range from firefighting through to Search and Rescue, pumping of large volumes of water, and, in a rapidly developing role, becoming ever more skilled in the delivery of medical services. The personal protective equipment (PPE) available to the FRS has also seen it take the role as a lead agency in any incident involving Hazardous Materials and when initial or large-scale decontamination is required (Joint Emergency Services Interoperability Principles, 2016b).

The New Dimensions programme aims to supply regional assets and additional equipment and training across three incident types:

I) Mass Decontamination of a population and Detection Identification and Monitoring (DIM) following, for example, the release of a hazardous material;

II) Urban Search and Rescue (USAR), for response to technical rescue operations such as rescues from a collapsed building; and finally

III) flooding response, moving masses of water as well as performing rescues and evacuations within this environment.

New Dimensions has sought to place assets for these eventualities around the UK in strategic locations to support local FRS response to a major emergency (Communities and Local Government, 2008).

2.4 Legal Framework

Alongside the need for the additional capabilities provided by New Dimensions to meet the gaps in the preparedness of the UK Emergency Services for new and emerging hazards, the lack of a legal framework in place requiring the UK FRS to provide response to such hazards including the decontamination of members of the public was identified.

The Fire and Rescue Services Act (2004), which is the foundation of the UK Fire and Rescue Service Powers, makes no explicit reference to this area of operations. Part 2 Section 11 gives Fire and Rescue Services the Powers to act in situations where *"(a) one or more individuals to die, be injured or become ill; (b) harm to the environment (including the life and health of plants and animals)",* however, as this is a Power and not a Duty, Fire and Rescue Authorities (either as Metropolitan Bridges, Combined Fire Authorities or as a department of a County Council) could choose not to respond to Hazmat/CBRN Incidents.

In order to address this issue, The Fire and Rescue Services (Emergencies) (England) Order (2007) was introduced which made decontamination of members of the public a duty of the FRS', ensuring that they must be prepared to deal with the consequences of Hazmat/CBRN incidents.

It is also worth noting that The Civil Contingencies Act (2004), along with The Fire and Rescue Service Act (2004) and the Fire and Rescue Services (Emergencies) (England) Order (2007), is a key piece of legislation for the UK Fire and Rescue Services. The Civil Contingencies Act replaced the Civil Defence Act (1948) and seeks to establish a definition for the term "emergency", so as to include war or attack by a foreign power, alongside acts of terrorism and also any other events which threaten serious damage to the people or the environment within the UK.

Prior to this, civil protection was defined only in relation to civil defence for defence against a hostile foreign power during war (Cabinet Office, 2004). However, in light of events, such as the fuel protests of 2000, or natural crises, like the mass flooding in 2000 and the outbreak of Foot and Mouth Disease in 2001 (Taylor and Tricker, 2006), such a limited provision for civil protection was deemed insufficient and consequently the Civil Contingencies Act was introduced. This Act drives a principle that organisations and, in particular, Category 1 responders adhere to a standard of being well prepared to manage crises and disasters (Dillon 2014).

As such, these various pieces of legislation make it a fundamental duty of the UK FRS' to have well established plans in place for decontaminating large numbers of the public in the event of a Hazmat/CBRN incident. Plans which are well thought through and tested, so as to be fit for purpose, are necessitated not simply to ensure operational effectiveness but also to meet their legal obligations.

If such scenarios occur within the UK, it is the role of the FRS to undertake the decontamination component of any emergency response (Fire and Rescue Emergencies (2007) Order). In preparation for this role, there are numerous questions that need to be considered by disaster planners and the emergency services, some of which are currently being missed.

Human factors in particular, currently lack sufficient consideration in relation to planning and training for such incidents, even though such factors may result in reduced effectiveness, should a mass decontamination operation be required (Long *et al.,* 2020).

2.5 Modelling of Mass Decontamination Operations

In conjunction with the training and competencies of first responding FRS crews, it is essential to consider their preparedness in order to deal with incidents requiring them to decontaminate the public in large numbers. This is the level and distribution of resources required for this type of operation. Large scale decontamination operations, referred to as Mass Decontamination Incidents, are covered by the New Dimensions Programme, which has provided nationwide coverage of Mass Decontamination capabilities through the deployment of MDUs at strategic locations.

However, it worth considering the following:

I) how has the siting and subsequent coverage of these resources has been determined? and

II) how can emergency planners, given the uncertainty and complexity of the risks being faced, determine the adequacy of such arrangements?

In order to answer these questions, mathematical modelling has intervened as an effective tool in the armoury of planners, assisting in determining the systemic effects of incidents. Godschalk (1991) identifies the importance of "actions taken in advance of an emergency to develop operational capabilities and to facilitate response in the event that an emergency occurs" (p.136), asserting how essential this is, as "effective preparedness and response activities help save lives, reduce injuries, limit property damage, and minimize all sorts of disruptions that disasters cause" (p.136).

Computer simulation models are widely used in the research and preparation for a vast array of emergencies, complemented by live exercises (Johnson and Matthews*, 1997*; Kyle *et al.,* 2004; Office of the Deputy Prime Minister, 2007; Mishra *et al.,* 2019).

Such modelling is utilised widely by FRS across the country and was used in the planning of the New Dimensions Programme. The planning and positioning of resources are often based upon modelling focusing on the criteria of first response times and the 'weight of attack', usually referring to the completion of a predetermined allocation (PDA) of resources by incident type, based upon what is usually required to bring such an incident under control. Likewise, the MDU assets responsible for mass decontamination capabilities are also strategically based upon their response times and the assumptions made as to the: i) risk regarding likely numbers of casualties and ii) the speed of the decontamination process required.

However, there appears to be a gap in this modelling capability, with an absence of literature available exploring how to model numerous aspects of the work undertaken by first responders and their influence at an incident.

Disaster modelling appears to be fragmented or conducted in disparate, unconnected spheres. Models are built for to predict people movement or traffic flows and remain isolated from other areas of modelling (Moussaïd *et al.,* 2011; Pel, 2012). FRS' also seem to undertake their modelling in isolation, considering response times for incidents based upon past experience and data without any consideration of how this will alter in exceptional or unique circumstances (Hampshire Fire and Rescue Service, 2014).

There appears to be a need for a more holistic approach to how emergency first responders and their operations are included within wider disaster modelling (Cheng *et al.,* 2018; Mishra *et al.,* 2019). Examples of this include the following:

i) how people and traffic flows may be expected to operate following certain circumstances which may impact first responder's ability to reach the scene of an incident, or

ii) how the arrival or responders will then impact flow rates and people movements.

iii) the type of incident which has occurred along with how this may impact upon emergency services response, e.g., should a CBRN attack occur close to the location of a MDU, this may remove this asset from use and thereby significantly alter expected response times. Likewise, in the instance of a CRBN attack, a cloud plume from such an incident may well render any access routes impassable causing delay for oncoming responders.

Modelling was used in planning for a mass decontamination response by Albores and Shaw (2008), who utilised a Discrete Event Simulation (DES) in order to support the New Dimension Programme around mass decontamination. They designed their modelling system to be used prior to major incidents, including terrorist attacks or industrial accidents, in order to support the decision making of senior officers and managers in their planning around the geographic distribution of resources and training requirements of first responders. Their aim was to assist in providing the most effective response possible to any incident should it occur.

Albores and Shaw (2008) identify the focus of their paper as being to develop government 'preparedness' which they argue is vital in allowing decision makers to

fully comprehend the wide-ranging variables occurring during a single incident, for example the number of people who can be decontaminated within a set time frame depending on the speed of arrival of first responders.

Albores and Shaw (2008) seem to identify the complexity of such incidents and the potential wider context in which they are set and utilise Discreet Event Simulation to assist planners in dealing with the complexities and interdependencies which can occur. However, whilst technical considerations in relation to speed of response and number of casualties per hour this will allow to be decontaminated seems of paramount focus in the model, what is apparent is the complete absence of any reference to the impact which human behaviour will have.

2.6 The Significance of Casualty Behaviour: Compliance

Mass Decontamination incidents are a unique type of incident given the need for casualties to undertake several activities detailed by emergency responders for themselves, all of which require a high level of engagement and compliance by the casualties involved (Long *et al.,* 2020).

FRS decontamination responses rely heavily upon the actions of those being decontaminated (Long *et al.,* 2020). Responders will be competent in setting up and delivering the required materials to perform decontamination operations (National Operational Guidance, 2022a). However, these operations depend heavily upon casualties undertaking calmly, compliantly, and quickly the instructions given to them. Without this, decontamination operations cannot be achieved without forcible intervention, which understandably is, problematic both from ethical and operational perspectives.

As such, the importance of understanding, preparing for and being ready to influence the behaviour of the public during a Hazmat/CBRN incident to encourage compliance is a critical component for the success of decontamination procedures (Carter *et al.,* 2012).

Fortunately, very few Hazmat/CBRN incidents requiring decontamination of members of the public have occurred, especially on a large scale. However, smaller scale events have occurred and have been studied to try and understand the likely human behaviours, which may occur (Carter *et al.,* 2012). A review of the literature identifies

several studies that clearly recognise the important role which human behaviour will play in an efficient decontamination process.

Compliance is a particularly crucial concept and in emergency situations refers to the actions of the public in taking recommended measures provided by emergency responders so as to successfully achieve the tactical operations being instigated to resolve a situation (Long *et al.,* 2022). These actions could involve any range of instructions: from staying put in a certain area, through to disrobing and partaking in decontamination following a chemical or radiological exposure. A mass decontamination incident will be an unfamiliar situation where emergency service instructions may seem confusing or stressful, such as the potentially embarrassing interventions of disrobing in public for decontamination. Given the unfamiliarity and stressful nature of a mass decontamination incident, coupled with the potentially unpleasant or unwelcome interventions required by emergency services, members of the public may be reluctant to comply with responder instructions (Long *et al.,* 2022). This, of course, will prove to be even more likely should the operations being undertaken be executed ineffectively (Holloway *et a*l., 1997). Such occasions where members of the public fail to comply fully with responder instructions, offer the potential for delays in undertaking operations, which may exacerbate a situation (Edwards *et al.,* 2006). This then has the potential to escalate and prolong an incident which risks lives and further disruption (Lillie *et al.,* 2006; Lake and Schulze, 2009). Since the potential for non-compliance or un-cooperative behaviours by members of the public involved in a mass decontamination incident is clearly present, and given the potentially serious consequences of the disruption to operations such behaviour may cause, methods of increasing public compliance and helpful behaviours during major incidents can result in lives being saved (Carter *et al.,* 2013c; Carter *et al.,* 2015a).

The US Fire Administration (Stern, 1997) produced a case study of an incident, which occurred at the headquarters of B'nai B'rith, an international Jewish organisation based in Washington, DC. The incident involved a suspected white powder release requiring the decontamination of those at the headquarters, who were exposed to the white powder, and of emergency service responders. The incident was eventually discovered to be a hoax. However, initially this was not apparent, and the incident was deemed real and saw the Fire Service decontaminate thirty people, including civilians, Fire Service personnel, and Police Officers.

The case revealed several interesting themes. Pertinently, it highlighted the significance of non-compliance, with even Police Officers refusing to undergo decontamination and becoming aggressive towards Fire Personnel performing the decontamination operations. The report identifies such non-compliance as a substantial challenge and one which significantly interfered with an efficient process (Stern, 1997).

Alongside non-compliance the study also highlighted how several casualties presented to first responders with symptoms including headaches, dizziness, and other minor ailments even though the incident was a hoax, albeit unknown at the time. Again, it can be seen how behaviours around perceived symptoms could also significantly hamper decontamination efforts (Stern, 1997).

Other reports have also emphasised the issue of non-compliance during incidents that require decontamination. Hanley (1999) provides a case study of an incident in which 25 people were exposed to a pesticide and required decontamination. Like Stern (1997), Hanley (1999) reports how again non-compliance was experienced and how

emergency responders found themselves requiring the use of force to be able to conduct decontamination. Of course, those being decontaminated, the majority of whom were female, did not respond well to this intervention with many reportedly feeling that their dignity was ignored, and privacy invaded. Consequently, the decontamination operation was highly stressful for victims, thereby increasing non-compliance and again greatly impacting operational effectiveness.

The importance of human behaviour can be seen through these examples of minor incidents, where non-compliant behaviours can have significantly adverse impacts upon the effectiveness of first responders performing decontamination tasks (Stern 1997, Hanley 1999).

Currently, however, there is very little recognition of this vital component by emergency planners in setting resourcing levels and asset distribution and quantity for mass decontamination response (Carter and Amlôt, 2016). FRS' also only offer limited training concerning human behaviour during decontamination operations and, as such, most crew are not fully prepared to deal with the casualty behaviours they are likely to encounter during these operations (Carter *et al.,* 2013b). This has also led to only limited strategies or tactics being developed to assist crews in influencing the public's behaviours in a manner which will aid a compliance and therefore successful operational interventions (Carter *et al.,* 2013b).

FRS Policy for incidents can be locally set. However, recently a programme of work has been undertaken so as to create greater alignment across UK FRS' and begin to create best practice. This programme of work is known as National Operational Guidance and

acts to inform the local operational policies and procedures of UK FRS' (National Operational Guidance, 2022i).

An examination of the National Operational Guidance for Hazardous Materials (National Operational Guidance, 2022i) identified a limited section referencing human behaviour with a focus on the need for good communication by responders and a very limited exploration of what this would involve. However, no reference was made to how responders' engagement with and management of the public would influence their behaviour at such incidents, nor any attempt to explain why good communication would be so vital (National Operational Guidance, 2022d).

A further examination was conducted of the training materials used by Hampshire Fire and Rescue Service, the Isle of Wight Fire and Rescue Service[3] and available on the UK Fire Service Training materials sharing site FRS Learn. None of these had any material dealing with the likely human behaviours to be faced at an incident requiring decontamination, nor how to influence those behaviours, suggesting even the very limited content put forward by National Operational Guidance has not currently made its way to front line training.

As such, it is apparent that given the requirements of decontamination incidents there is a need for crews to be aware of and, if possible, capable of positively influencing behaviours during these operations. However, this necessity does not appear to have received the attention it requires as an element of competence for FRS first responders.

[3] These two Fire and Rescue Services have since combined to form Hampshire and Isle of Wight Fire and Rescue Service

It is therefore a focus of this Thesis, to develop an understanding of the factors involved in how people behave during emergencies. Human behaviour is a crucial element to consider when modelling and subsequently planning for major emergencies (Albores and Shaw, 2008; Hawe *et al.,* 2012; Mustapha *et al.,* 2013; Hawe *et al.,* 2015). There seems a great need to explore areas such as the likely level of crowd compliance that will be experienced by first responders and how this can be influenced (Pan *et al.,* 2007; Chu *et al.,* 2015). Will evacuation orders or stay in place orders be heeded? And in the event of a mass decontamination operation being required, can members of the public be expected to simply queue patiently, strip off in public and then efficiently undergo decontamination?

While most modern research has dismissed the idea of crowds being prone to irrational panic when faced with danger (Drury *et al.,* 2013), with most instead arguing that crowd behaviour in emergencies is socially structured (Gantt and Gantt, 2012; Drury *et al.,* 2013; Carter *et al.,* 2015b), crowd behaviour is none the less not necessarily the most conducive to participants' wellbeing. Cocking *et al* (2009) state that during the evacuation of buildings during fire, people will often evacuate through the route they used to come into a venue even if it is not necessarily the closest exit to their position. Whilst such behaviour may be deemed rational for ensuring a definitive exit route, the additional time delay and ensuing crowd problems render such behaviours counterproductive and will undermine planning assumptions for the number of emergency exits and size of emergency exits etc. which have been modelled for and instigated to ensure safe egress can occur.

Environmental requirements, such as number of decontamination units available for use and flow space within each unit., has been measured with regards to the duration of

decontamination without any thought as to the internal motivation and decision-making stimuli which will influence how the casualties will engage in the process, which will, as has been argued, significantly impact the decontamination time required and as such the number of mass decontamination resources required.

2.7 Conclusions

Table 1 summarises the main findings of this Chapter and sets the research presented in this Thesis in context. Human behaviour and especially compliance is identified as a crucial aspect of emergency situations and the successful execution of planned strategies for dealing with large incidents will require the control and organisation of large bodies of people in unfamiliar and dangerous situations. The success of most plans will, to some extent, rely upon the effectiveness of those responding to influence the public's behaviours to participate in a manner that is planned for and required by set plans. However, it appears that there is limited research into the impact that emergency responders will have during disasters and also a need to fit any modelling of emergency workers' responses into wider modelling assumptions so as to be able to draw realistic and valid conclusions.

In particular, this Thesis seeks to provide greater understanding about human behaviour during mass decontamination. Such an understanding may include improving the ability of responders to ensure both crowd compliance and assistance. There is therefore a need to both:

i) further develop an understanding of potential strategies for reducing non-compliant behaviours and improving responder effectiveness, as well as

ii) providing grounding for the need to build into first responder training awareness of human behaviours and strategies for engaging with the public (Long *et al.,* 2020).

Furthermore, a basis will also be sought through this Thesis to ensure planners understand the need to effectively integrate issues of human behaviour, particularly non-compliant behaviours, and the impact of first responders into their modelling, planning and preparations for major incidents.

Table 1 Contextual Areas Overview

Contextual Areas	Overview of Area	Uncertainties[4]
Construction of a Mass Decontamination Operation at a Hazmat/CBRN Incident	This section of the Chapter set out how mass decontamination operations at a Hazmat or CBRN incidents would be setup. It describes the establishment of the hot, warm, and cold zones and how both ambulatory and non-ambulatory casualties would be assisted setting out the use of Initial Operational Response (IOR) and the move to Specialist Operational Response (SOR) in the form of Mass Decontamination.	• How the Hot, Warm and Cold Zones can be identified will be dependent upon the specialist equipment available. • How the enforcement of cordons around the various zones can be enforced for members of the public leaving the hot/warm zone and entering the cold zone prior to decontamination. • How the enforcement of cordons around the various zones can be enforced to stop members not involved in the incident from entering the warm/hot zone.

[4] Italics in this column indicates where in this Theis these uncertainties have been explored.

	The effectiveness of decontamination operations was highlighted as being dependent upon the behaviours of those involved and highlighted the importance of understanding and managing public responses at Hazmat or CBRN incidents.	• How the behaviours of the public in relation to awaiting and undergoing decontamination in a co-operative manner would impact the effectiveness of mass decontamination operations? *(See: Chapter 5: 5.3.3 and 5.4.3 Compliance; Chapter 9: 9.3.3 Waiting Times; Chapter 9: 9.3.4 Willingness; Chapter 11: Recommendation 4 11.2.4 Public Awareness Campaign; Chapter 11: Recommendation 5 11.2.5 Mass Decontamination casualty behaviour and communications training).* • Where would those leaving the scene of a Hazmat/CRBN go? Would it be to a hospital or home and what impact would this have? *(See: Chapter 5: 5.3.1 and 5.4.1 Stay in Place vs. Leave; Chapter 5: 5.3.2 and 5.4.2 Hospital or Home: Most Likely Destinations for Casualties Who Leave the Scene; Chapter 11: Recommendation 2 11.2.2 Mass Decontamination Units to be deployed directly to Hospitals).*

New Dimensions	The Chapter moves onto explain the New Dimensions program. It highlights how the changing nature and complexity of risks being face in the early part of the 21st century led the UK to undertake the New Dimensions program to construct a robust emergency preparedness infrastructure capable of meeting these new challenges with the introduction of the mass decontamination capability being one resulting element for the FRS. The strategic positioning of these assets in support of local FRS' was also explored.	• The potentially slow responses times of MDUs in responding to emergencies is a major constraint due to the limited number of units and their wide geographical spread across the UK. *(See: Chapter 5: 5.3.4 and 5.4.4 Speed of Decontamination; Chapter 11: Recommendation 1 11.2.1 Utilisation of Interim Decontamination)*

Legal Framework	The next section of this Chapter discussed the legal framework relating to mass decontamination. The Fire and Rescue Services (Emergencies) (England) Order (2007) was discussed and the duty it put onto FRS'. Alongside this duty wider duties under The Fire and Rescue Services Act (2004) and the Civil Contingencies Act (2004) were also explored in relation to mass decontamination.	• Planning for mass decontamination often assumes that the Police may need to enforce cordons in order to keep people at the scene to undergo decontamination. There is, however, significant concern about if there is the legal power to do this as well as whether it would be feasible. As such co-operation is often seen as the only viable and legal approach to ensuring a success decontamination operation.

Modelling of Mass Decontamination Operations	The modelling utilised to plan the mass decontamination process was also discussed. The work of Albores and Shaw (2008) who used Discrete Event Simulation (DES) to help plan the mass decontamination process was explored. However, it was also discussed how most existing modelling primarily focuses on environmental and technical requirements and overlooks the human behavioural areas such as internal motivations and decision-	• The lack of consideration in modelling concerning the behaviour of casualties. • How limited mass decontamination resources and corresponding slow response times would impact casualty behaviours particularly willingness to co-operate and wait at the scene of a Hazmat/CBRN incident to undergo decontamination? *(See: Chapter 5: 5.3.4 and 5.4.4 Speed of Decontamination; Chapter 9: 9.3.3 Waiting Times; Chapter 11: Recommendation 3 11.2.3 Mass Decontamination Model).*

	making stimuli which is crucial for casualty engagement during decontamination. Therefore, the absence of human behavioural factors in the modelling used in mass decontamination planning is identified as a potentially major gap in operational preparedness for a mass decontamination incident.	
The Significance of Casualty Behaviour during Mass Decontamination Operations	The human behavioural aspects of mass decontamination were also discussed in depth with particular focus on the need for compliance amongst those who are required to undergo decontamination.	• How willing will those involved in a Hazmat/CBRN incident be to stay and the scene of an incident and await decontamination? *(See: Chapter 5: 5.3.1 and 5.4.1 Stay in Place vs. Leave; Chapter 9: 9.3.3 Waiting Times).*

	Mass decontamination incidents, present unique challenges where casualties will be required to actively participate in the decontamination process. The success of FRS responses therefore hinges on the compliance and engagement of those undergoing decontamination. Understanding and influencing human behaviour in these situations is crucial for effective decontamination procedures. This section of the Chapter discussed the dismissal of the myth that casualties involved in such incidents will become	• How willing will those involved in a Hazmat/CBRN incident be to undergo decontamination? *(See: Chapter 9: 9.3.4 Willingness).* • How can emergency responders effectively engage with casualties to improve co-operation at the scene of a Hazmat/CBRN incident requiring decontamination? • How prepared are the emergency services to effectively engage with casualties to encourage co-operation during a mass decontamination incident? *(See: Chapter 5: 5.3.5 and 5.4.5 Training and Operational Readiness for Human Behaviour; Chapter 11: Recommendation 5 11.2.5 Mass Decontamination casualty behaviour and communications training)*.

	irrational and panicked, and pointed instead to current research which recognizes how those involved in emergencies have the ability to remain rationale and how emergency responders will have the ability to effectively engage with the public.	

Chapter 3 – Casualty Behaviour and Mass Decontamination: A Literature Review

3.1 Introduction

The aim of this Chapter is to examine the literature relating to factors affecting casualty behaviours during disasters and emergencies, specifically those involving Hazmat/CBRN materials and mass decontamination, and how emergency responders can influence these behaviours to improve co-operation.

The literature review will aim to identify previous scholarship in the area of human factors during disasters and emergencies specifically emergencies relating to mass decontamination. This will be done to prevent duplication, as well as to support the identification of gaps in the research or areas of discrepancy or conflict which require resolution and further research. Finally, the literature review will look to provide a context to the work of this PhD.

There is limited literature on human behaviour in decontamination incidents, but a lot can be learned from other disaster events which have been more extensively studied. The literature was examined in relation to factors that affect public behaviour including risk perception, fear and anxiety, communication from responders and trust in responders.

The majority of the available literature in this area has looked at the role of crowds in influencing these relationships (Carter *et al.,* 2013a; Carter *et al.,* 2015a; Carter *et al.,* 2015b) and this literature review was able to add to this by seeking to understand what

literature there is relating to factors that affect human behaviour on an individual level during disasters and emergencies broadly, and decontamination specifically.

Increasingly there is recognition that the psychological effects which a Hazmat/CBRN incident will have on the public will affect their behaviours and consequently how they engage with emergency responders, influencing the efficacy of any emergency operations (Krieger and Rogers, 2013; Lemyre *et al.,* 2010; Wessely, 2005), with Rogers and Pearce (2013) stating that *"the success of government interventions before, during and after a crisis…"* relies *"on the cooperation of the public"* (p. 66).

There is some suggestion in the literature that incidents involving the need for decontamination, likely to be as a result of a Hazmat or CBRN event, have the potential for disorderly (Bhardwaj, 2010; Clarke *et al.,* 2008), or aggressive behaviours (Koenig *et al.,* 2008); and that these types of non-co-operative behaviour would present a significant challenge for responding emergency services when trying to undertake decontamination operations.

Whilst Hyams *et al* (2002) identified that fear, anxiety and confusion would be likely responses of the public to a Hazmat/CBRN release; Carter *et al* (2013b) identified how such fear and anxiety during such incidents is likely to be increased if operations are not effectively managed by emergency services. However, planning and preparations for mass decontamination incidents has primarily revolved around technical elements of operations and although this failing has begun to be rectified with the introduction of behavioural science input into guidance and mass decontamination instructor training there still remains only limited focus on human behavioural aspects (Carter *et al.,* 2013b; Carter and Amlôt, 2016). This can be seen in the aftermath of the Tokyo Sarin

attack where analysis of the incident response focused primarily on the technical effectiveness of response capabilities as detailed by Beaton *et al* (2005) and Okumura *et al* (1998a and 1998b).

Where human behaviour is considered, it has often led to contradictory planning assumptions when human behaviour has been considered. Either it is assumed that members of the public requiring decontamination will be anxious and afraid and as a result simply accept and follow emergency service instructions or more commonly it is assumed that those involved in an incident requiring decontamination will become irritational and even disorderly and will require strong control by emergency services if they are to be decontaminated (Harvard School of Public Health, 2013).

The belief in the need for strong control of casualties is based upon misconceptions of the likelihood of public disorder and myths surrounding mass panic with many authorities assuming that *'large gatherings have a tendency to act illogically and instinctively in the event of an emergency'* (Sheppard *et al.,* 2006). However, literature on this topic has for some time shown such occurrences as being unlikely, with helpful and cooperative behaviours being more likely (Aguirre, 2005; Aguirre *et al.,* 2011; Cornwell *et al.,* 2001; Cornwell, 2003; Carter *et al* 2020c; Lügering, 2023). As recognised by Rogers and Pearce (2013) *'when faced with disasters and emergencies, people become co-operative and panic is rare'* (p. 72).

Even so planning for emergencies will often *'fail to incorporate human behaviour and are based on contradictory expectations'* (p. 72) (Rogers and Pearce, 2013). Such misconceptions concerning human behaviour have led to strategies relating to human behaviour becoming focused on controlling those members of the public requiring

decontamination in order to guard against disorderly behaviours (Heide, 2004; Drury *et al.,* 2013). Carter *et al* (2020b) also point out that part of these control measures includes withholding information from members of the public and that such a lack of information coupled with controlling strategies can in fact create public disorder and reduce casualties' co-operation with any decontamination process. Carter *et al* (2020b) suggest one reason for this is the illegitimacy with which members of the public will view these actions by emergency responders.

Beyond the risk of disorder and reduced public co-operation, the limiting of information provided to the public is also likely to inhibit the ability of members of the public to participate even willingly in the decontamination process. They will require instruction and advice so that they are capable of helping themselves and others (Carter *et al.,* 2014).

There is a need therefore to explore these ideas around co-operation and how emergency responders can look to positively influence and support members of the public to achieve an effective response to any Hazmat/CBRN incident requiring mass decontamination as without such an understanding inappropriate approaches may be utilised inhibiting the potential for an effective response.

3.2 Methodology

This literature review uses a narrative approach examining the literature associated with Mass Decontamination and Hazmat/CBRN events specifically and disasters and emergencies more generally. A narrative approach allows for a comprehensive, critical and objective analysis of the current knowledge on a topic and as such allowed this

Thesis to take a wider ranging look across numerous fields to inform understanding in a manner which a systematic review would not have allowed (Ferrari, 2015).

Given the necessity to expand beyond the existing literature, particularly acknowledging the dominance of Dr. Carter's contributions in the UK CBRN/Mass Decontamination field, a narrative review approach was deemed appropriate. Unlike traditional systematic reviews which typically focus on synthesizing existing evidence, a narrative review allows for a more exploratory and comprehensive examination of diverse sources, enabling the discovery of new ideas and perspectives.

The narrative review was undertaken with the specific aim of exploring and synthesizing a wide range of literature pertaining to the intersection of psychology, human behaviour, and emergency management. In particular this review focussed on risk perceptions and communication in disaster situations, as well as CBRN incidents and mass decontamination procedures.

To accomplish this a search was undertaken using Googles Scholar as well as a more general internet search and a review of NFCC (National Fire Chiefs Council) and National Resilience documentation repositories. All documents relating to Mass Decontamination in the NFCC and National Resilience depositories was reviewed whilst the general internet search and Google Scholar search reviewed material until saturation when consistently no new or relevant materials was being found.

Google Scholar was chosen as the primary database for conducting a search of the literature due to a number of advantages which it holds over other platforms. Google Scholar covers a very wide range of scholarly literature as alongside academic articles it also includes access to theses, books and conference papers. The topic of this thesis is

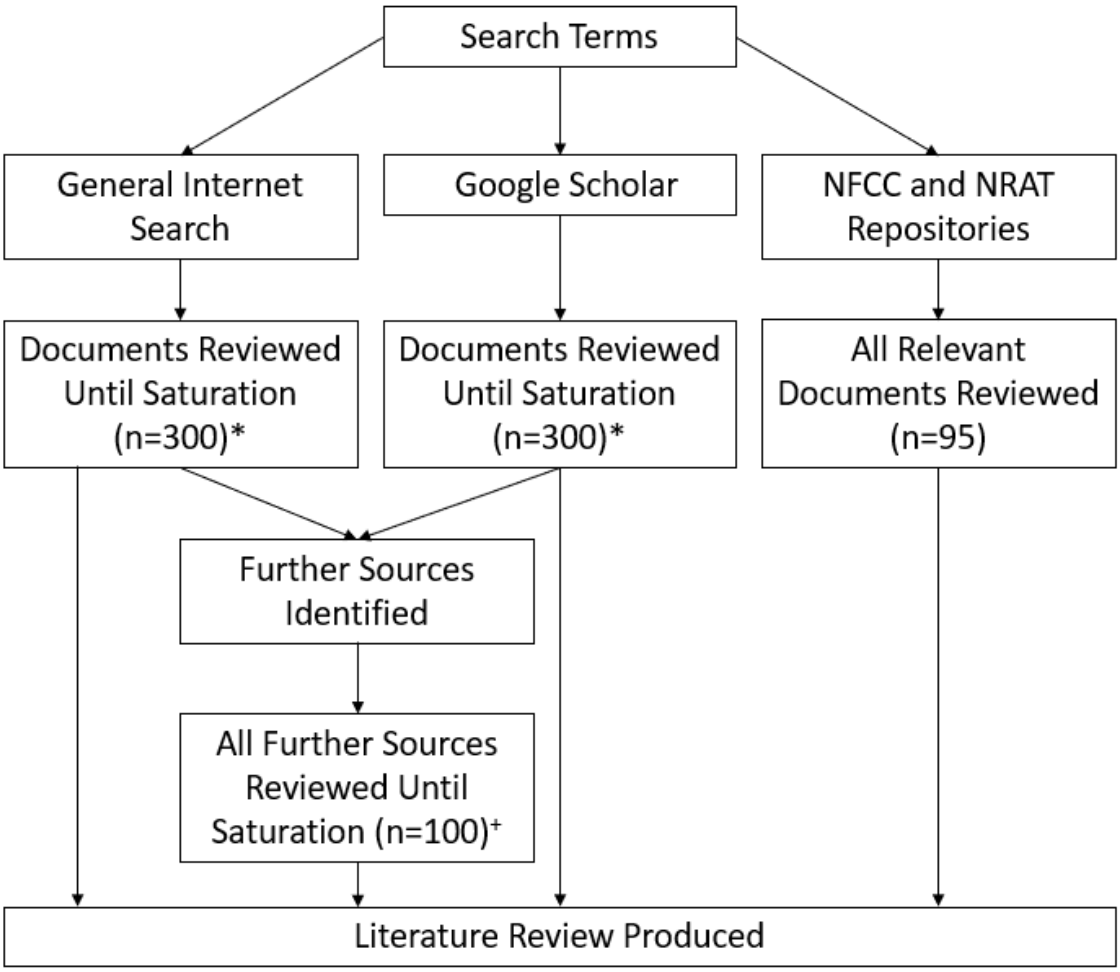
by its nature explored in greater depth by emergency practitioners than academics and as such access to conference papers and books in particular helped to ensure crucial literature on the topic was not overlooked by solely focussing on academic work.

Likewise, the subject area of this theists also means there was a high potential for pertinent documents to not have been shared publicly and it was for this reason that reviews of the National Fire Chief Council and National Resilience document repositories was undertaken.

Search terms used across these platforms were “Risk Perceptions CBRN”, “Risk Perceptions Mass Decontamination”, Risk Communication CBRN”, Risk Communication Mass Decontamination”, CBRN Communications”, “CBRN Psychology”, CBRN Human Behaviour”, Mass Decontamination Communications”, “Mass Decontamination Psychology”, and “Mass Decontamination Human Behaviour”.

The initial literature identified in the review was then used to inform further literature warranting review. The process for choosing literature is set out in Figure 6 below.

Figure 6 Narrative Review Process



* 30 results from each search were reviewed at which point saturation had been reach which refers to there having consistently been no new or relevant materials appearing.
+ 100 further sources were identified from the initial document reviewed and subsequently reviewed at which point saturation had been reach which refers to there having consistently been no new or relevant materials appearing.

A narrative literature review is a type of review that provides a comprehensive summary and analysis of the current knowledge and research on a particular topic or research question (Jahan, *et al* 2016). Unlike systematic reviews, which follow a specific set of guidelines and protocols to identify, select, and evaluate relevant studies,

narrative reviews rely on the expertise and judgment of the author to identify and synthesize the relevant literature (Jahan *et al.,* 2016).

A narrative approach also allows for reflexivity to occur in the literature review process. Reflexivity allows for a process of reflection upon the researcher's own background to influence the research process (Corlett and Mavin, 2018).

A distinction needs to be made between reflection and reflexivity. Reflection seeks to provide insight by looking at an action or event and critically examining what happened, what was learned, and how it could be improved (Corlett and Mavin, 2018).

Reflexivity is a more active process involving ongoing self-awareness and critical examination of the researcher's positionality and assumptions. Reflexivity acknowledges that the researcher is embedded in a context and that this will shape the perspectives, biases, and assumptions of the research (Corlett and Mavin, 2018).

Throughout the literature review the narrative process coupled with engaging with reflexivity allowed for the researcher's own background and experiences in the field to shape the review whilst acknowledging their positionality and how it influenced the review. This allowed for the researcher to synthesize a much broader range of literature than would have been recognised by a systematic review.

The narrative review was therefore valuable for providing a broad overview of the research area, identifying gaps and inconsistencies in the literature, and highlighting areas where further research is needed. The narrative approach allowed for a wider look at literature beyond the boundaries which a systematic view would put in place

allowing for new and novel ideas on the topic to be developed which, having not previously been explored in relation to Hazmat/CBRN or mass decontamination incidents, would not have been identified by a systematic review. However, because narrative reviews rely heavily on the author's expertise and judgment, they are more prone to bias and subjectivity than systematic reviews.

3.3 Results

3.3.1 Risk Perceptions

Carter *et al* (2020b) identify how casualties will respond to both a perceived threat such as their being contaminated as well as the way the threat is managed, and that this perception of risk being faced by casualties will influence how they behave during the decontamination process and as such directly affect the operations of emergency responders.

This is termed risk perception and is the subjective judgements of the perceived characteristics, likelihood and severity of a risk being faced (Slovic, 2016; Brewer *et al.,* 2004; Godovykh *et al.,* 2021). How risks are perceived is dependent upon a wide range of factors including traits of the individuals involved such as personality traits, previous experience, age, traits of the situation such as the framing of risk information and availability of alternative information sources as well as how the risks are processed by individuals such as through affective or cognitive processing (Godovykh *et al.,* 2021; Krieger *et al.,* 2014). When people are faced with a hazard their risk perceptions of that hazard will affect how they react to it. It is crucial that emergency responders consider how members of the public requiring decontamination view the risks to their life and health (Lemyre *et al.,* 2010).

Any strategy put in place by emergency responders to manage a Hazmat/CBRN incident must consider the public's perceptions of their risk or else there is significant potential for non-cooperative or even a hostile response and certainly a likelihood to degrade trust in emergency responders (Collins *et al.,* 2021a).

Feelings such as anxiety and fear resulting from the uncertainty, unfamiliarity and lack of control which a Hazmat/CBRN incident requiring mass decontamination will create will not be equally experienced the same way in all contexts as further factors such as past experiences and varying sociocultural factors will create differences between how social groups, cultures or nationalities perceived risks. A comparative study undertaken by Pearce *et al* (2013) compared the differences between Germany and the UK in their levels of fatalistic response to the use of a radiological explosive device more commonly referred to as a dirty bomb. The research showed fatalism to be stronger in Germany and related this to the dread risk widely felt in relation to nuclear risks driven by the country's association with the Chernobyl disaster.

There is a large amount of literature published on how the general public perceives risk (Barnett and Breakwell, 2001; Slovic, 1987; Kahneman, 2003; Lazo *et al.,* 2000; Kasperson *et al.,* 1988; Siegrist and Árvai, 2020; Siegrist, 2021) but of particular interest to this Thesis are the mental processes which influence risk perceptions and how these can be influenced by emergency responders. Two factors stand out most prominently from the literature on risk perceptions; affect and trust (Visschers and Siegrist, 2008; Liu *et al.,* 2020). Affect refers to the general positive or negative feelings which are felt toward a particular event, situation, or person (Finucane *et al.,* 2000; White, 2017),

whilst trust has been defined as the willingness to make oneself vulnerable to another because of expected beneficial outcomes (Earle and Siegrist, 2008).

3.3.2 Risk Perception and Affect

Hazmat/CBRN releases are associated with strong emotional responses by any members of the public affected by them (Krieger *et al.,* 2014). These emotional responses are termed 'Affect'. Affect has been used to explain how risks are perceived (Finucane *et al.,* 2000; Loewenstein *et al.,* 2001) by acting to provide a positive or negative evaluation of a stimulus. Zajonc (1980) proposed the idea of affective primacy, suggesting that an affective evaluation of risk will occur before a cognitive evaluation of a stimulus. The affective evaluation is based on approach-avoidance which asks if a situation is safe or hazardous and if it requires actions to be avoided. It is a very fast and instinctive process which is in constant use to help people keep themselves safe regardless of any hazard present (Zajonc, 1980).

Alongside this approach the psychometric paradigm looked to understand drivers of risk perceptions and also noted the role of affect (Fischhoff *et al.,* 1978; Slovic, 1987; Savadori *et al.,* 2004; Siegrist *et al.,* 2005). These studies identified the role of familiarly, certainty and control and how these factors could produce 'dread' risks, which are far less readily accepted by individuals as they are perceived as risks which are uncontrollable and of very high severity. These findings have also been supported by the work of Krieger *et al* (2014). Slovic *et al* (2013) suggest that such dread risks will be affectively driven by fear and instinctive perceptions.

The use of affect to judge risk is also explained through the affect heuristic (Finucane *et al.,* 2000; Skagerlund *et al.,* 2020). The affect heuristic states that people will hold positive and negative feelings towards a hazard built upon knowledge or some form of experience or exposure to that hazard (Kahneman, 2011). Their affective impression built upon these positive and negative feelings will determine how an individual perceives the risk of that hazard (Finucane *et al.,* 2000; Skagerlund *et al.,* 2020).

In relation to decontamination this may mean that should a member of the public require decontamination due to exposure to a radioactive material they may view the risk as particularly high if their experience of this scenario is based on, say, the HBO TV drama Chernobyl (2019), which presents a particularly stark view of the outcomes of radiological exposure. This experience would leave them with a very negative view of this risk even if the current exposure is significantly lower risk than the radiological risk following the Chernobyl disaster itself (Visschers and Siegrist, 2008).

These theories have developed into a dual process approach which seeks to explain how people perceive risk (Trumbo, 1999; Loewenstein *et al.,* 2001; Slovic *et al.,* 2013; Capraro, 2019). Dual process theories delineate between immediate and deliberate processes which influence risk perceptions. The immediate processes are a quick appraisal requiring minimal effort and relying on simplistic rules to develop a perception of the risk being faced, whereas deliberate processes are considered cognitive process which require more time and effort than the immediate processes. Chaiken *et al* (1989) proposed that should an individual have sufficient time and cognitive capacity then it will be the deliberate process which will influence risk perception and if not, the immediate process will be utilised instead. Both of these processes can be used simultaneously (Loewenstein *et al.,* 2001; Visschers and Siegrist,

2008) and, as identified by Loewenstein *et al* (2001), the two processes may influence each other and their outcomes.

Overall affective feelings have been shown to have a significant influence upon risk perceptions, however, cognitive processes will influence and be influenced by the affective process and can overrule the affective process in the development of risk perception when people have enough time, cognitive capacity and motivation (Loewenstein *et al.,* 2001).

3.3.3 The Role of Trust in Risk Perceptions

Rosseau *et al* (1998*)* define trust as being a psychological state involving an individual accepting vulnerability with an expectation of a positive behaviour or intention of others in response. Trust appears as a critical element in how risk is managed (Cvetkovich and Löfstedt, 1999; Siegrist *et al.,* 2007; Ye and Lyu*.,* 2020; Siegrist, 2021) and has been used to explain how casualties perceive responders especially in unfamiliar situations (Siegrist and Cvetkovich, 2000; Earle and Cvetkovich, 1995; Luhmann, 2018).

Furthermore, trust has been shown to have wide-ranging impacts in social interactions within risky scenarios. It has been shown to simplify how risk information is processed and has been described as a lubricant of social interactions (Tyler and Degoey, 1996; Yuan *et al.,* 2022). Trust has been shown to reduce social uncertainty and complexity (Luhmann, 2018) and influence risk perceptions, with increased levels of trust leading to an increase in the likelihood of adoption of information or adherence to instructions (Blanchard *et al.,* 2005; Pearce *et al.,* 2019.). Further, it has also been shown to directly

impact the likelihood of cooperation occurring (Das & Teng, 1988). Finally, trust has been shown to be a critical component of how public risk perception is formed and how effective risk communication is (Lofstedt *et al.,* 2011; Meredith *et al.,* 2007; Rogers *et al.,* 2013). A high-profile example of this is found following the anthrax attacks in the US in 2001, where Blanchard *et al* (2005) identified that information was held as trustworthy and therefore more likely to be acted upon if it came from a trusted spokesperson.

The trustworthiness of responders will therefore be crucial in reducing the uncertainty and unfamiliarity of members of the public involved in a Hazmat/CBRN incident, and the actions of emergency responders will shape the levels of co-operative and compliant behaviours experienced (Krieger *et al.,* 2014). Likewise, Krieger *et al* (2014) state how pre-existing low trust or a loss of trust during an incident will have an adverse effect on likely levels of co-operative behaviours impacting the emergency response process. Trust is therefore likely to influence casualty behaviours in relation to co-operation with recommended protective behaviours (Gauntlett *et al.,* 2019; Rubin *et al.,* 2012) and compliance with the authorities (Meredith *et al.,* 2007). Trust appears in the literature as a two-dimensional concept, with separate parameters of legitimacy and competence which will now be looked at in more detail (Carter *et al.,* 2013c; Siegrist *et al.,* 2012).

3.3.4 Trust: Legitimacy

Legitimacy can be described as the willingness to be vulnerable based on the similarity of intentions or values of another person or group (Gau, 2011).

The legitimacy of emergency responders is built from a belief that the emergency services should be listened to and followed as well as a belief that responders hold the

wellbeing of the public as their main priority (Tyler, 2006a; Tyler, 2006b; Tyler, 2007; Tyler and Fagan, 2008; Carter *et al.,* 2020). Legitimacy has been explored extensively in recent years in relation to policing (Jackson and Gau, 2016) and is seen as crucial to eliciting compliance and cooperation with the lawful authorities, most specifically the police (Tyler, 2006a, 2006b).

Tyler (2006a, 2006b) identifies that for members of the public to see the police as legitimate, they must believe it rightful to follow the instructions of police officers and that they are exercising their powers appropriately. Tyler (2006a, 2006b) therefore asserts that legitimacy is (a) the belief that an institution exhibits properties that justify its power and (b) a duty to obey that emerges out of this sense of appropriateness. In literature concerning mass decontamination Carter *et al* (2013b) also link public perceptions of legitimacy to the increased co-operation from the public in relation to compliance with emergency response instructions, which is then followed by Carter *et al* (2015b) stating that increases of perceived emergency responder legitimacy will improve cooperation and compliance.

3.3.5 Trust: Competence

Confidence can be defined as the belief that certain future events will occur as expected given the actions of another group.

Pullon (2008) recognises the role of competence in building trust by studying healthcare professionals through the use of qualitative in-depth interviews with individual nurses and doctors working in primary care settings, identifying that a belief in a doctor or nurse's competence was critical in their being respected and trusted to

undertake their role. This will also be true regarding the public perception of whether the emergency services have the capability to effectively manage an emergency (Earle and Siegrist, 2006). Should the public not perceive emergency responders as being capable of effectively managing an incident, that is to say they do not view them as competent, then trust in the emergency responders will be diminished and whilst the public may well still believe that responders are well meaning and legitimate in their efforts, they will not trust their instruction, not believing them to be capable of helping (Long *et al.,* 2022). If both legitimacy and competence are perceived as being present, then emergency services will be trusted and as a result their ability to influence risk perceptions and encourage co-operative behaviours will be greater (Long *et al.,* 2022).

3.3.6 Communication

Communication is a crucial influencing factor of risk perceptions, with 'risk communication' being developed as a cross-disciplinary field which seeks to ensure targeted audiences understand the risks potentially affecting them or their communities (Sheppard *et al.,* 2012). Becker (2004) states that risk communication *"is vital for facilitating and encouraging appropriate protective actions, reducing rumours and fear, maintaining public trust and confidence, and reducing morbidity and mortality"* (p. 3).

Effective risk communication requires the alignment of several factors between the communicator and the audience. Fischhoff (1995) describes the development of the risk communication field, tracing its course over the previous quarter of a century leading up to 1995. He identifies how, early on in the development of risk communication strategies, there was a strong focus on delivering accurate information to people with the belief that by doing so these individuals and groups would be able to take this

information, process it and, should they be effectively informed, come to a beneficial decision. As research progressed the risk communication field moved towards strategies which sought to put the pertinent information required for beneficial development into the specific contexts for which it was being aimed. More recently again an understanding developed of a need to build trust and relationship between those communicating risk information and those receiving these messages.

Risk communications theory has steadily looked to provide accurate and timely information, which it is believed will be heard by a receiver and rationally and logically weighed as pros and cons, with a beneficial decision being taken as a result. Fischhoff and Scheufele (2013) clearly demonstrate this concept of thinking through the publication of their seminal paper "The Science of Science Communication". Fischhoff and Scheufele (2013) propose within this paper the use of a mental model's methodology in effectively communicating risk. Once again, the model utilizes the concept of understanding what gaps exist and then looking to fill these gaps with pertinent information. As a result, the paper suggests that "effective science communications inform people about the benefits, risks, and other costs of their decisions, thereby allowing them to make sound choices" (p. 14033) (Fischhoff and Scheufele 2013).

Leik *et al* (1981) reviewed disaster management research, identifying that those disaster warnings which were specific both to the culture and location of an audience over more generic communications improved compliance with any recommendations. Further factors including the level of certainty to the message, the familiarity and trustworthiness of the communicator and hearing the message reiterated through

multiple sources have also been suggested to enhance compliance with recommendations and advice (Cozma, 2006). Numerous papers have also identified how providing accurate and timely information by responders in regard to the threat being faced and information about why certain actions are being undertaken, will improve casualty compliance and operational outcomes (Holloway *et al.,* 1997; Sternberg, 2005; Wray *et al.,* 2004; Cornish, 2007; Carter *et al.,* 2015b; Collins *et al.,* 2021b).

Communications between casualties and responders is paramount to ensuring effective engagement between the two groups and therefore ensuring both legitimacy and competency trust can be maintained and improved. (Carter *et al.,* 2016; McHugh, 2012). Carter *et al* (2014) identified during mass decontamination field exercises three key elements to ensuring communications with members of the public were effective in increasing compliance, reducing anxiety and increasing perceptions of responder legitimacy. Casualties need to be provided with a) health focused information as to why decontamination is necessary, b) information about what actions emergency services are taking and c) enough practical information about what casualties should do during decontamination. This research therefore once again highlighted the efficacy of good communications on improving casualty behaviours during emergency incidents and in doing so improving operational outcomes. Carter *et al* (2014) also identified that communication needs to be both open and honest and provided regularly to update the public on what actions are currently being taken. Such communications are linked to trust both in relation to competencies and legitimacy and will assist in encouraging co-operative behaviours amongst casualties (Carter *et al.,* 2019).

The literature suggests that communications need to focus on why decontamination is required in relation to the health of those involved and why the decontamination process is both required due to the risk from any contaminant and why it will be effective in removing this threat (Meredith *et al.,* 2007; Carter *et al.,* 2014a). It is essential that information is provided to allow members of the public involved in the incident to actually engage with the process of being decontaminated. Information must be communicated which provides casualties with information/instruction on what they are required to do in order to be decontaminated in an effective manner (Carter *et al.,* 2019). Should communication be delivered in this manner and provided that the above content as set out in Carter *et al* (2019) be included then casualties will be more co-operative and a more efficient and effective decontamination operation can be run.

There are also potential drawbacks with not effectively communicating the negative aspects of an incident. It has also been noted that communications during Hazmat/CBRN incidents may also be used to downplay threats through over-reassurance. In such instances this may lead to non-compliant behaviours as members of the public may not see the need for interventions such as decontamination should the threat not seem sufficient (Rogers *et al.,* 2013; Rubin *et al.,* 2012).

There are some real world Hazmat/CBRN incidents which have shown the importance of risk communication. During the nuclear disaster in 2011 at the Fukushima-Daiichi nuclear power both the Japanese government and plant operator TEPCO sought to reassure the public and provide limited pieces of information periodically. As Yilmaz (2011) states *"This is anathema to accepted crisis communication best practices. Experts recommend being truthful, forthcoming, and transparent throughout the crisis in order to remove uncertainty"* (p. 1). By understanding effective risk and communication

principles emergency responders will be able to most effectively engage with members of the public and in doing so form the public's perceptions of the threat and responses to any Hazmat/CBRN incident.

3.3.7 Risk Perception in Emergency Situations

As has been discussed above, there is often a focus on technological and organisational approaches to emergency response during emergencies and disasters and particularly Hazmat/CBRN incidents, while there is only limited recognition of what is required to enable the public to engage effectively with the response. Risk perceptions therefore have been shown by the literature to be an essential component of how risks are weighed. How then will risk perceptions during emergency situations influence decision making by members of the public caught up in them?

Hurricane evacuations present a useful parallel for investigating risk perceptions in Hazmat/CBRN incidents.

Both situations involve mass evacuations, forcing individuals to decide whether to evacuate or take protective measures. Hurricanes and Hazmat/CBRN incidents share elements of uncertainty and ambiguity, as well as psychological aspects like fear, anxiety, and social influence which are similar in both contexts, influencing risk perceptions and decisions-making.

Both scenarios entail perceived lethal threats, whether from a hurricane's destructive power or Hazmat/CBRN materials, affecting risk perceptions and responses. Factors influencing evacuation decisions, such as prior experience and information sources, are

relevant to both hurricanes and Hazmat/CBRN incidents as are lessons from hurricane warnings on clear and timely communication which are also applicable to Hazmat/CBRN risk communication.

As such studying how the public responds to evacuation orders and deals with the stress of hurricanes can inform our understanding of behaviour in Hazmat/CBRN incidents leveraging existing and more common hurricane research to enhance public preparedness and response strategies in Hazmat/CBRN situations.

Numerous studies have looked at risk perceptions of members of the public in relation to hurricane evacuations where people's perception of the risk they are exposed to is a crucial consideration in their decision-making process. Adeola (2009) investigated the evacuation of New Orleans following hurricane Katrina and identified a number of drivers which affected people's perceptions with uncertainty, lack of control and trust cited as three key areas. However, most importantly it identified that it was the perceptions of the risk being faced that would influence evacuation behaviours.

A further parallel can be found in earthquakes, where studies have identified that actions relating to preparedness were positively correlated to a greater awareness of the risks of earthquakes. Actions ranging from higher levels of insurance cover through to stockpiling of food and medical supplies was greater in those who had a greater understanding of the earthquake risk (Tierney *et al.,* 2002; Ma *et al.,* 2021; Zaremohzzabieh *et al.,* 2021). As shown by Lindell *et al* (2016) awareness of a risk and the associated recommended mitigating actions correlates to greater preparedness of individuals and likelihood to act in accordance with recommended behaviours.

As already noted, the literature points towards a strong relationship between perceptions of risk relating to uncertainty and control and their influence upon people's decision making and this has been noted during emergency situations. Slovic and Peters (2006) suggest that risk perceptions during emergency situations can develop along two different routes. There is an analytical and logical or rational pathway and an affective or irrational pathway driven by emotional and heuristic responses to perceived risks. Each of these pathways suggest a different process by which casualties' will process risk information and as is made clear from the literature, how casualties perceive the risk facing them will significantly influence their decision making.

Human behaviour can be difficult to predict, and this can be even more true during emergency situations where those involved will be stressed and anxious in the midst of what can be very chaotic events (Raphael, 1995; Lawson, 2011; Kuligowski, 2016). There are a number of theoretical frameworks proposed within the literature to help explain behavioural responses to a threat. Many are based around the promotion of health behaviours and identify that such behaviours are motivated by threat perception and the intent to avoid adverse outcomes. Such approaches have also been explored in relation to Hazmat/CBRN and mass decontamination events (Krieger *et al.,* 2014).

Protection Motivation Theory (Rogers, 1975) and The Person Relative to Event approach (Mulilis and Lippa, 1990) suggest that self-protective behaviours will be undertaken as a result of a perception of a risk being faced and an evaluation of a person's own capability to undertake said protective behaviours (response-efficacy and self-efficacy) in relation to a hazard.

The Protective Action Decision Model (Lindell and Perry, 2012) specifically looks at human behaviours during emergencies and disasters in relation to taking action in preparedness for or response to an ongoing event and often focuses on issue of evacuation. The model suggests that risk appraisal and the perceived efficacy of certain protective actions influences individuals' decision-making with risk appraisal comprising of the perceived expectations of both the likelihood and severity of a hazard being faced as well as its imminence and the extent to which the severity of the hazard would directly impact their own personal safety either relating to physical harm of the potential loss of property or disruption to their lifestyle (Tierney *et al.,* 2002).

The Social Attachment Model (Mawson, 2005) has also been suggested for explaining human behaviour during emergencies and looks at the immediate response to disastrous events. The Social Attachment Model is a psychological theory that describes how humans form and maintain social relationships. The model postulates that people have an innate need for close, secure relationships and that this need influences their thoughts, emotions, and behaviours in their social interactions. Shapira et *al* (2018) reported on studies which had looked at responses to earthquakes and identified that individuals will be more likely to seek shelter with those familiar to them rather than evacuate and that this behaviour was conscious, rational and adaptive.

Risk perceptions also appear in the literature concerning emergency and disaster decision making to be strongly influenced by sociodemographic factors. This suggests that people's willingness to adopt certain preparedness measures will also be impacted by the previous experiences, beliefs and attitudes of different sociocultural groups (Paton *et al.,* 2005). Wilson and Tiefenbacher (2012) and Donner and Rodríguez (2008) suggested the reasons for differences in disaster preparedness and actions taken during

an emergency between different sociodemographic groups was due to different populations having differing propensities to take actions to improve preparedness or to take protective behaviours during a disaster. Other factors including previous experiences of emergencies or disasters have been suggested to motivate people in the adoption of advised protective behaviour (Weinstein, 1989; Cugliari, *et al.,* 2022). However, conversely others have suggested the opposite effect in what is referred to as the experience-adjustment paradox. This phenomenon has been suggested to occur following experiences of incidents which did not result in any major impact and as a result left those having experienced such events to perceive the risk of future such incidents as lower as a result (Baker, 1991; Titko and Ristvej, 2020). As such previous experience of an incident is likely to influence risk perceptions which may either increase or decrease the likelihood of taking protective actions and following advice.

The literature appears then to confirm the importance which the perception of risk will have upon casualties' actions during an emergency including their willingness to co-operate during a mass decontamination incident.

The questions which now arises and is most pertinent to this Thesis is to what extent is it possible for emergency responders to influence casualties' perceptions of risk and encourage co-operative behaviours?

3.3.8 Risk and Decision-Making Pathways

Risk perception has been shown in the literature to be crucial to how those involved in emergency situations will make decisions. Elements such as affect, trust and communications appear crucial in informing how people will perceive risks, especially in

unfamiliar and uncertain emergency situations, and that as a result such risk perceptions will influence the levels of co-operation those involved in an emergency are willing to give to any emergency advice or instructions.

Carter *et al* (2020b) in their summary of key findings around emergency response find that the public process risk perceptions in two broadly dichotomous approaches. The two approaches can be grouped into the 'irrational 'or 'rational' or more affective approaches and more cognitive approaches, as described by Loewenstein *et al* (2001) who identified these approaches and how whilst being distinct have the ability to influence each other.

3.3.9 Irrational Pathway

Approaches that make assumptions about 'affective' public behaviour during emergencies suggests that people will panic, act instinctively, and be unable to make informed decisions about the actions they should take to protect themselves (LeBon, 1890; Kahneman, 1979). These approaches emphasise the high levels of anxiety that people will experience and the accompanying negative impact this will have on their ability to take recommended actions.

Proponents of theories that suggest more affective responses within public behaviour suggest that the lack of control, unfamiliarity and uncertainty inherent to emergency situations will result in an emotional, anxiety-based response, which will be the major factor affecting public behaviour. In line with this, Slovic *et al* (2013) describe the essential role of affective decision-making, as the "fast, instinctive and intuitive reactions to danger" (p. 24) and it has been suggested that these rapid, affect-based processes drive behaviour in situations where people are confronted with a risk for

which they have insufficient knowledge or time to use more time-consuming cognitive processes (Finucane *et al.,* 2000).

Slovic (2000) identifies factors that may affect the way in which the public interpret risk: the extent to which the risk is perceived as voluntary (voluntary risks are more acceptable than involuntary risks); the extent to which the risk is personally controlled (personally controlled risks are perceived as less risky than those controlled by others); and the extent to which the risk is familiar (familiar risks are perceived as less risky than unfamiliar risks). Risks that are perceived as being involuntary, uncontrollable and unfamiliar are perceived to be the most risky and are sometimes referred to as 'dread ' risks (Slovic, 2000). Such dread risks are therefore seen to rely on more affective processing given the lack of information and understanding and therefore a reliance on affect for decision making is more likely, as Slovic *et al* (2013) state "*reliance on affect and emotion is a quicker, easier, and more efficient way to navigate in a complex, uncertain, and sometimes dangerous world"* (p24)*.* These approaches therefore envisage behaviour during emergencies as emotional and instinctive, resulting from the anxiety people will be experiencing, and are largely pre-determined i.e. people will behave in a certain way and the role of responders will be to manage that behaviour.

Likewise, Kahneman and Tversky (1979) identified two systems used in decision making: 'fast think' and 'slow think'. Slow think is a measured process involving a conscious cognitive process whilst fast think is a quick automatic reflexive process which doesn't require any conscious effort. Emergency situations are characterised by a lack of control, unfamiliarity and uncertainty and this results in an emotional, anxiety driven response (Bhardwaj, 2010; Cornish, 2007). This, it is has been suggested, will be the primary factor driving public behaviour (Finucane *et.,* 2000; Loewenstein, 2001).

The literature also points toward a lack of control, uncertainty and unfamiliarity as likely to be highly prevalent in casualties during any Hazmat/CBRN or mass decontamination operation due to the fact that it may take a significant amount of time for the emergency services to identify fully the agents and substances involved and then to determine appropriate further interventions which casualties will likely not have a choice but to comply with. All of this will be beyond the experience and knowledge of most casualties involved. It is therefore likely that members of the public will be anxious in the face of these uncertain and unfamiliar risks. It is likely that the unfamiliarity, uncertainty and lack of control will generate high levels of anxiety (Krieger *et al.,* 2014).

Anxiety can be understood as a *"tense, unsettling anticipation of a threatening but vague event; a feeling of uneasy suspense"* (p. 3) (Rachman, 2013) and distinct from fear as it is without an '*identifiable threat*' (p. 29) (Carter, 2014). Incidents involving Hazmat/CBRN materials which require casualties to be decontaminated are particularly likely to invoke anxiety as such incidents will give people limited control of a situation which they will also have a limited understanding of (Long *et al.,* 2020; Bhardwaj, 2010; Cornish, 2007).

Carter (2014) identifies the need for effective management and communications in order to manage anxiety and improve co-operative behaviours. Carter (2014) also emphasises that whilst anxiety and fear is to be expected panic is not. Crucially panic, unlike fear or anxiety, involves an irrational state (Sheppard *et al.,* 2006) and has been shown to be a rare occurrence during major incidents (Johnson, 1987; Johnson, 1988; Quarantelli, 1954). Whilst panic and associated irrational behaviour may be considered

rare this does not necessarily equate to any certainty that casualties will be co-operative with responders. Anxiety and fear, both of which are likely to be present (Carter, 2014) may well impact upon co-operative willingness as may a wide variety of other factors.

Kahneman (2011) identified two systems with which people may process information: the 'fast think' and 'slow think' systems. Fast think is a reflexive process that happens very quickly and doesn't require conscious effort. Slow think is a slower process involving a conscious cognitive process. Decision making is viewed as occurring following careful weighing of the advantages and disadvantages with risk communication looking to influence this. However, the role of affect in decision making and has come to prominence *(*Slovic *et al.,* 2013*;* Chaiken and Trope, 1999*;* Kahneman and Frederick, 2002). As such risk communication has begun to focus more on 'fast think' when seeking to understand how people make risk-based decisions.

The more affective approach therefore is seen as being likely to occur during emergency situations due to high levels of uncertainty, unfamiliarity and lack of control driving anxiety which will see people utilise their emotions and feelings and as a result this will make communications and rational engagement from emergency responders seeking to encourage effective protective behaviours at best difficult if not unachievable. As a result, strategies to contain and control people during emergencies are viewed as being required in order to undertake any form of emergency management.

3.3.10 Rational Pathway

The 'irritational' or more affective approaches assume that people involved in emergencies will be prone to panic and are likely to act instinctively whilst being less or completely unable to make rational decisions in relation to what actions they need to take in order to protect themselves (LeBon, 1890; Kahneman and Tversky, 1979). However, while such theories have largely been discredited within the literature (De Goyet, 1999; Tierney *et al.,* 2006), they still inform aspects of operational planning for mass decontamination response with the myth of mass panic still persisting with its potential for causing negative consequences in its informing of strategies and tactics which may inhibit emergency response (Fahy *et al.,* 2012; Carter *et al.,* 2016).

As a result of this thinking there has been a lack of planning regarding how to communicate to those who may be caught up in a mass decontamination incident. Mass panic refers to an irrational level of response to a perceived threat whereby those involved have lost the ability to act rationality and with any form of self-control. Further, to this is the idea that mass panic spreads like a "contagion," and, as a result, all of those involved will begin to lose rational processing abilities leading to unrest and unthinking behaviours of any group or crowd (McDougall, 1920; Schultz, 1964; Strauss, 1944; Chertkoff and Kushigian, 1999; Mawson, 2017). As stated by Jacob *et al* (2008) emergency incidents "bring out the worst in people" (p. 556). However, while research shows that actual examples of panic during Hazmat/CBRN incidents are rare, it is also seen that members of the public believe that a) they would be unlikely to panic, and b) they believe others would be likely to panic (Fischhoff *et al.,* 2003).

An article on Wikipedia summarises this popularist view stating "*Scenes of mass contamination are often scenes of collective hysteria, with hundreds of thousands of victims in a state of panic. Therefore, mass decontamination may require police, security, or rescue*

supervision to help control panic and keep order" (Wikipedia 2022). Such views also permeate emergency service policy as shown by Deegan and Donald, in Holdsworth *et a*l (2012) who state, *"A challenge [during incidents involving mass contamination] is that of rapidly establishing and maintaining an impermeable cordon of sufficient size to contain the population in an area of high population density following an incident that may cause distress and panic"* (p. 60). However, as Drury *et al* (2013) has shown such beliefs leading to strategies which look to control people are counterproductive. The research in this area has for several decades pointed to the behaviour of casualties in emergency and disaster situations being co-operative and socially structured dispelling the myth of mass panic and irrational behaviours (Aguirre *et al.,* 2011; Donald and Canter, 1992; Fritz and Williams, 1957; Johnson, 1987; Solnit, 2010).

Parallel to the concept of mass panic, there is also the theory that casualties caught up in emergencies and disasters will become helpless as a result of the incident stunning or shocking them into a state where they are then unable to heed any advice or take any actions to help themselves or those around them (Webb 2002). Drury *et al* (2013) argue that theories of panic and helplessness allow for authorities to utilise authoritarian command and control strategies believing casualties unable to be partners in response and instead something to manage. As such withholding information is seen as being a justified approach to minimise panic and there is a belief that efforts to communicate will be wasted. Drury *et al* (2013) go on to highlight how this fear of mass panic has led to code words being used in public arenas and even why the public will not be told of a fire (Fahy *et al.,* 2012; Proulx and Sime, 1991). Further to this, Ripley (2008) identifies how such concerns about panic has led to policies within the US Federal Emergency Management Agency (FEMA), among others, which direct the withholding of information

from the public about Hazmat/CBRN incidents and what actions the public would need to take in the event of an incident.

Myths about irrational and counterproductive public response to emergencies can therefore significantly hinder and exacerbate emergency preparedness and response. In response to Hurricane Katrina, Drury *al at* (2013) recognize how the consequences of fear about looting led to a focus on a military rather than humanitarian response with disastrous impact for residents of New Orleans (Solnit, 2010; Tierney *et al.,* 2006). Drury *et al* (2013) argue that these myths and associated strategies of restricting information from the public and thus limiting the public's ability to partake in their own safety reduce the public's trust in responsible agencies and reduces their own sense of agency and perception of their ability to cope with any emergency situation (Furedi, 2007; Furedi, 2008; Wessely, 2005).

More cognitive or rational approaches recognise this and suggest that rather than panic, members of the public involved in an emergency will remain rational and maintain normative behaviours (Tierney *et al.,* 2002; Drury, 2012) and that the approach taken by emergency responders in the management of an incident will influence the behaviours of those involved.

The literature points to the role trust can play in influencing the decision making of members of the public during incidents. Carter *et al* (2013a) suggest that the greater the levels of trust the public holds for emergency responders the more willing they will be to follow advice and recommendations.

Carter *et al* (2014) categorises legitimacy as the belief that responders are acting fairly and in line with the best interests of the public. Competency is then based upon the perception of the public that the emergency responders have the ability to effectively assist them and manage the incident. Earle and Siegrist (2006) recognise that for trust to exist responders must be perceived as both competent and legitimate. Holding and maintaining trust will then increase public compliance and co-operation with emergency responders and the instructions they give (Carter *et al.,* 2013c; Carter *et al.,* 2014; Carter *et al.,* 2015a).

The literature identifies that the actions of responders during an emergency will influence trust with effective communication being of particularly significance. To enhance trust, communication should be open and honest seeking to explain the actions required for those involved to protect themselves and why protecting themselves is required. Sufficient practical information was also required so that the recommended actions could be effectively undertaken by those involved (Carter *et al.,* 2015a; Symons *et al.,* 2021). What is clear from the literature is that how emergency responders manage an incident will directly impact casualty behaviours and, as a result, impact the likelihood of co-operation, which will be a major factor in the success of any emergency response (Carter *et al.,* 2013a; Carter *et al.,* 2012; Carter *et al.,* 2013b; Carter *et al.,* 2014; Carter *et al.,* 2013c; Carter *et al.,* 2015a; Quinn *et al.,* 2005; Spence *et al.,* 2012; Meredith *et al.,* 2007).

In conclusion, this literature review shows that there is a need for first responders and managers to understand public behaviour and plan accordingly having effective tactics and strategies in place in order to assist the public. However, even though current research has shown the concept of mass panic to be unfounded this idea still plays a

large role in the perceptions and preparations of emergency responders and planners (Drury *et al.,* 2013, Drury *et al.,* 2019).

The strategies and tactics that have been utilised by emergency services have often been based upon these wrongly held assumptions of public panic and as a result strategies have revolved around containing and controlling the public (Drury *et al.,* 2013). Sharing of information and reassurance have been deemed as not necessary, or even potentially harmful, with the public being viewed as unlikely to cope with receiving this information (Furedi, 2008; Gantt and Gantt, 2012). This has resulted in effective strategies for engaging with crowds not becoming part of responder training or awareness.

There is a need then to understand how to avoid creating perceptions of mistrust and illegitimacy both of which are likely to contribute towards a lack of compliance and threaten the potential for an orderly and effective operation (Stott *et al.,* 2012; Kyprianides *et al.,* 2021). Theories of mass panic and their consequential operational outcomes can serve to only potentially worsen a situation and reduce compliance and positive affective feelings and should therefore be discounted and discouraged from use by first responders or emergency planners.

3.3.11 Mass Decontamination and Crowd Behaviours

Mass decontamination operations will involve interaction between emergency responders and larger groups of people. For this reason, where human behaviour during mass decontamination has been studied this has most often been in relation to crowd behaviours (Carter *et al.,* 2013c, Carter *et al.,* 2015a; Carter *et al.,* 2015b).

Mass decontamination events are characterized by large numbers of people in a single location and as such must be considered to be a crowd situation. As a result of this and the significant impacts and difficulties that large numbers of casualties will present over smaller scale incidents, crowd theories have been the focus of inquiry when considering the question of casualty behaviour. So, alongside the understanding of individuals risk perceptions and decision making already explored in this Chapter the literature surrounding how this will be impacted in relation to crowds should a mass decontamination incident occur will also now be considered.

Theories of crowd behaviour date back to Gustave Le Bon (1895) who introduced the irrationalist approach in his 1895 book the Psychology of Crowds. However, the concept of mass panic has since been widely discredited as little support could be found for it. Quarantelli (1954) argues strongly for how during disasters behaviour is often socially structured. By the 1960's these theories of mass panic in crowds had been largely dispelled and more rationalist approaches such as Emergent Norm Theory had begun to be developed (Turner and Killian, 1987). Johnson (1988) detailed the behaviour of people evacuating during a fire at the Beverly Hills Supper Club and was able to detail how those escaping through fire exits still waited in a patient and orderly manner even when these exits were crowded, and evacuation of the premises was required. Instead of panic those inside maintained their usual social principles as they waited to escape. These theories have since been developed further and by the 1980's the Social Identity approach had begun to be considered (Turner and Reynolds, 2010).

The social identity approach appears most prominently in the literature in describing the likely crowd interaction at a mass decontamination incident (Carter *et al.,* 2015a; Carter *et al.,* 2015b), and it explains likely group behaviours during such incidents

(Carter *et al.,* 2020b). The social identity approach suggests people will have a personal and a social identity and that the social identity is built upon membership of groups. People's perception of who does and does not share their social identity influences how they will interact with others.

A shared social identity results when there is a perception that an individual is similar to others in a group with factors such as proximity to others, a shared sense of fate, or a shared perception of a threat. These factors are all likely to enhance the likelihood of an individual's categorising themselves as similar to others. Within mass decontamination incidents such a shared identity is likely to influence people's willingness to co-operate with others in their group and maintain the social norms of the group as well as their willingness to engage with emergency responders (Lindell *et al.,* 2016). During the London 7/7 bombings (Drury *et al.,* 2009a) it was shown that many members of the public who had been caught up in the explosions but were not significantly injured rendered assistance to those in need around them rather than considering their own needs and wellbeing following their exposure to the attack.

3.3.12 Effective Decontamination

The final section of this literature review looks at the literature relating to understanding what actions are required to facilitate effective management of decontamination incidents.

The literature has identified a number of crucial elements that need to occur in order to facilitate the effective management of a decontamination operations. Carter *et al* (2020b) explored the effective management of decontamination operations by looking

at findings from smaller-scale decontamination incidents, literature relating to decontamination of members of vulnerable groups, focus groups with members of the public, mass decontamination field exercises and mass decontamination online and visualisation experiments. As a result, Carter *et al* (2020b) identified five areas required to effectively manage a mass decontamination incident. These are:

- it will be necessary to get members of the public requiring decontamination to agree to undergo decontamination;
- good management will also help people to effectively go through the decontamination process;
- while it will also be necessary to get them to co-operate with others during decontamination;
- reducing anxiety will also be crucial;
- as will supporting those who may need additional support to undergo decontamination.

Given the nature and scale of mass decontamination in relation to the number of casualties involved, it will be necessary to get the agreement of those who need to be decontaminated if the process is to be successful. Given that the actions required of the public will involve disrobing and undergoing a decontamination shower this may be difficult (Carter *et al.,* 2020a) and it is likely that those involved may not readily agree to undertake such actions (Hanley, 1999; United States Fire Administration, 1997; Vogt and Sorensen, 2002). In field exercises those participating as casualties have provided feedback that they didn't feel they had enough information to do what was being asked and that they were often confused by what emergency responders wanted of them (Carter *et al.,* 2013a; Carter *et al.,* 2013b).

Such reticence of casualty's to undergo decontamination is only likely to be exacerbated in situations where those being required to undertake decontamination do not feel they have been properly informed of what actions are required of them in the decontamination process and where issues such as consideration of privacy have not been duly considered (Carter *et al.,* 2015b). In order to get the agreement of those needing to be taken through decontamination it will therefore be essential that they are effectively communicated with so that they understand why they need to undergo decontamination using a health-focused explanation of how it will reduce the risk to them of further harm from the contaminant and also the risk to others from contamination (Carter *et al.,* 2014; Carter *et al.,* 2015b). It will also be important to ensure they feel that their concerns are being heard and considered (Carter *et al.,* 2015a).

Alongside explanations of why decontamination is needed and communication of concerns for privacy and casualties' welfares, casualties also need to be provided with practical information in order that they can carry out the actions required to effectively undergo decontamination. Such actions by responders will show to the casualties involved that the incident is being managed both legitimately and competently and in doing so will improve trust in emergency responders and increase the likelihood of their instructions being heeded (Long *et al.,* 2022).

Carter *et al* (2013a) found that casualties who had been given the most detailed information were able to complete the decontamination process more quickly and efficiently than those provided with less detailed or no communication on what actions needed to be taken. This finding clearly demonstrated the need for emergency responders to be prepared and capable of providing those needing to undergo

decontamination with sufficiently detailed information about what is required of them during the decontamination process.

3.4 Narrative Literature Review Limitations

Alongside the advantages discussed the narrative approach also has several limitations which must be considered.

Narrative reviews lack a systematic approach meaning that the selection of studies, data extraction, and synthesis of findings will be subject to the author's bias or personal preferences (Jahan *et al.,* 2016). As a result, a narrative literature review has the potential for biases to be introduced (Jahan *et al.,* 2016). However, as discussed, the use of reflexivity can guard against this and support a narrative review's advantage in affording the reviewer the ability to seek wider and more diverse literature as a result (Jahan *et al.,* 2016).

A narrative literature review may also have a limited search strategy due to the lack of a systematic approach and this could lead to the exclusion of relevant studies. Alongside potentially missing relevant studies narrative literature reviews do not usually include a formal quality assessment of studies that are included in the review meaning that studies of varying quality may be included (Jahan *et al.,* 2016).

There can also be a lack of transparency in how the review is conducted due again to the narrative literature review not following a systematic approach. As such it may be difficult for readers to understand how the review has been conducted and how the findings have been produced (Jahan *et al.,* 2016).

In summary, while narrative literature reviews can provide a useful overview of a research area or topic, they have some limitations that should be considered when interpreting the findings. However, overall, the advantage of the narrative approach in allowing for a wide review of literature to allow for new insights not previously explored within the field of mass decontamination outweighs these drawbacks.

3.5 Summary

This literature review has looked to examine the literature relating to factors affecting casualty behaviours during Hazmat/CBRN and mass decontamination incidents and how emergency responders can influence these behaviours to improve co-operation. Risk perceptions were looked at to explore this question with the literature identifying the roles of trust and communication as being critical to how those involved in an emergency and, in particular, a Hazmat/CBRN related emergency make decisions especially around their willingness to co-operate with emergency responders. A summary of the literature is laid out in Table 2 below.

The literature shows a split on how decisions are made with two distinct dichotomous camps existing. These camps are the 'affective' or 'cognitive' approaches. The 'affective' approach suggests that members of the public involved in emergencies are likely to become panicked and prone to acting instinctively rather than making informed decisions about what actions they need to take to keep themselves and their dependants safe (LeBon, 1890; Kahneman, 1979). Whilst the 'cognitive' camp assumes that public behaviour will be measured and considered with the public looking to take

actions to protect themselves, and others and importantly are likely to cooperate with each other and with emergency responders (Cocking *et al.,* 2009; Drury *et al.,* 2013).

Trust was identified as a crucial component of what influences behaviours and co-operation, with both legitimacy and competency being identified as required in order for trust to be built. Communication was another area associated with building trust and was detailed in the literature as vital in all emergency situations and especially in order to facilitate successful incident management of a mass decontamination operation.

This split in the literature highlights the important need to further consider how those involved in a Hazmat/CBRN incident requiring decontamination will behave and how these behaviours may impact a mass decontamination operation and how emergency responders should engage with those involved in order to influence behaviours which assist in achieving an effective mass decontamination response. This Thesis will now seek to explore these areas in further detail.

Table 2 Literature Review Summary

Area	Previous Research Summary
Risk Perceptions	The literature surrounding risk perceptions highlighted the importance of considering the public's risk perception during a Hazmat/CBRN incident requiring mass decontamination. The way people perceive risks is subjective and influenced by various factors such as personality traits, past experiences, and situational factors. Risk perception can lead to anxiety and fear, affecting how people respond to the situation. Emergency responders need to take into account the public's risk perception to avoid non-cooperative or hostile responses, degradation of trust, and ensure successful management of the incident.
Risk Perceptions & Affect	The influence of affective responses on risk perception, particularly in the context of Hazmat/CBRN release was emphasized in the literature. The affective response is a fast and instinctive evaluation of whether a situation is safe or hazardous and if it requires avoidance. The affect heuristic is a way in which people judge risks based on positive or negative feelings towards a hazard. Dread risks, which are perceived as uncontrollable and of high severity, are particularly affected by affective responses. Dual process theories explain how people perceive risk, with immediate processes relying on simplistic rules and deliberate processes requiring more time and effort. Overall, affective feelings

	have a significant influence on risk perceptions, but cognitive processes can overrule them when people have enough time, cognitive capacity, and motivation.
The Role of Trust in Risk Perception	Trust was identified as crucial in how risk is managed and impacts social interactions within risky scenarios. Trust influences risk perceptions, cooperation, and compliance, and is crucial in reducing uncertainty and unfamiliarity during a Hazmat/CBRN incident. Trust is a two-dimensional concept with separate parameters of legitimacy and competence. The actions of emergency responders shape the levels of cooperative and compliant behaviours experienced, and a loss of trust during an incident will have an adverse effect on likely levels of cooperative behaviours impacting the emergency response process.
Trust: Legitimacy	The literature identified that in emergency response situations, the legitimacy of responders will be built on a belief that they prioritize the public's well-being and should be listened to and followed. Legitimacy is crucial to eliciting compliance and cooperation with the authorities, and public perception of legitimacy is linked to increased cooperation and compliance. Tyler (2006a; 2006b) identifies legitimacy as the belief that an institution exhibits properties that justify its power and a duty to obey that emerges from this sense of appropriateness.
Trust: Competency	Competence was seen in the literature as an important aspect of building trust, and a belief in the competence of healthcare professionals and emergency responders is critical in building trust with the public. Legitimacy is also

	important, as it is the belief that an institution exhibits properties that justify its power, and a duty to obey that emerges out of this sense of appropriateness. Both competence and legitimacy must be present for emergency services to be trusted, and as a result, their ability to influence risk perceptions and encourage cooperative behaviours will be greater.
Communication	Effective risk communication was seen as crucial for ensuring targeted audiences understand the risks potentially affecting them or their communities. Research has shown that specific, culturally appropriate messages, delivered by trusted and familiar communicators, and reiterated through multiple sources are more likely to be complied with by the public. Good communication can help build trust and relationships between the communicator and the audience. Effective communication between casualties and responders during an emergency incident is essential to ensure engagement between the two groups and to maintain and improve trust. Communications need to focus on why certain actions are being taken and provide information about what casualties should do. Not effectively communicating negative aspects of an incident or over-reassuring can lead to non-compliant behaviours.
Risk Perception in Emergency Situations	The literature identified that a focus on technological and organizational approaches to emergency response during disasters, including Hazmat/CBRN incidents, often overlooks the importance of enabling the public to engage effectively in response. Risk perceptions of individuals caught up in such situations play a crucial role in their decision-making process, as shown by studies on hurricane evacuations and earthquakes. Risk perceptions develop through analytical and affective

	pathways and are influenced by sociodemographic factors. Theoretical frameworks such as Protection Motivation Theory, The Person Relative to Event approach, and the Protective Action Decision Model have been proposed to explain behavioural responses to a threat during emergencies. Overall, the literature affirms the importance which the perception of risk will have upon casualties' actions and particularly their willingness to co-operate during an emergency.
Risk and Decision-Making Pathways	How risks is perceived was deemed crucial in emergency situations and can be influenced by factors such as affect, trust, and communications. The literature suggests that these perceptions will impact how cooperative people will be in following emergency advice or instructions. The emergency response literature describes two broad approaches to risk perception and decision-making during emergencies: an affective approach and a cognitive approach, which can influence each other.
Irrational Pathway	Within the literature one approach identified assumed that people will panic, act instinctively, and be unable to make informed decisions, with emotional responses, such as anxiety, playing a significant role in public behaviour. It suggests that emergency situations, characterized by a lack of control, unfamiliarity, and uncertainty, will result in anxiety-driven responses.

Rational Pathway	The literature also identified a second perspective that says people involved in emergencies will not panic and become irrational but that members of the public involved in emergencies will remain rational and maintain normative behaviours which can be effectively influenced by emergency responders
Mass Decontamination and Crowd Behaviours	Theories of crowd behaviour, including the irrationalist and rationalist approaches, were discovered within the literature. Most commonly in relation to mass decontamination was social identity theory which was is highlighted as being particularly relevant to mass decontamination incidents, as it suggests that people's perception of their social identity influences their willingness to cooperate with others in their group and engage with emergency responders.
Effective Decontamination	Five key areas for effective management of a decontamination incident were identified: gaining agreement from the public requiring decontamination, helping them go through the process effectively, getting them to cooperate with others, reducing anxiety, and supporting those who need additional help. Communication with the public is essential in gaining their agreement and trust in emergency responders. Detailed information about the decontamination process is also necessary for effective management. The review suggests that providing practical information and effective communication will increase the likelihood of the public following instructions during a decontamination incident.

3.6 Discussion

This literature review has sought to explore the literature which relates to the study of casualty behaviour during mass decontamination operations in response to Hazmat/CBRN incidents.

Understanding how individuals and groups respond during such events is essential for designing effective strategies for decontamination and mitigating distress to those requiring decontamination. Several psycho-social factors have been explored in the study of casualty behaviour in this context, but there are however notable gaps in the current research.

3.6.1 Risk Perceptions, Trust and Rationality: The Cognitive Behavioural Approach

A large part of the literature examined explored themes such as risk perceptions, the role of trust and the rationality of casualties during emergencies.

These themes fall under the cognitive-behavioural approach which emphasizes the role of thoughts, emotions, and behaviours in shaping responses to mass decontamination. The literature in this section examined how individuals process information, perceive, and assess risks, and make decisions during the decontamination process.

Understandings from the cognitive-behavioural approach have been used to develop tailored interventions for improving casualty behaviour during decontamination. These

interventions have looked to target specific cognitive biases, fears, or anxieties that individuals experience as by understanding how individuals cope with stress and uncertainty, factors that contribute to psychological resilience can inform training and preparedness efforts.

While the areas covered by the literature associated with this approach provide valuable insights into individual decision-making, they do not fully account for the social dynamics and group behaviours that can influence casualty behaviour during mass decontamination.

Furthermore, research which has explored cognitive based approaches has often relied on controlled simulations or hypothetical scenarios. While these are valuable, they may not fully capture the complexity and emotional intensity of real-world mass decontamination situations.

The literature surrounding cognitive processes does not always therefore translate into accurate predictions of how individuals will behave in high-stress situations. People's responses can be unpredictable, and factors beyond cognitive processes, such as past experiences and personality traits, also play a role.

This approach also does not adequately consider cultural and contextual differences in how people perceive and respond to risk and threat, which can vary significantly among different populations.

So, whilst the areas explored in the literature within the cognitive-behavioural approaches provides valuable insights into individual decision-making and cognitive

processes during mass decontamination, there is a need for these various factors to be considered more holistically with elements such as risk perceptions, trust and communications consider in relation to each other in order to create a more comprehensive understanding of casualty behaviour in such scenarios.

3.6.2 Mass Decontamination and Crowd Behaviours: The Social-Psychological Approach

The literature review also explored mass decontamination in relation to crowd behaviours within what can be described as the social-psychological approach. This explores the impact of group dynamics, social influence, and communication on casualty behaviour. It considers how individuals' decisions are influenced by the presence and actions of others.

This element of the literature recognises that behaviour during mass decontamination is not solely determined by individual decisions but is significantly influenced by group dynamics, social norms, and interactions with the literature acknowledging that people are not isolated actors but part of a social context.

The literature in this area considers the impact of others' actions, peer pressure, and cooperation or conflict within groups and highlighted the importance of effective communication and the role which emergency responders can have in shaping behaviour.

The literature pointed towards how social-psychological approaches can inform strategies to prevent and manage undesirable behaviours by understanding social dynamics and developing interventions that promote cooperation and compliance and that such approaches can also be adapted to consider the diverse needs and responses of different population groups, such as children, the elderly, and individuals with disabilities.

However, casualty behaviours in group settings can be unpredictable and will be context dependent. It is therefore difficult to predict how a specific group will behave during an emergency.

It is also true that the elements of the social-psychological approach, much like the cognitive approach will not operate in isolation. The elements of the social-psychological approach will interact with individual cognitive processes, emotional reactions, and situational factors.

In conclusion, the social-psychological approach offers valuable insights into how group dynamics and social factors influence casualty behaviour during mass decontamination. However, as stated for the cognitive behavioural approaches these areas should be combined with other psychological approaches and practical insights to create a comprehensive understanding of behaviour in these complex and high-stress situations.

3.6.3 Cultural and Societal Factors

Another area which is woven throughout the other two approaches and is often cited within practical guidance can be summarised as culture and societal factors.

Here the literature refers to the importance of understanding the cultural and societal factors which influence casualty behaviour. Different cultures may have varying perceptions of risk, trust in authorities, and expectations during decontamination.

Research has often under considered the cultural and contextual aspects of mass decontamination such as the diverse needs and responses of different population groups, such as children, the elderly, and people with disabilities. Indeed, it does not stand out in the literature review as a single topic but is rather found being discussed within other areas.

When it has been considered the cultural and societal context within the literature emphasises the influence of cultural, social, and contextual factors will have on casualty behaviour during mass decontamination incidents providing valuable insights into how different populations may perceive and respond to such events.

The literature underscores the importance of considering cultural diversity in emergency planning and allows for the development of tailored interventions and communication strategies that are sensitive to the needs and beliefs of diverse populations. This can improve the effectiveness of response efforts.

However, it must be noted that cultural and societal factors are highly complex and diverse and understanding and addressing the needs of various cultural groups within a community is both challenging and resource intensive.

There is also a risk of overgeneralizing cultural behaviours and responses, assuming that all members of a particular group will react in the same way and not accurately comprehending that people within the same cultural or societal context can have diverse reactions.

While this approach helps identify cultural and contextual factors that may influence behaviour, it may not always predict specific behaviours during mass decontamination incidents, as individual responses can vary widely within cultural groups.

Furthermore, the tailoring of response tactics and strategies for different cultural and societal contexts will require a high level of additional resources which will be a strain on emergency response organisations, especially in large-scale incidents.

3.7 Conclusion

This chapter critiques the relevant literature associated with both cognitive behavioural and social-psychological approaches, as well as cultural and societal factors. A broad range of literature that considers how casualties respond to emergencies in general and, in particular, mass decontamination was assessed, and two major shortcomings revealed.

Firstly, there is a need to consider casualty behaviour during emergencies such as a Hazmat/CBRN incident requiring mass decontamination more holistically. This appears

to be particularly true within the cognitive behavioural approach. The various elements which influence individual decision-making such as, risk perceptions, trust and communication need to be considered in relation to each other in order to create a more comprehensive understanding of casualty behaviour. An approach that combines insights from these various elements of the cognitive behavioural approach would therefore be a more effective way to inform preparedness and response efforts.

Secondly, considerable literature is based upon research conducted utilising controlled simulations or hypothetical scenarios. Given the limited number of real-world occurrences of mass decontamination incidents, this is a perfectly understandable approach. Nevertheless, any research which can utilise real world events would add great value in supporting or countering the theories put forward across most of the current literature.

Chapter 4 – Methodological Overview

Having reviewed the relevant literature, this Chapter details the considerations underlying the development of the methodological approach for the investigation of behavioural responses during a Hazmat/CBRN incident requiring mass decontamination. This Thesis utilises the "research onion", a technique developed by Saunders *et al* (2007) which discusses the different decisions required when developing a research methodology. The Saunders *et al* (2007) research onion approach supports holistic thinking in the development of a research methodology, helping to determine the decisions required in a research design.

4.1 Research Philosophy

Initially, a research philosophy must be considered as this is the foundation of any research study and describes the set of beliefs upon which the research is built. A research philosophy can be an approach that is either (Denzin and Lincoln, 2018):

i) ontological, i.e. asks what we know and understand; or

ii) epistemological, i.e relates to how knowledge can be obtained and understood.

This Thesis pursues an epistemological approach as this is the branch of philosophy dealing with the nature of knowledge, how knowledge is acquired it, and how we it can justify our views of the world. It is therefore capable of providing a solid foundation for understanding and evaluating the knowledge claims and methodologies involved in the study of mass decontamination.

The epistemological approach is particularly suited for mass decontamination research as it also allows for the examination of ethical considerations, so crucial to informing any human behavioural response with the literature highlighting areas such as consent, privacy and perceptions of risk that are crucial to how people will behave (Carter *et al.,* 2013c; Long *et al.,* 2020). Furthermore, this approach can examine such areas and, in fact, encourages the integration of diverse perspectives and interdisciplinary collaboration (Nowotny *et al.,* 2001).

Mass decontamination research involves multiple stakeholders, including members of the general public in addition to scientists, emergency responders, public health officials and policymakers, whose differing perspectives must all be assembled in order to fully understand what is likely to happen during an incident requiring mass decontamination.

By utilising the epistemological framework, this research is able to engage across disciplines and thereby enhance both the richness and applicability of findings, contributing to the development of a robust knowledge base and enhancing the credibility and relevance of research findings (Nowotny *et al.,* 2001).

In contrast, the ontological research philosophy concerns itself with the nature of reality and the existence of phenomena, rather than knowledge dealing with questions relating to the nature of reality and the existence of entities (Denzin and Lincoln, 2018). While this approach may be applicable to certain aspects of mass decontamination research, it was deemed to be inappropriate for the requirements of this Thesis. There is a need for mass decontamination research to address questions that relate directly to the nature of contaminants, how they may affect casualties and what technical decontamination is

required to remove or neutralise them. However, many questions relating to mass decontamination require more practical applications and evidence-based approaches, which align more closely with empirical research methodologies and epistemological concerns, rather than ontological speculations. Ontological approaches typically overlook important dimensions of the mass decontamination operation which go beyond the nature of reality and must include dimensions of public health, engineering, policy making and social considerations. Hence, an ontological research philosophy, focussing on the nature of existence, will neglect these crucial dimensions and cannot provide a holistic view of the complexities and challenges of a mass decontamination incident (Cater *et al.,* 2013b).

Therefore, this Thesis deemed the epistemological research philosophy to provide the more suitable framework for addressing its research questions, especially when coupled with a pragmatic research philosophy.

The Pragmatic research philosophy emphasizes the use of the optimal tools required to study a phenomenon. It seeks to approach research from a practical perspective, where knowledge is constantly evaluated and reinterpreted and involves the researcher's participation and subjectivity in developing conclusions based on participants' responses and choices. Pragmatism is not bound to a particular philosophy, but recognises the need to undertake what is most effective for answering the research question (Creswell, 2014).

It therefore compliments the epistemological philosophy by assisting in the integration of multiple methods and approaches so as to gain a comprehensive understanding of a research problem, allow for the epistemological philosophy's consideration of multiple

viewpoints and enable the role of social and cultural contexts in shaping knowledge to be realised (Creswell, 2014).

4.2 Research Approach

The next stage in developing the overall methodology for this Thesis was to consider the research approach. In line with the Pragmatic research philosophy of this Thesis, deductive reasoning was used. This is a type of logical reasoning, in which a conclusion is drawn from starting with a set of general premises, in this case previous research and operational development concerning mass decontamination, and developing these into more specific conclusions (Glaser and Strauss, 2017).

The literature review highlighted that significant gaps exist concerning casualty behaviours during CRBN incidents requiring mass decontamination. As such, further research is required to gain information on such behaviours, thus then leading to the development of theories and practices. For this reason, a deductive approach was required to establish how current theories and practice need to be developed and validated through the research undertaken in this Thesis.

For deductive approaches to be successfully used, this Thesis uses a mixed methods approach that employs both qualitative and quantitative research. A mixed methods process allows for the deductive approaches to use existing theoretical foundations within a particular context by first utilising qualitative methods which can subsequently be explored utilising quantitative methods to see whether there is a fit with the theory (Creswell and Clark, 2017).

4.3 Research Strategy

This section details how the research philosophy established above delivers the aims of this Thesis through the use of several research strategies, as explained below and laid out in Figure 6 at the end of the Chapter.

4.4 Chapter 5 Research Strategy

Following the introduction, context setting of emergency decontamination operations, literature review and this Chapters' overview of the methodical approach, the Thesis then utilised a Grounded Theory approach to allow the data being gathered to inform the development of new theories relating to the importance of human behaviour during a CRBN incident requiring mass decontamination and the impact of current limitations on an emergency response.

In Chapter 5, semi-structured interviews with emergency responders were utilised to gather qualitative data. The aims were to understand the following:

i. Catalogue responder perceptions of casualty's behaviours during mass decontamination incidents;

ii. Catalogue how responders believe they would impact these behaviours;

iii. Catalogue how prepared responders feel about dealing with these behaviours.

Grounded theory was ideal for this purpose as it sought to identify and understand new or under-researched areas. This theory is well suited for this role as it allows researchers to develop theories and concepts directly from the data, rather than rely on preconceived notions or existing theories, allowing the data to guide understanding. Its emphasis on

theory development, flexibility, and focus on rich and contextual understanding make it well-suited to explore novel phenomena, relationships and insights that may have been overlooked or yet to be explored (Glaser and Strauss, 1967).

4.5 Chapter 6 Research Strategy

A case study utilising existing materials as its source of data was implemented as the research strategy for this Chapter, in particular, the transcripts from the Grenfell Tower fire inquiry.

A case study is an in-depth examination, in this case of the inquiry following the Grenfell Tower fire in June 2017, with the aim of gaining a comprehensive understanding of the situation (Yin, 2018). This qualitative approach used deductive reasoning to take into account the social and cultural context, alongside existing theories, in order to produce outcomes to answer the research question (Denzin and Lincoln, 2018). The aim was to catalogue and describe factors that affected the way in which those involved in the Grenfell Tower Fire behaved.

The transcripts from the Grenfell Tower inquiry provided valuable first-hand accounts of the experiences of those involved and, like case studies in general, represent an invaluable resource from which to learn and explore complex phenomena in real-life contexts.

This will then be analysed utilising framework analysis. Framework analysis is a technique used to organise and analysing data, particularly in social science research. It is especially useful for offering a systematic approach to examining and interpreting large

amounts of qualitative data and allows for exploration of relationships between themes answering specific research questions based on pre-defined categories in a structured approach which still allows the flexibility to consider detailed exploration of participants' perspectives.

4.6 Chapter 7 Research Strategy

Chapter 7 utilised a survey as its research strategy. Members of the public involved in an evacuation resulting from the risk of a hazardous material release due to a large industrial fire were surveyed. The results were then used in order to develop a psychological model of what influences casualty behaviours during such an emergency incident, and to validate this model in a real-world incident involving hazardous materials.

This survey research strategy is effective in collecting data from a large sample in a structured manner utilizing standardized questionnaires, so as to ensure consistency in data collection (Fowler, 2013).

This consistency then supports quantitative analysis allowing for the examination of relationships and testing of hypotheses. In this Thesis, this then allows for a form of Structural Equation modelling called Path Analysis to be undertaken to validate the hypothesised behavioural model facilitating this Chapter's research aims (Kline, 2023).

Path analysis was used to analyse the survey results due to its ability to move beyond regression analysis and accommodate more complex models. This analytical approach

allowed for the investigation of the interrelationships among multiple dependent variables in a sequential manner (Kline, 2023).

4.7 Chapter 8 Research Strategy

In this Chapter, action research was adopted as the research strategy in order to both understand the variables which will influence casualty willingness to stay at the scene of a CRBN incident and develop a range of scenarios which can subsequently be used to investigate the amount of time that casualties will be willing to remain at the scene.

The Chapter looks to engage with Hazmat/CBRN and mass decontamination experts, aiming to:

- Create a list of variables which will influence casualty willingness to stay at the scene of a CRBN incident and undergo decontamination.
- Develop a range of scenarios which can subsequently be used to investigate the amount of time that casualties will be willing to remain at the scene and their willingness to undergo decontamination.

Action research is a method of learning through action (Reason and Bradbury, 2008). In this Chapter this was through a workshop involving expert respondents discussing the research questions and providing qualitative feedback of their thinking.

The focus of action research is on the participants, who are the individuals involved in the issue being studied (Reason and Bradbury, 2008). The researcher brings questions to the workshop, which are then discussed to determine answers to the topics in the

questions. Through this collaboration between the researcher and the participants, the research aims are achieved.

4.8 Chapter 9 Research Strategy

This Chapter used an experimental research strategy as it sought to utilise the findings of Chapter 8 in order to identify both the:

i. How long casualties will be willing to wait at the scene of a Hazmat/CBRN incident and how willing they would be to undergo decontamination.
ii. How the roll of communications by emergency responders influences casualties' willingness to wait at the scene of a Hazmat/CBRN incident and undergo decontamination.

This research strategy involved manipulation of independent variables so as to observe a change in the dependent variable and assess the relationship between them. The purpose of this experimental research strategy was to follow the principles of the scientific method with the aim of testing theories developed throughout the Thesis and thereby to inform further recommendations (Mertens, 2015).

4.9 Chapter 11 Research Strategy

In the final Chapter, a Survey, as described for Chapter 7, was again utilised as the research strategy, this time to collect the views of experts in order to validate the recommendations postulated by this Thesis with the aim of:

4.10 Specific Methodological Considerations

For each Research Strategy, it was also necessary to consider the methods of data collection, the time horizon of collection and the techniques and procedures for data collection (Babbie, 2016).

The research method for each Chapter had to consider the appropriate use of qualitative and quantitative approaches. There are three approaches which can be used (Babbie, 2016).:

i) mono-method, i.e., uses one data collection approach, be that either qualitative or quantitative;

ii) combined method, i.e., uses both quantitative and qualitative data collection approaches, or

iii) multi-method, i.e. uses multiple quantitative and qualitative approaches.

The next step for each research methodology was to select the time horizon, outlining how many points in time data collection would be undertaken. This can either be:

i) longitudinal, referring to data collection over multiple points in time to study changes over this period, or

ii) cross-sectional where data is collected at a single point in time to reflect the situation at a given point.

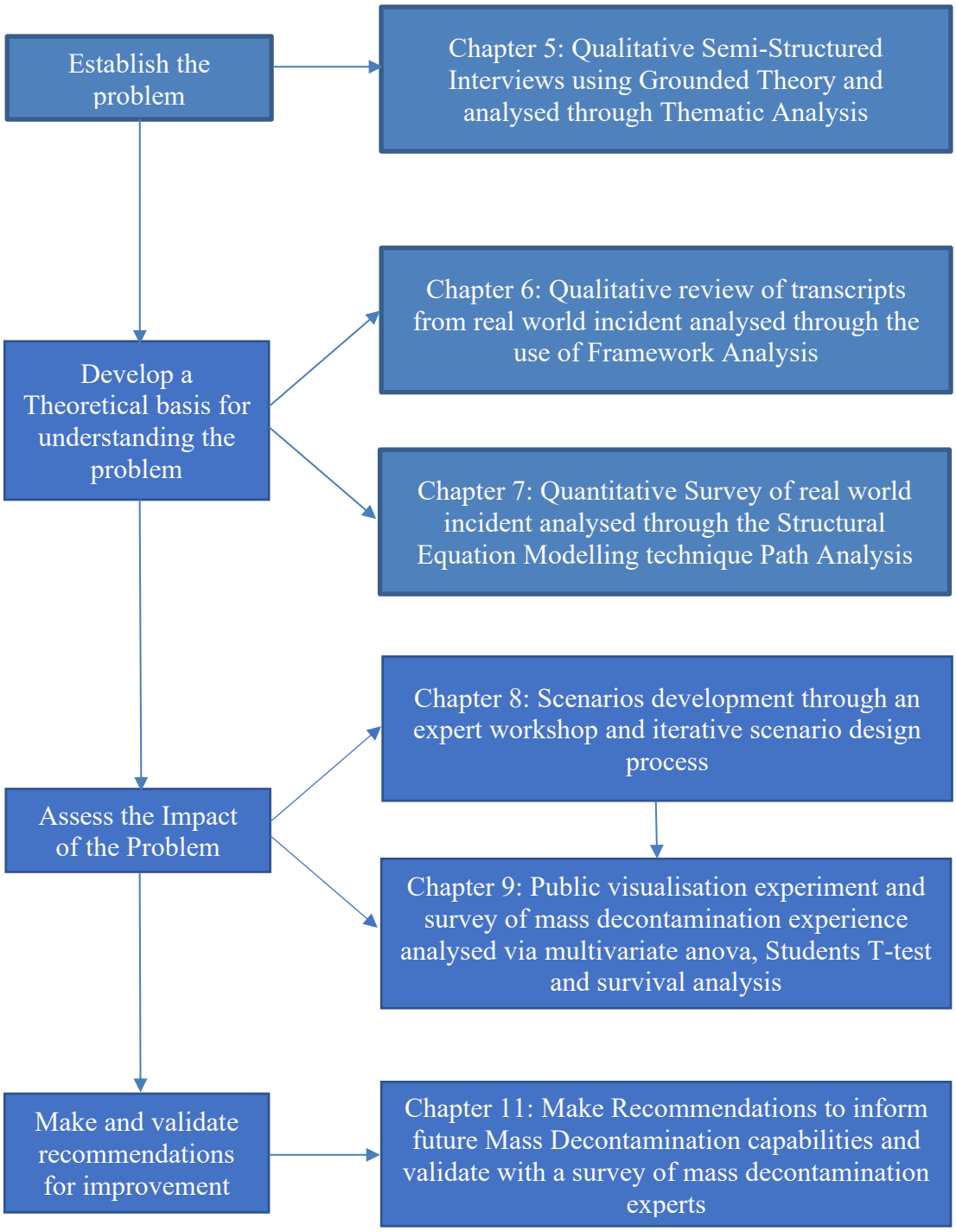
The final consideration in research design regards the specific techniques and procedures to be used. This asks questions concerning what data needs to be collected and what data collection methods will be used to do this. For example, this could be a survey or a focus group discussion, the appropriate sample required and how this

will be selected. It then needs to be determined how the data will be analysed in order to meet the research aims of the study. Whilst all these practicalities are being considered, they need to be aligned to the research philosophy and approach selected to deliver the aims of the Thesis (Babbie, 2016).

Full details of each Research Strategy are provided in the method section of each Chapter.

An overview of the Research Strategy is shown below in Figure 6, which outlines how each subsequent Chapter is connected into forming the overall methodological approach to meeting the aims and objectives of this Thesis.

Figure 7 Thesis Research Strategy Flow Chart



Chapter 5 – The Impact of Fire and Rescue Service First Responders on Casualty Behaviour During Hazmat/CBRN Incidents

Chapter Three examined the literature in relation to casualty behaviours during emergencies and highlighted the importance of risk perceptions and the roles of trust and communication in how decisions regarding co-operation with emergency responders during Hazmat/CBRN related emergencies are made. The literature also showed a dichotomous set of views of how casualties will make decisions, with a spectrum ranging from 'affective' through to 'cognitive' approaches. Furthermore, Chapter Three highlighted the need for further research to consider casualty behaviour during a Hazmat/CBRN incident requiring decontamination and how emergency responders should engage with casualties in order to influence co-operative behaviours.

This Chapter therefore builds upon these findings by utilising one-to-one semi-structured qualitative interviews with FRS personnel for the purposes of both to: i) further explore the role of human behaviour during decontamination and ii) assess how prepared emergency responders are for such behaviours.

5.1 Introduction

As demonstrated through the literature review, how humans behave during disasters and emergency situations is of critical importance for the planning and preparation of responses for such eventualities. This was shown to be particularly true for the behaviours of individuals needing to undergo decontamination activities following an

incident involving a hazardous substance. These incidents are particularly unique in comparison to other emergency incidents. For example, in a fire evacuation, usually a singular, simple and often apparently common-sense instruction to leave an area is given, and in a medical response situation, an individual can be passive in the process. By contrast, in a decontamination situation, casualties are required to undertake activities for themselves, detailed to them by emergency responders, which requires a greater level of engagement and compliance by casualties involved. Although these procedures are conducted infrequently, they are essential to ensuring the safety of those caught up in hazardous material incidents. In recent months, this has been particularly pertinent in the United Kingdom, following the events surrounding the poisoning of individuals in the city of Salisbury using the nerve agent, Novichok (Dodd *et al.,* 2018).

During decontamination incidents, it is crucial that all hazardous materials are removed from individuals in order to mitigate any potentially harmful effects they may have on a person's health. If such an event occurs within the UK, it is the role of the FRS to undertake the decontamination component of the emergency response. In preparation for this role numerous questions should be considered by disaster planners and the emergency services, some of which are currently being omitted. The majority of these omitted questions are concerned with the behavioural aspects of the individual's requiring decontamination. As a result, many assumptions are made of public response, and the subsequent aspects of planning these assumptions inform are reduced in their reliability and effectiveness.

The key issues examined by this Chapter concern the behavioural aspects of participants involved in decontamination processes, as acquiring a better

understanding of these issues would greatly help with improving decontamination processes for hazardous material incidents. The outcomes of investigating these issues may include improving the ability of responders to ensure crowd compliance and assistance, understanding potential strategies for reducing stress and improving responder effectiveness, as well as providing grounding for the need to build into first responder training awareness of human behaviours and strategies for engaging with the public. Further to this, grounding will also be sought to ensure planners understand the need to effectively integrate issues of human behaviour and the impact of first responders into their modelling, resourcing and preparations for major incidents.

Compliance is a particularly crucial concept and in emergency situations refers to the actions of the public in taking recommended measures provided by emergency responders, in order to successfully achieve the tactical operations being instigated to resolve a situation. These actions could involve a range of instructions: from simply staying put and remaining in a certain area at an incident, through to undertaking disrobing and partaking in decontamination following a chemical or radiological exposure. During emergencies, those involved will face unfamiliar and often stressful circumstances. Following instructions from emergency responders such as evacuating a home or workplace or undergoing decontamination may feel confusing or uncomfortable. Given the stress and discomfort these situations will cause, it's reasonable to anticipate individuals hesitating to comply with emergency responders' commands. This non-compliance may be exacerbated should the operations being undertaken not be executed effectively (Holloway *et al.,* 1997).
Should members of the public not comply fully with responder instructions there is the potential for decontamination operations to be significantly hindered (Edwards *et al.,*

2006). This then has the potential to worsen the incident risking lives (Lillie *et al.,* 2006; Lake and Schulze, 2009).

With the likelihood of non-compliance and the considerable consequences that such behaviour might bring a clear possibility, strategies aimed at bolstering public compliance and fostering supportive actions during major incidents could significantly contribute to saving lives.

The aim of this research was therefore I.) to understand responder perceptions of casualties' behaviours during mass decontamination incidents. II.) how responders believe they would impact these behaviours III.) how prepared responders feel for dealing with these behaviours.

5.2 Methodology

In order to validate the findings of the literature review regarding a lack of preparedness for the role of human behaviour during a Hazmat/CBRN incident and the impact of first responder's actions on these behaviours a series of one-to-one semi-structured qualitative interviews with FRS First Responders, Hazardous Material Advisers (HMA's) and Strategic FRS Officers were conducted between January 2018 and June 2018.

5.2.1 Ethics

This study is deemed to be an Evaluation and as such did not require ethical approval through Imperial College London (See Appendix I).

All participants provided consent to their participation in the study and had the right to withdraw from the study at any time. This was achieved at the start of each interview via a briefing to the participant at the end of which they provided their consistent in order to continue with the study.

All participants data will be anonymised and stored securely for 10 years.

5.2.2 Participants

A total of 17 participants were interviewed for this study drawn from Mass Decontamination Operatives *(10)*, Hazardous Material Advisers (HMA's) *(4)* and Level 4 FRS Strategic (Gold Command) Managers *(3)*.

Mass Decontamination Operatives and HMA's represent the two tiers of FRS first responders whose responsibility it will be to carry out decontamination operations.

Level 4 Officers are the highest level of FRS Incident Command and are responsible for the Strategic element of operations.

These participants provided a total of 5 hours of interview with an average length of 18 minutes and 30 seconds.

All Recruitment was done directly, reaching out to Fire and Rescue Service personnel who were Mass Decontamination Operatives, HMAs or Strategic Officers.

5.2.3 Qualitative Semi-Structured Interviews

Semi-Structured interviews were utilized for this study as they allow for a set of open questions specific to the studies inquiry to be explored whilst allowing the participants to deliver their responses beyond the questions asked allowing issues to be raised that may have not have been consider so far by the study whereas a more structured intervention such as a questionnaire would have limited the participants responses.

Semi-structured interviews are open ended enough to allow interviewees to express their opinions on a topic, but also allows for the collection of data that can be compared across respondents. In total, 17 respondents were interviewed, with all participants providing written or verbal consent for their interviews to be utilized by this research.

Each session had a facilitator who utilized a framework of areas identified for discussion through the literature. The facilitator prompted interviewees where the issues raised were pertinent to the Chapter's enquiry and moved the conversation on when it was felt that the line of enquiry was no longer relevant.

Each session was examined for any pieces of relevant information. These pieces of information were then coded to identify common and important themes. Information was coded if it was repeated numerous times, if it was something which was a surprise

to the research, if it was something which was explicitly stated as being important, or if it clearly pertains to the research question.

Thematic analysis was used to identify themes within the research interviews, with a grounded theory approach (Glaser and Strauss, 1967) used to discover themes emerging from the data. An exploratory deductive approach was taken as it allows the flexibility to discover themes, building upon exiting theories (Braun and Clarke, 2006). Nonetheless, thematic analysis has been suggested as lacking rigour (Sandelowski and Barroso, 2003) and reliability (Vaismoradi *et al.,* 2013) and in order to addresses this the study has clearly laid out how the analysis of the data was conducted following the guidelines set out be by Braun and Clarke (2006) (see Table 3).

Table 3 Thematic Analysis Process

Taken from Braun and Clarke (2006). Using thematic analysis in psychology. p87.

Phase	Description of the process
1. Familiarizing yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes	Checking if themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.

5.	Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6.	Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Through this process all interviews and their transcripts were effectively reviewed to identified themes and subthemes, which emerged from the interviews (Lincoln and Guba, 1985; Ryan and Bernard, 2003). A coding guide was used to support this process and the template used for this can be seen in Figure 7 below.

Figure 8 Coding Guide Template

Themes	Subthemes	Definition	Example Quotes

5.2.4 Validation of Codes

In order to improve the reliability of the coding and ensure a more objective approach, inter-rater reliability was utilised using two additional researchers from Public Health England's Emergency Response Department.

Both researchers were provided with 30% of the quotes identified as being coded, as well as names and definitions of identified themes. They were then asked to categorise these quotes into the themes. SPSS versions 25 was then used to determine an inter-rater correlation for these measures.

5.2.5 Quantitative Validation Questionnaire

A questionnaire was developed in order to more widely test the reliability of the themes identified through the qualitative interview and provide statistical support to their credibility.

The questionnaire utilised a 7-point Likert scale asking questions related to the themes identified and asking respondents to what extent they agree with these statements from not at all (Dodd *et al.,* 2018) to strongly agreed (Hanley, 1999) to determine whether they agree with these themes or not (See Appendix II).

A pilot of the questionnaire was run in order to ensure that the questions being used were clear enough to warrant the opinions being sought. The pilot questionnaire was run with mass decontamination operatives and their thoughts on the questions were sought to ensure the questions held the meaning which was intended.

Following this, 36 mass decontamination operatives were asked to complete the questionnaire and a mean was determined for each question relating to a theme.

5.3 Results

5.3.1 Stay in Place vs. Leave Results

Those interviewed identified a major concern around casualty behaviours at a mass decontaminated incidents as the likelihood of casualties leaving the scene before being decontaminated.

Describing a real deployment one responder noted *"They had already gone to the supermarket, the local B&B (bed and breakfast) and stuff, where they would have interacted with nearing hundreds of people already who would have then had the potential to spread things before the time we had even arrived at the incident"* (*Mass Decontamination Operative* 2).

"will you even stay in the vicinity anyway or will you have moved around further away from there" (Mass Decontamination Operative 2).

"Somebody covered in a white powder, which could happen on a daily basis in some workplaces, they will go home for a shower, they get in their cars, go home and have tea" (HMA 1).

"No, basically we were just told that if anyone's still there we'd be lucky, they're probably gonna leave" (Mass Decontamination Operative 5).

"People tend to flee in panic, don't they? Take a bus or a train station or a shopping centre, people aren't going to want to stay in a danger area whether they know they're

contaminated, whether they know they're going to be entering even a bigger risk area. They are going to…to coin a phrase…a bomb burst, aren't they, away to a point of safety which is going to make our life harder" (Mass Decontamination Operative 10)

5.3.2 Hospital or Home: Most Likely Destinations for Casualties Who Leave the Scene Results

Respondents identified that if casualties were indeed to leave the scene they would most likely go to Hospital or go home.

"The last thing you want is for everyone to bomb burst, which is probably what's going to happen and they'll all end up at their own A&E (Emergency Room in the USA) or GP (General Practitioner)" (HMA 2).

"So I would suggest in that situation, what they might try to think to do is bypass any decontamination and get to hospital" (HMA 3).

"However, if there is a substance that does not initially affects them, i.e Anthrax, they will think oh why am I being told to stand here and undress. I've got things to do. I need to go home" (HMA 4).

"I'm not affected. I'll go home or if I do feel ill I'll go to the hospital later or see my GP and that's exactly what happened when Bryan Ferry's son threw the purple powder in the houses of parliament. There was no containment of the MP's. Some people, some of them went home" (HMA 4).

"Well go home, perhaps self-present at hospitals" (Mass Decontamination Operative 1).

5.3.3 Compliance During Mass Decontamination Results

The theme of compliance was identified in relation to the difficulty responders felt they would experience in attempting to get casualties to follow their instruction either to remain at the scene or undertake decontamination.

"It will work but I just think the numbers are unrealistic, about how you would get them through." (HMA 2).

"the ability to contain people will be quite difficult, we've no legal power" (Strategic Commander 1).

"Because in a training scenario, I'd imagine that we would meet compliance if the individuals are in pain due the substance being corrosive. I would suggest that we're likely to be overrun and an attempt to use our equipment would take over" (Mass Decontamination Operative 9).

"But when you introduce a proper incident where perhaps someone has been covered with some contaminant or whatever, they're going to be in a heightened state of stress. They may well be burning, because it's caustic. They are not going to be compliant, you know "(HMA 2).

5.3.4 Speed of Decontamination Results

Numerous respondents identified how they believed that the speed of response of mass decontamination capabilities would be a crucial factor in keeping casualties at the scene of an incident. It was expressed that should a response take too long casualties would increasingly become more likely to leave. Respondents also suggested that current arrangements would likely be too slow to keep most casualties at the scene and that alternative arrangements needed to be considered in order to speed up their ability to effectively provided decontamination at an incident.

"What we found with a lot of the exercises, even the compliant people were getting pissed off about being held in an area waiting for the structure to be set up" (HMA 2).

"10,000 people, we are doing 150 an hour. We'd make up for more IRU's[5] *but they could be an hour, two, three, four, five hours away by the time they come, set up, sort out all the areas, though hopefully we would have done that beforehand we would have started. There could be people stood there for 10, 12 hours before they are decontaminated, now on top of what they have on them is what they need to sustain life. So you'll have medications, you'll have food, water, toilets the list is long and endless." (HMA 1).*

"Part of the problem with it is you can only fit a limited amount of people through at a time. So even if you have numerous IRU's there or what we've got now, but you know it's going to take a long time for us to get there and set up and people aren't going to want to hang around and wait to be decontaminated." (Mass Decontamination Operative 1).

[5] The term IRU stands for Incident Response Unit and is the former name of Mass Decontamination Units.

5.3.5 Training and Operational Readiness for Human Behaviour Results

This theme was identified as respondents suggested that they felt their current training in relation to casualty behaviours during mass decontamination incidents is insufficient and as a result their ability to effectively engage with casualties during a real operation would be hampered.

"We are talking about mass decontamination, decontaminating hundreds of people, possibly thousands of people, we've really got to understand how they are going to react" (HMA 1).

"more discussion around it [casualty behaviours] *but no real guidance" (HMA 3)*

"I don't believe we've ever actually tested what human behaviour would be in the event of contamination" (Strategic Commander 1).

"People play act but that's not an emergency environment, people don't play act in an emergency environment they will show different traits. Training is always tricky as it's not a real environment. You're missing one key ingredient, the emergency. Everyone knows it's a safe environment. People would not act as they do in a training environment" (HMA 1).

"No, we haven't [received training]*. We've kind of gone under the impression that on the day you have to react to what's given. There's no sort of workshops on dealing with people" (Mass Decontamination Operative 7).*

"No, it hasn't [Training delivered on casualty behaviour]. *Never been told, explained or, you know, informed about people's behaviour" (Mass Decontamination Operative 10).*

5.3.6 Trust During Mass Decontamination Results

The concept of trust was also one which stood out in respondent's statements.

"What I think you may find would be that the citizen has a great level of trust in the fire service asking them to do something. They don't see it quite as an instruction perhaps as they would do from the police and probably would be more likely to think we're acting in their interests." (HMA 3).

As one respondent identified *"it's human nature that people will perceive a danger and they will seek to minimize that danger, but they'll all have a different perception and all have a different place where they see as safe and where they all think is the right place to go. Which, not necessarily knowing all the risks are and what's actually going on may not be the right thing". (Strategic Commander 3).*

With another stating *"I think the citizen wants to know that whatever is being done to them is in their best interests, don't they? They need to have that trust that we're organised, and we know what we're doing". (HMA 3).*

5.3.7 Quantitative Analysis

In order to validate the themes identified by the Semi-Structured Interviews, 30% of the codes were re-coded by two independent mass decontamination subject matter expert researchers from Public Health England to provide an inter-rater reliability measure.

Alongside this a quantitative questionnaire was developed to further validate the themes identified by the qualitative interviews, asking a larger sample of 36 Mass Decontamination Operatives to rate their level of agreement with the themes identified.

Tables 4 and 5 below illustrates the results of the SPPS version 25 inter-rater correlation measures. These were run to determine the level of agreement between each of the independent research studies' coding and the original coding and also between the coding of the two independent research studies while accounting for the possibility of agreement through chance.

The Inter-Item Correlation scores for each rater were as follows with rater 1 being the original researcher. Raters 1 and 2 had a .818 inter-rater score and raters 1 and 3 a 0.744 inter-rater score with raters 2 and 3 one of .720. According to McHugh (2012) any score above 0.7 indicates a strong level of agreement between raters. As such the scores between raters in this research indicates a strong level of agreement showing a reliability in the coding of the qualitative data (McHugh, 2012).

Table 4 Inter-Item Correlation Matrix

	Coder 1	Coder 2	Coder 3
Coder 1	1.000	.818	.744
Coder 2	.818	1.000	.720
Coder 3	.744	.720	1.000

Table 5 Interclass Correlation Coefficient

	Inter-Class Correlation	95% Confidence Interval	
		Lower Bound	Upper Bound
Single Measure	.760	.684	.824
Average Measure	.905	.867	.934

5.3.8 Quantitative Follow-up Questionnaire

The validation questionnaire was used to provide further validation to the themes identified and asked thirty-six Mass Decontamination Operatives to rate their agreement with eight statements relating to the themes identified on a 7-point Likert scale to determine whether they agreed with these themes or not.

The eight questions identified a strong level of agreement with the themes identified through the semi-structured interviews, with agreement being deemed as any answer

over a 4-rating on the Likert scale. The results of agreement can therefore be seen below:

- Question 1: People leaving the scene before being decontaminated will be a major challenge. 89% agreement with statement.

- Question 2: Those who do leave the scene are most likely to go to hospital. 80% agreement with statement.

- Question 3: Those who do leave the scene are most likely to go home. 75% agreement with statement.

- Question 4: Casualties not complying with emergency responders' instructions will be a major difficulty. 86% agreement with statement.

- Question 5: Currently the speed with which we would be able to decontaminate people is too slow. 89% agreement with statement.

- Question 6: The training provided for crews regarding human behaviour is inadequate. 80% agreement with statement.

- Question 7: Emergency responders are not well prepared for dealing with the human behavioural aspects of mass decontamination operations. 94% agreement with statement.

- Question 8: The trust with which casualties hold emergency responders will be critical to them following instructions. 100% agreement with statement.

5.4 Discussion

The semi-structured interviews provided numerous insights into operational considerations and the current state of decontamination operational planning and training in relation to human behaviour, whilst also identifying the role which human behaviour would have during decontamination operations.

The semi-structured interviews identified six key themes of relevance to the Chapters research question which looked to understand whether human behaviour during decontamination operations was well considered by planners and FRS managers and well considered in planning and training assumptions and whether such behaviours would likely impact a decontamination operation.

These themes will now be explored in comparison to the literature to identify insights into the crucial elements of decontamination operations and the impact of human behaviour, and FRS first responders' impact upon these behaviours.

Selected quotations are used alongside the literature to exemplify the topics, problems, and concerns that were the basis for the themes identified.

5.4.1 Stay in Place vs. Leave Discussion

The literature that surrounds mass decontamination operations has sought to understand these operations during the decontamination phase. That is to say, from a point in the incident where the materials and manpower from all responding agencies have been gathered and organized to provide the mass decontamination facilities and casualties are being moved through decontamination showers or other decontamination activities. This focus appears to make sense, as it is this phase where the actual decontamination, the point of the operation, occurs. Success or failure here it would seem will determine the overall success or failure of the operation.

When human behaviour and concerns around casualty compliance have been considered, it has been again in this phase with a focus upon the difficulties likely to be incurred by trying to get a large volume of people to disrobe and undertaking showering activities. Such focus is again not unfounded and has been shown by a number of studies (Albores and Shaw, 2008; Carter *et al.,* 2013a; Carter *et al.,* 2014) to be an area of significant importance to mass decontamination operations.

The research conducted by this Chapter, however, identified a crucial, but so far missed, element of human behaviour effecting the overall operation. The semi-structured interviews identified that the potential for casualties to leave the contaminated scene before undergoing decontamination, potentially directly in contradiction to responder advice, is a critical moment of the operation.

Respondents identified how in the early stages following the release of a contaminant it will be imperative for the very first responders to try and keep all contaminated

persons at the scene. Failure to do so will increase the risk to those individuals, as they may not undergo any form of decontamination or receive any medical assistance. Furthermore, they risk spreading the contaminant further afield increasing the contaminated area potentially over a vast space and contaminating other people who they come into contact with. This was shown to be a particular problem in the wake of the 1995 Tokyo Sarin attacks, where a number of emergency hospital workers suffered from secondary exposure to the agent, thus highlighting the potential impact of this problem (Nozaki *et al.,* 1995; Okumura *et al.,* 1998a; Okumura *et al.,* 1998b).

As one responder noted from a real-life experience of a decontamination incident *"Most people will self-deploy themselves away or to hospital". (Mass Decontamination Operative 9).*

The responder then went on to describe how this impacted the incident and what the impact of this could have been. *"They had mostly disappeared", "They had already gone to the supermarket, the local B&B and stuff, where they would have interacted with nearing hundreds of people already who would have then had the potential to spread things before the time we had even arrived at the incident".* (*Mass Decontamination Operative 9*).

Other respondents shared this concern, with one commenting on casualties *"will you even stay in the vicinity anyway or will you have moved around further away from there".*

Another commented that, *"Somebody covered in a white powder, which could happen on a daily basis in some workplaces, they will go home for a shower, they get in their cars, go home and have tea". (HMA 1).*

It was a common theme and a significant worry for many respondents. Most felt that people would almost certainly leave the scene and there was a lot of concern regarding their abilities to keep people at the scene and undertake decontamination activities.

Such understanding will be of critical importance in informing training requirements, pre-planning assumptions and wider decontamination requirements such as how to deal with people who will leave the scene and ensuring that nearby hospitals are prepared for the likely influx of contaminated casualties and whether the FRS should be considering providing assistance.

As stated earlier in this Thesis modelling of a more holistic nature, beyond the movement rates and flow rates of casualties in the decontamination tents, will be of great use in operational planning for Hazmat/CBRN incidents. An appreciation of the likely levels of casualties who 'stay put vs. leave' and the impact different actions will have on this will be useful in determining response planning, resourcing levels, and to highlight the impact of varying factors, for example the role of communication by responders.

5.4.2 Hospital or Home: Most Likely Destinations for Casualties who Leave the Scene Discussion

Alongside establishing the likelihood of casualties remaining at the scene as a major concern respondents also identified that it was highly likely that those that did leave would either return home or self-present at hospital.

"The last thing you want is for everyone to bomb burst, which is probably what's going to happen and they'll all end up at their own A&E or GP". (HMA 2).

Such opinions of where people will go finds common ground in the literature with both Okumura (1998a) as well as Heide (2006) studying the 1995 Sarin attacks in Tokyo and finding that decontamination stations set up by FRS' were bypassed with large numbers of casualties self-presenting to hospital.

Likewise, both Vogt and Sorensen (2002) and Berkowitz *et al* (2004) through their research into hazardous materials incidents indicate that casualties will be more likely to seek out a hospital or other medical support or return home than simply wait at the scene for help.

Meanwhile, research into a potential radiological attack has shown that many people feel safest in their own homes with compliance rates for stay in place being significantly higher when people are in their homes and rates of evacuation being significantly lower (Dombroski *et al.,* 2006). Therefore, returning home following being caught up in an emergency seems to be a highly realistic and likely option.

This is very important point to consider as if, as respondents suggested, a proportion of casualties are likely to leave a scene contaminated it is important to consider where they will go in order to prepare and respond effectively to this challenging element of a decontamination operation. This will be especially true for the readiness of hospitals, where staff and facilities can be properly prepared for a large influx of contaminated patients should a Hazmat/CBNR incident occur in their vicinity. An understanding that

this will be the case will be important to ensure that systems are in place for informing these local hospitals and for their ability to meet this demand.

5.4.3 Compliance During Mass Decontamination Discussion

As suggested by this Thesis review of the literature, compliance was strongly identified as being of major concern by all respondents, with many questioning whether casualties at an incident would respond to their instructions and questioning in particular the number of casualties per hour that could be taken through a mass decontamination setup due to this unwillingness to follow such commands.

As one respondent commented, *"It will work but I just think the numbers are unrealistic, about how you would get them through".* (HMA 2).

However, it was recognized that with the Police in attendance it would eventually require their intervention should casualties refuse decontamination.

The greater concern, as has already been identified was that in the initial phases the instructions given to stay in place and undertake the Initial Operation Response procedures of disrobing and utilizing dry decontamination would not be followed and that crews would have no ability to enforce these necessary actions: *"the ability to contain people will be quite difficult, we've no legal power"* (*Strategic Commander 3).* This concern around compliance in relation to staying at the scene, therefore reinforces the overall concern around how many people would have left without being decontaminated potentially escalating the incident more widely.

5.4.4 Speed of Decontamination Discussion

A critical theme that respondents suggested as the variable of FRS actions which would most likely impact casualties' likelihood to stay in place and their compliance was the speed with which the FRS would be able to arrive at the scene and begin decontamination operations;

"What we found with a lot of the exercises, even the compliant people were getting pissed off about being held in an area waiting for the structure to be set up". (HMA 2).

Another emphasised the need to offer faster decontamination, highlighting some of the practical limitations of a slower response by stating: *"10,000 people, we are doing 150 an hour. We'd make up for more IRU's but they could be an hour, two, three, four, five hours away by the time they come set up, sort out all the areas, though hopefully we would have done that before hand, we would have started. There could be people stood there for 10, 12 hours before they are decontaminated, now on top of what they have on them is what they need to sustain life. So you'll have medications, you'll have food, water, toilets the list is long and endless."* (HMA 1).

Responders clearly felt that current methods, the use of Specialist Operational Response, centred around the deployment of MDU's would simply take too long. Respondents felt that at a large scale incident the relatively low throughput rate for decontamination of 150 people an hour and the slow times for beginning decontamination due to travel distances and the time taken to setup the decontamination units would see many people simply leave the scene and either go home or to hospital instead.

"Part of the problem with it is you can only fit a limited amount of people through at a time. So even if you have a numerous IRU's there or what we've got now, but you know it's going to take a long time for us to get there and set up and people aren't going to want to hang around and wait to be decontaminated." (*Mass Decontamination Operative* 1).

Therefore, it appears that there is a need to consider strategies that the FRS can employ which will allow for faster responses to a decontamination incident and which can, whilst still being effective, reduce the waiting times of casualties. Without such strategies it is believed the current approach would simply take too long, the result of which respondents suggest will be ever-decreasing compliance and an increased likelihood of casualties leaving the scene and therefore significantly escalating the incident.

5.4.5 Training and Operational Readiness for Human Behaviour Discussion

"We are talking about mass decontamination, decontaminating hundreds of people, possibly thousands of people, we've really got to understand how they are going to react". (HMA 1).

The interviews detailed that there has been a lack of training and preparedness for decontamination operations in general and in particular it was widely considered to be a lack of awareness and understanding as to what human behaviours were likely to be which was most prominently missing from training packages and exercises. There was also no experience of having received any training on the importance of human

behaviour during decontamination operations or any understanding by operatives of why their interaction with casualties may be crucial to a successful outcome. All training for FRS responders appears to have been focused upon their technical duties of setting up and running the decontamination units.

However, human behaviour was recognised as being an important area with one respondent referring to human behaviour at a decontamination incident commenting, *"I think it would catch a lot of people out".* (HMA 1).

A lack of training in general on decontamination was described by respondents with a near complete lack of preparation for human behavioural elements. One responder noted in regards to understanding human behaviour that there are *"more discussion around it but no real guidance"* (HMA 3), with one of the Level 4 Strategic Managers noting in relation to field exercises *"I don't believe we've ever actually tested what human behaviour would be in the event of contamination"* (Strategic Commander 1).

This gap is therefore clearly supported by a lack of guidance documents and validated by Operatives, HMAs and Level 4 Officers and it appears that this is an area, which is clearly seen as being important and of value, but which is currently being missed.

Respondents identified how the training exercises they had taken part in had always utilized volunteer actors from the public or occasionally members of the military. Respondents remarked how this meant a high level of compliance and that they never experienced any trouble or witnessed any signs of nervousness or apprehension.

"People play act but that's not an emergency environment, people don't play act in an emergency environment, they will show different traits". (HMA 1).

"Training is always tricky as it's not a real environment. You're missing one key ingredient, the emergency". (HMA 1).

"Everyone knows it's a safe environment". (HMA 1).

"People would not act as they do in a training environment". (HMA 1).

These field exercises focussed only on the technical elements of the role, the construction of the showers and the operation of the units being practiced with casualties moving through in a very calm and controlled manner without operatives or officers being required to engage with the casualties in order to facilitate a successful operation.

Interestingly the use of field exercises has been one of the main areas of data collection for mass decontamination research. Studies by the likes of Carter *et al* (Carter *et al*., 2012; Carter *et al*., 2013a and Carter *et al*., 2014) have looked to engage participants in field exercises to try and understand their feelings and behaviours and then extrapolate these into theories to explain human behaviour at real life incidents. However, as respondents suggested there would be a large difference between being a volunteer at a field exercise, which you are prepared for and can stop at any moment, and a real-life event, at which you have been contaminated. Therefore, the validity of such methodologies must be carefully considered in light of how operatives and officers view the realism of volunteer casualty behaviours during such exercise.

5.4.6 Trust During Mass Decontamination Discussion

A number of participants expressed views regarding the role trust would play during such incidents. This theme occurred numerous times and was used to express respondents' opinions that casualties would need to trust responders in order to follow their instructions and display co-operative behaviours.

Trust is an interesting concept for the relationship between casualties and responders and has been identified in the literature as critical in situations where people are not familiar with the risks facing them. Siegrist and Cvetkovich (2000), Earle and Cvetkovich (1995), and Luhmann (2018) identify that decisions and judgments made by people without the necessary knowledge will be guided by social trust. Social trust acts as a way of reducing the complexity faced by people in their decisions and judgements and so instead of needing to make rational judgments based on knowledge, they can employ trust as a mechanism of choosing which expert to listen to.

Trust therefore seems to be seen by respondents as a crucial element in the ability of responders to engage effectively with casualties. This is also supported by the literature.

5.5 Future Research

The understanding gleaned from this study has pointed towards furthers areas of research into the influence of first responders upon the behaviours of casualties during

Hazmat/CBRN incidents. This Chapter suggests the following areas of research would be valuable to investigate:

1. Understanding what casualty behaviours are likely to occur during a Hazmat/CBRN incident and what these will mean for stay in place requirements.
2. Understanding how the response by emergency first responders will impact whether people stay or leave the scene of a Hazmat/CBRN incident.
3. Modelling the effects of this in order to more fully understand resourcing requirements and operational effectiveness.
4. What new training, policy and procedures are required in light of this new understanding?

5.6 Conclusions

Given the importance of human behaviour during a Hazmat/CBRN incident where decontamination operations are required, this Chapter identified the need to further understand what these behaviours are likely to be and how FRS responders can influence these behaviours in order to ensure more successful operations.

This Chapter further highlighted questions regarding the likely behaviours of casualties and their response to FRS responders and how these considerations are widely overlooked in planning and training for FRS personnel. This was conclusively backed up by both the operational guidance and training documents reviewed in this Chapter and also by the interviews conducted with FRS Mass Decontamination Operatives, HMA's and Strategic FRS Officers. By developing an understanding of human behaviours and

the impact FRS responders will have on them it is hoped that the findings in this Chapter will help to influence the planning assumptions and training provided in this area.

However, whilst the research also identified a number of interesting themes that require consideration in relation to decontamination operations and human behaviour, it was the identification of the initial stages of a decontamination operation as the most crucial and the most reliant upon the behaviours of the pubic, which is of greatest interest.

The initial phase was articulated by participants as being particularly crucial given that arriving FRS responders would have no way of keeping people at the scene until further resources and support arrived, beyond their ability to influence casualties to make such a decision to stay for themselves. Casualties leaving the scene present a major hazard of spreading any contaminant over a wider area, thereby significantly increasing the difficulty of an operation, whilst also putting themselves at greater risk through not receiving any decontamination or medical assistance.

This need to understand human behaviour regarding stay in place vs. leaving the scene decision-making at a Hazmat/CBRN incident and the role FRS responders can play in influencing this is hugely pertinent to achieving successful decontamination operations and warrants further research to fully understand the issue and to allow for more accurate modelling of such incidents[6].

[6] This work has been published in the International Journal of Emergency Services – Long, F., Bateman, G. and Majumdar, A., 2020. The impact of fire and rescue service first

Chapter 6 - The Role of Trust in Casualty Compliance with Emergency Responder Instructions During Emergencies

The previous Chapter strongly identifying human behaviour as the most significant influence upon the ability of the emergency services to conduct a mass decontamination operation. Having established the importance human behaviour would have at a Hazmat/CBRN incident requiring mass decontamination, it is necessary to understand what might influence these behaviours in order to better inform how responders can prepare for and act during a mass decontamination incident to most effectively engage with casualties.

However, there has never been a Hazmat/CBRN incident requiring mass decontamination in the UK. Instead, this Chapter examined the Grenfell Tower Fire in order to explore casualty behaviours during emergency situations which can then inform greater understanding of what could be expected in a mass decontamination incident.

6.1 Introduction

The Grenfell Tower Fire on 14th June 2017 claimed the lives of 72 residents and was the worst residential fire in the UK since the Second World War. During the course of this incident, residents in Grenfell Tower were advised by the London Fire Brigade (LFB)

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responders on participant behaviour during chemical, biological, radiological and nuclear (CBRN)/Hazmat incidents. *International Journal of Emergency Services*, *9*(3), pp.283-298.

about actions they should take including: stay in place; move to a 'safer room where there is no or less smoke'; close doors and keep them closed; block gaps in doors with sheets or towels to stop smoke and fumes getting in and also to evacuate the building (Grenfell Tower Inquiry 2018). These actions changed as the incident developed and residents therefore had to make rapid decisions about what actions to take, and whether to follow the advice given to them by the LFB. Ultimately, public behaviour (in terms of decisions whether to evacuate the building or not) played a key role in the outcomes from the incident, and therefore an improved understanding of the factors that affected public behaviour during this incident can help to optimise emergency management.

Research indicates that numerous factors affect the way in which members of the public behave during emergencies, and which therefore may have affected public behaviour during the Grenfell Tower Fire.

The term the 'public involved in the emergency' or similar as appropriate, is used to describe anyone impacted either directly by the fire such as residents or indirectly such as those with friends and family in the tower and differentiates them from emergency services or unaffected bystanders.

Research into public behaviour during emergencies tends to fall under two broad, largely dichotomous , approaches: 'affective' or 'cognitive'. Approaches that make assumptions about 'affective' public behaviour suggest that people will panic, act instinctively, and be unable to make informed decisions about the actions they should take to protect themselves (e.g LeBon, 1890; Kahneman 1979). These approaches emphasise the high levels of anxiety that people will experience and the accompanying

negative impact this will have on their ability to take recommended actions. In contrast, approaches that make assumptions about 'cognitive' public behaviour emphasise that members of the public will want to take actions to protect themselves, and others, during emergencies and will cooperate with each other and with emergency responders (Cocking *et al* 2009; Drury *et al* 2013). These approaches emphasise that people will want and need information about what actions to take and why.

Proponents of more affective approaches to public behaviour suggest that the lack of control, unfamiliarity and uncertainty inherent to emergency situations will result in an emotional, anxiety based response, which will be the major factor affecting public behaviour. In line with this, Slovic *et al* (2004) describe the essential role of affective decision-making, as the *"fast, instinctive and intuitive reactions to danger"* (p.24) and it has been suggested that these rapid, affect-based processes drive behaviour in situations where people are confronted with a risk for which they have insufficient knowledge or time to use more time-consuming cognitive processes (Finucane *et al* 2000; Cheng and Yiu 2022). Slovic (2000) identifies factors that may affect the way in which the public interpret risk: the extent to which the risk is perceived as voluntary (voluntary risks are more acceptable than involuntary risks); the extent to which the risk is personally controlled (personally controlled risks are perceived as less risky than those controlled by others); and the extent to which the risk is familiar (familiar risks are perceived as less risky than unfamiliar risks). Risks that are perceived as being involuntary, uncontrollable and unfamiliar are perceived to be the most risky and are sometimes referred to as 'dread 'risks (Slovic 2000). Such dread risks are therefore seen to relay on more affective processing given the lack of information and understanding and therefore a reliance on affect for decision making is more likely as Slovic *et al* 2005 states "*reliance on affect and emotion is a quicker, easier, and more*

efficient way to navigate in a complex, uncertain, and sometimes dangerous world" (p4). These approaches therefore envisage behaviour during emergencies as emotional and instinctive, resulting from the anxiety people will be experiencing, and are largely pre-determined i.e. members of the public will be expected to exhibit specific behaviours, and it is the aim of responders to effectively manage and address these behaviours.

However, proponents of more cognitive approaches to emergency behaviour suggest the opposite; with those involved in emergency incidents utilising their cognitive functions and maintaining normative behaviors and as such the way in which responders manage an incident will have a direct impact on the way in which the public behave. These more cognitive approaches emphasise the importance of trust in shaping public behaviour, i.e. the more that members of the public trust the emergency responders, the more likely they are to follow advice about recommended behaviours. Trust can be seen to result from two related but distinct constructs: legitimacy and competence (Drury *et al* 2003; Long *et al* 2020; Siegrist *et al* 2012). The former is based upon a belief that responders will manage an incident fairly and act in the best interests of members of the public (Han *et al* 2017, Deyoung and Peters 2016; Carter *et al* 2014), while the latter is based upon a belief that responders are capable of managing an incident effectively. For trust to exist responders must be perceived as both competent and legitimate (Earle and Siegrist 2006; Long *et al* 2020). To the extent that responders are perceived as acting both competently and legitimately, this will increase public willingness to comply with their instructions (Carter *et al* 2013; Carter *et al* 2014; Carter *et al* 2015). Evidence suggests that trust is shaped by the manner in which responders manage an incident, with effective communication being particularly important. To enhance trust, communication should: be open and honest; explain what actions people need to take to protect themselves and why such actions are important;

and provide practical information to enable people to know how to take protective actions (Carter *et al* 2015, Symons *et al* 2021).

During emergencies such as the Grenfell Tower Fire, members of the public will respond both to the perceived threat (i.e. the fire itself) and the way the threat is managed (i.e. the actions of emergency responders) (Long *et al* 2020). The extent to which those affected perceive the risk of the threat to outweigh the risk of any recommended behaviours, will influence how likely they are to take the actions recommended by emergency responders. Whilst the more affective approaches view these risk-based decisions as largely based on emotional, instinctive reactions (thereby largely pre-determined and unrelated to actions taken by emergency responders), more cognitive approaches see such risk-based decisions as being shaped by the actions of emergency responders and the way the incident is managed. It is important to understand the behaviour of those affected by the Grenfell Tower fire, so that the management of these types of large-scale emergencies can be optimised.

It is also recognized that the Extended Parallel Process Model (EPPM)(Witte 1992) is also potentially relevant to the current Chapter. EPPM was developed as a result of inconsistencies in the literature concerning fear appeal. Originally, based upon Leventhal's Parallel Process Model which looked at how adaptive protective behaviours arose from attempts to control perceived dangers (Leventhal 1971). It also draws from Roger's Protection motivation theory, which proposes two responses to fear; a threat appraisal and a coping appraisal (Rogers 1975).

EPPM posits that fear-inducing situations cause two simultaneous methods of processing information. This is either via a cognitively based efficacy appraisal or

through an emotional threat appraisal. The appraisal used will then lead to either a danger control process or a fear control process. EPPM states that the fear control process will lead to message rejection, whilst the danger control process leads to message acceptance and consequently to adaptive behavioural changes.

However, further exploration of the EPPM is not included within this Chapter. This Chapter has focused on the areas of competency, legitimacy and trust and the role of more affective or more cognitive decision making which are area not covered by EPPM. The Chapter has sought to extend an understanding in this area, and it would be of interest to consider EPPM alongside competency, legitimacy and trust in particular in any future studies but is not the focus of this Chapter.

Following the Grenfell Tower fire, a public inquiry was established to understand the circumstances leading up to and surrounding the fire. The inquiry was announced on the 15th June 2017 and formally established under Section 5 of the Inquiries Act 2005 on the 15th August 2017.The inquiry was split into two phases with Phase 1 focusing on the factual narrative of events (Grenfell Tower Inquiry, 2018). As part of this Phase, a number of interviews were conducted with those affected. These were conducted by those appointed by the Chairman under Section 11 (2)(b) of the Inquiries Act 2005 with more details available on the Grenfell Tower Inquiry website (Grenfell Tower Inquiry, 2018). The transcripts from these interviews contain key information relating to how those in Grenfell Tower decided whether to evacuate the building, and if so when, or whether to take other protective actions.

By analysing the transcripts from these interviews, the current study explored factors affecting decisions to evacuate, in order to contribute to an understanding of public behaviour during emergencies which can then be utilised in the field of mass

decontamination. Whilst there has been intense scrutiny as to whether the stay in place advice was correct in this situation (Guardian 2019, Independent 2019), this Chapter does not aim to draw conclusions about correctness or otherwise of the advice given. Instead, this Chapter examines what actions residents took, how they made their decisions regarding these actions and why residents were, or were not, willing to follow any advice given. Such understanding is required as although panic as an expected response has been discredited by emergency response academia (Quarantelli, 2001) there still persists beliefs that behaviour during emergencies in not cognitively driven but rather those involved in emergencies cannot be expected to be capable of making well informed decisions (Carter and Amolt 2016; Carter *et al* 2020). A clear example of such thinking can be found in the aftermath of the Grenfell fire where British MP Jacob Rees-Mogg when speaking on national radio commented that common sense on behalf of those in the Towers should have led them to evacuate the towers implying a deficiency in the decision making of those in the towers by their willingness to stay in place even though these actions had been recommended by the London Fire Brigade (Tekin & Drury, 2021).

As such further exploring the ability of casualties to make cognitively based decision during emergencies is vital.

6.2 Aims

This study aims to:

- Identify factors that affected the way in which those involved in the Grenfell Tower Fire behaved.
- Develop the understanding of factors that affect casualty behaviour during large scale emergencies, by means of qualitative analysis of secondary data sources.

An understanding of factors that affect public behaviour during emergencies, will facilitate appropriate planning and training to prepare for and effectively manage such emergencies.

6.3 Methodology

6.3.1 Ethics

This study utilised publicly available data and as such did not require ethical approval through Imperial College London.

6.3.2 Design

A secondary analysis of published data from the Grenfell Tower Public inquiry was conducted. Data were transcripts from interviews carried out as part of the Grenfell Inquiry, all of which were publicly available on the Grenfell Inquiry website (Grenfell Tower Inquiry, 2018). 72 of the transcripts that were available as of 1st February 2019 were randomly selected using a systematic approach before reading, representing 30% of the available witness transcripts. No transcripts were rejected from the analysis. A sample size of 30% of available transcript was selected as this was deemed sufficient for the purpose of the study and supported the capacity of the researcher to undertake the analysis.

These 30% of transcripts chosen fell into one of three categories in the following numbers; eyewitness statements from those inside the tower who survived (n = 42), eyewitness statements from those who were not inside the tower but witnessed the

incident at close proximity (n = 19) and statements from those who were on the phone to friends or relatives in the tower (n = 11). The proportions of transcripts within each category were not representative of the overall transcripts available but appeared as part of the random selection of the 30% of selected transcripts. Once the 30% of transcripts had been selected the remaining transcripts where not reviewed to determine which category, they would have represented had they been reviewed. The categories chosen represent the three statement types taken for the Grenfell Tower inquiry. The Grenfell Tower inquiry also took transcripts of emergency responders and other agency staff involved in the response which are not included as part of this study.

6.3.3 Data Analysis

This study was not looking to focus on testable theories but rather analysis sought to explore the relationships between more affective behaviours and more cognitive behaviours during emergencies, with a view to potentially informing further quantitative research in this area. In order to examine the data held in the Grenfell transcripts, framework analysis was utilised.

Framework Analysis was selected as it particularly good for supporting thematic analysis due to it providing a systematic model for managing and mapping the data. It is also well suited for analysis of interview data, as it is able to generate themes through comparisons both within and between cases (Gale *et al* 2013).

Ritchie and Spencer (1994) developed this methodology as a way to organise data into themes and categories (Ritchie *et a* 2013). Qualitative analysis of detailed interview transcripts is a continuous and iterative process that requires the researcher to first

manage the data and then make sense of it through descriptive and explanatory analysis.

Framework Analysis involves five consecutive steps (see Ritchie and Spencer 1994), which were followed in the analysis of the transcripts. A priori themes were identified based upon existing literature. The transcripts were then read through so as to become familiar with them and allow further themes to emerge from the data.

Sections of the transcripts were then indexed against these themes and sub-themes. These themes and sub themes were then chartered to examine the data systemically through organizing it into a matrix. Finally, learning from the previous 4 stages is brought together to look across the data sets for clusters of data in order to review and re-appraise the data to create a narrative for how the data is structured.

A coding guide was agians used to support this process and the template used for this can be seen in Figure 7.

The coding framework was applied by two additional researchers from the UK FRS, who are experts in high rise firefighting, and who each reviewed 30% of the quotes which were selected at random. 30% was selected as a robust sample which could be reviewed within the time allowance of the two FRS experts. Any disagreement between researchers was discussed, prior to the development of the final thematic framework. The results below are quotes from transcripts of one of three conditions:

- IT = In Tower and escaped
- OP = On the Phone

- EW = Eyewitness Not in the Tower

6.4 Results

The following four main themes were identified as relevant in understanding how members of the public made decisions during emergency situations:

1. Uncertainty and Anxiety: This theme identified the presence of anxiety in those involved in the Grenfell fire and how this was influenced by the uncertainty of the situation.
2 Environmental Factors in Evacuation Decision Making: This theme identified variables which influenced decisions on whether to stay in place or to evacuate. There were three sub-themes relating to why people chose to evacuate or stay in place:
    a. Physical cues (e.g. seeing smoke entering their flat)
    b. Physical Barriers, (the presence of fire or thick smoke blocking an exit route),
    c. Weighing the risk of evacuating against the risk of staying in place (e.g. the risk of moving through a smoke filled corridor to exit the building against remaining where they are and awaiting rescue or further instruction for the FRS).

3. Trust: This theme described the trust that those involved had in the FRS, and how this influenced public likelihood to follow advice, and their expectations of how the incident would develop. There were two sub-themes relating to trust:
    a. Competency: this related to how members of the public perceived the ability of the FRS to effectively deal with the situation and assist them in

maintaining their safety and returning them to normalcy. This is distinct from the concept of legitimacy, below, as it relates to perceived ability of firefighters to manage the situation rather than to a belief that firefighters will manage the incident fairly and in line with the public's own values.

b. Legitimacy: this related to how likely members of the public were to believe that the FRSs would manage the incident fairly prioritising them appropriately and acting in their best interest and is a subjective measure with the public's perception of legitimacy being of importance to this study.

4. Helping and Co-Operative Behaviours in Emergencies: This theme identified how those involved in the emergency helped each other.
    a. Members of the public are helpful and co-operative: This theme described helping and cooperative behaviour displayed by members of the public. E.g. waking up neighbours to alert then to the fire.
    b. Advice from friends, family and neighbours: This theme identified how members of the public sought advice and shared information with those close to them be they neighbours or friends and family. E.g. discussing whether to evacuate or remain in place.
    c. People go to the scene to help: This theme described the behaviour of relatives and friends of those in Grenfell Tower, particularly in relation to their desire to attend the scene to assist those involved. E.g. friends and family trying to enter the Tower to go and rescue their loved ones.

6.4.1 Coding Framework Results

There was broad agreement between the raters with Rater 1 agreeing with 77.4% of the codes and Rater 2 agreed with 93.5% of the code. There was an 81% agreement between the two raters.

The inter-item correlation scores for each rater were as follows with rater 1 being the original researcher.

- Raters 1 and 2 had a 0.620 inter-rater score
- Raters 1 and 3 0.902 inter-rater score
- Raters 2 and 3 0.700 inter-rater score

In accordance with McHugh (2012) this analysis identifies any score above 0.7 indicates a strong level of agreement between raters. As such the scores between raters indicates strong level of agreement between the original rater and rater 3 and between the two additional raters. Whilst the original rater and rater 2 is below the 0.7 to show strong agreement this still indicates a moderate degree of agreement (McHugh, 2012).

6.4.2 Uncertainty and Anxiety Results

Those involved often referred to feeling anxious and uncertain during the fire. Comments included "*G just didn't know what to do" (IT66)* and *"We're trying to understand what can we do and where can we go" (IT66).*

Alongside uncertainty, the transcripts correspondingly recorded anxiety in those inside the tower *"R told me to check the kitchen to put my mind at ease so I went to the kitchen to make sure everything was ok." (IT 31)*

"I did feel anxious at this point, but I tried to stay calm. I didn't know how bad the fire was" (IT 63)

"I tried to stay calm but I couldn't and neither of us knew what to do." (IT 63)

Many members of the public referred to themselves or others panicking:

"I don't know why we didn't call the fire brigade first but we didn't, maybe we were just panicking." (IT 71)

"He was looking panicked, but I can't remember him saying anything." (IT 68)

"It took me about 5 minutes to get myself together because I was panicking. I couldn't feel the ladder with my foot at first but I eventually managed it and I started to work my way down the ladder" (IT 31)

However, whilst the term 'panic' was used, this was often followed by a description of cognitively weighed actions e.g. *""I knew we had to get out of the building and started to panic. I ran into my son's room […] I shouted that we needed to leave as the building was on fire." (IT 62).* This suggests that, while those involved used the term 'panic', this appeared to be used interchangeably with 'anxiety' or 'fear' and did not necessarily represent a purely affective response.

6.4.3 Environmental Factors in Evacuation Decision Making Results

Analysis of the transcripts identified two environmental factors that affect individuals' decisions to either remain in the Towers and shelter in place or to evacuate: physical cues (physical factors that prompted people to evacuate); and physical barriers (physical factors that prevented people from leaving).

6.4.3.1 Physical Cues Results

Signs of fire or smoke appeared to be one of the main drivers of members of the public identifying a need to evacuate.

"I asked if they were coming to get us as the smoke was getting stronger outside the building. At this point I was told by the same firefighter that it might be best for us to take the stairs. I thought that was a good idea". (IT 31)

"It was an utter shock to see flames at the window and I realised then we needed to get out of the building quickly." (IT 64)

"I could see smoke outside which I think was coming from the flats below. I said to A 'Let's just get dressed and leave." (IT 63)

6.4.3.2 Physical Barriers Results

These physical cues could also become barriers to actions. There were a number of occasions where members of the public could not physically evacuate as the risk was too great and forced them to stay where they were e.g.

"Why aren't you coming out?' She said that she couldn't as the smoke was so bad and whenever she opened her front door she couldn't see anything." (OP 21)

"I was coughing as the smoke got stuck in my lungs. My eyes started burning so I quickly closed the door." (IT 31)

"She only opened it a small amount, but I could see that the landing was filled with thick black smoke and the heat of the smoke hit me straight away. M closed the door quickly and we went back inside the flat; back to the kitchen." (IT 71)

"explained to him that there was too much smoke in the hallway so we couldn't get out." (IT 63)

6.4.3.3 Weighing the Risk of Evacuating Against the Risk of Staying in Place Results

There was evidence that those involved considered the risks of taking each of the available actions (e.g. evacuating or staying in place) before deciding which action to take.

"Smoke was everywhere. It was absolutely terrifying. I tried to walk across the other side of the hallway towards the stairway. I had heard M shouting that he was going back to the flat. I remember him shouting "B" (which is my nickname) "we're not going to make it. We are going to die in here. I'm turning back." (IT 48)

Perceptions of risk often changed as a result of the changing circumstances of the fire, as can be seen in the quotes below. This respondent initially felt that the risk of evacuating was too great:

"My friends had been constantly telling me that we needed to leave the building, but we kept telling them that we couldn't as the smoke was too much" (IT 71)

However, as the risk of the fire increased, the risk of staying in place began to grow to a point where it was perceived as a higher risk than evacuating, which resulted in the individual deciding to leave:

"I spoke with M and said that we needed to try and get out. I told her that the fire brigade might not be able to get us and if we didn't try, then we would die in the flat. I told my friends that we were going to try and leave and asked them to relay that message to the fire brigade in the hope that they could come up and help us." (IT 71)

It can be seen how the risk of the threat (e.g. fire, smoke) was considered alongside the risk of any available protective actions (evacuation or stay in place) and that, as the risk changed, so too did individual decisions about whether it was safer to evacuate or stay in place. There was also evidence that at times, the physical risk of evacuating (e.g. falling from a ladder) was perceived as greater than the risk of the fire, and this resulted in delays to evacuation e.g.

"When I looked at the fireman's ladder it was very slim, seemed flimsy and unsafe. I asked the firefighter to tie me to the ladder or do something to make it secure but he said I had to go now and move quickly as the fire was approaching. He said the fire and smoke were

escalating and the building was burning rapidly. I will never forget him saying to me "please just get on the ladder so I can save your life". That is when the reality of the situation dawned on me. I just had to risk it if not I would die in the fire." (IT 31)

6.4.4 The Role of Trust in Casualty Compliance Results

A number of residents at different stages of the incident followed the advice given to them by emergency responders either via face-to-face communications or over the phone, and this therefore played a role in members of the publics decisions whether to stay or evacuate.

"H also told me that I needed to get out, but I told him that we had been advised to stay by the fire brigade" (IT 71)

"He asked me how I was and he said that they were in their house as well. He said that he had phoned the emergency services and they told him to wait and not to leave the flat. He said that he was sitting together with his children and he advised me to do the same with my children and that the emergency services would come and take us out and rescue us." (IT 65)

Several of those interviewed specifically stated that they trusted the responders, and that this was why they had followed their instructions:

"S for a second time told me that the fire fighters were coming for us and that we should wait for help. M was also saying, "Why are we staying, the fire is in the bedroom?". S clearly trusted the Fire Brigade advice to stay where we were and they

would rescue us". (IT 32)

"One of the roles of a firefighter is to save lives [….] We then sat down to wait because we trusted the advice the firefighter had given us." (IT 65)

"The firefighter told us to "Stay where you are and don't panic". I was shaking and scared but felt comforted that I had spoken to the firefighter. I thought we would be rescued". (IT 31)

The transcripts revealed two specific elements that contributed to trust: the perceived competency of the FRS (i.e. FRSs being seen as capable of taking appropriate actions to protect the public); and the perceived legitimacy of the FRS (i.e. FRS being seen as acting fairly and in the best interests of the public).

6.4.4.1 Competency

Several of those interviewed reported that they believed the fire service would be capable of managing the fire e.g.

"At first I was not worried because there have been small fires in other blocks before and they have always been controlled and put out by firefighters". (IT 22)

If the emergency services were viewed as competent and able to help, then their advice was more likely to be followed:

"[My wife] was reassured by having spoken to someone who seemed to know what they were talking about. My wife told me that the 999 operators had told her to put items around the bottom of door in order to stop smoke coming into our flat. I went immediately to get a quilt and I started putting it around the bottom of the door". (IT 38)

As such it appears that being viewed as competent and therefore able to help contributes towards a casualty's willingness to follow advice given by the emergency services.

There was also evidence that initial perceptions of FRS competency could be lost as a result of actions taken by responders during the emergency. On occasions where emergency responders appeared not to be capable of taking effective actions, members of the public felt anger and frustration as a result e.g.

"I remember people getting frustrated because it appeared ineffective, and we thought more fire engines would have been sent." (EW 69)

6.4.4.2 Legitimacy

Legitimacy is the belief that FRS' have the authority to manage an incident and will behave in a fair way and act in members of the publics' best interests. There was evidence that those involved perceived that the FRS would manage the incident legitimately, and that this affected their actions e.g.

"I decided that I should walk towards the firefighters and that if my life was in danger they would surely warn me," (IT 58)

"When the door was opened there was a firefighter in uniform. […] He said to stay in the flat and put a blanket around the door and cover every hole to stop the smoke coming in. And he said `you're safe.' Of course, we believed him." (IT 65)

As with perceptions of competency, if the belief in responders' legitimacy was lost (due to actions taken by responders), this led to negative perceptions of responders e.g.

"People around me were talking about how they felt betrayed because they had told residents in the Tower that it was safe to stay inside when it clearly was not." (EW) 15

"I do not believe the firefighters were helping as much as they could have. They could have done more during the early stages of the fire. The firemen did not look strong they looked shocked". (EW 29)

"I recall that other man said "we cannot guarantee we will get to them. They need to come out themselves." I'll never forget that and how it made me feel, like I was being slapped in the face. After three hours of being in the building I thought it was a joke." (IT 71)

The sense of betrayal indicates that the FRS were initially perceived to be legitimate and, as such, when they failed to meet the expectations associated with this legitimacy, such adverse reactions occurred.

6.4.5 Helping and Co-Operative Behaviours in Emergencies Results

6.4.5.1 Members of the Public are Helpful and Co-operative

Throughout the transcripts it was clear that members of the public caught up in the disaster looked to help each other. A large number of those in Grenfell Tower reported being awoken by phone calls or knocking on their doors from neighbours wanting to alert them to the fire, before looking to their own safety. Many also invited their neighbours into their properties to shelter in a place of perceived greater safety.

"But around four other people from her floor entered her flat because her corner of the building was the only side that was not affected by the fire at that time. People from the flat opposite to hers came in, and she was offering help and offering people to come in". (OP 8)

"She said she woke up because she could hear hard knocks on the door. There was a woman shouting and screaming. G and M opened the door and found two people outside, a young man and a woman. G thought that they must have lived on the same floor. They let them come into the flat." (IT 32)

"I recall seeing two adult males coming down the stairs just as I was opening the door. I would describe them as big, tall men. The stairs were not busy and I do not recall seeing any other residents I thought everyone else must have got out already. The two men that I had seen coming down were not people that I was personally familiar with. One of the men walked up to me and picked me up and placed me over his shoulder. He did this before I had said a word to him, although I was clearly in a distressed state". (IT 52)

6.4.5.2 Advice from Friends, Family and Neighbours

Residents frequently provided information and advice to those they encountered, and families and friends called or sought each other out to share information and discuss a course of action. As such, the advice and actions of others around them often influenced individuals' behaviour.

This was true both of advice provided via calls from those outside the tower e.g.

"She had been trying to call us both about the fire. H told W to get out of the building as it was on fire. […] We left so quickly that I was still in my nightdress. I think it took no more than five minutes for us to leave the flat". (IT 62)

"It was W. W told me to get out of my flat and by the power and strength of his voice, I knew not to argue with him and to just leave" (IT 59)

And from others in the tower e.g.

"leave urgently. She said that the flat was full of smoke. F works for X and so has received training about how to react in emergency situations. She was very clear and commanding" (IT 60)

"This was at around 1.00am. Whoever was banging did not stop and just kept on banging on our door. My husband got up to see who it was and found our neighbour from Flat X, which is on the same landing as our flat standing outside. I told us that he had heard that there was a fire on the 4th floor and he thought that it best for us to leave and just get out

of the building. Although there was absolutely no sign of fire at this stage at all, there were no flames or smoke anywhere, either in our flat or on the landing, I decided with my husband that it would be sensible to follow his advice and just leave the building." (IT 57)

6.4.5.3 People went to the Scene to Help

There was evidence that many people associated with those in the towers immediately went to the scene when they discovered what was happening. There was a clear and consistent desire from friends and family to make their way to the incident with a desire to assist those in need.

"My brother H and I devised a plan to separate and to go opposite ways around the tower in order to increase our chances of getting into the building to save our family members". (OP 6)

"Before this, I only saw normal people like me or residents or young people running in and getting people out. One of the men I recall, I think he was Somali, came from the Mosque. He said "I'm going in, I don't care" and "when I come out you can arrest me". He managed to go in and save his family members". (OP 8)

"She said that she had tried to go towards the Tower, but the police had stopped her going further. She had taken a few blankets and wanted to try and help rescue people. She said that she had seen people jumping from the window". (EW 15)

6.5 Discussion

The analysis of transcripts from the Grenfell Tower Inquiry provided numerous insights into the experiences and behaviours of those involved in the Grenfell Tower Fire. There was evidence that those involved experienced anxiety and uncertainty due to the incident, though this did not often prevent them from making cognitively weighed decisions regarding actions they should take.

Other factors that appeared to affect behaviour included the following: physical cues (e.g. the presence or absence of smoke), information provided by friends and family, and advice and instructions provided by emergency responders. The extent to which those involved acted upon emergency responders' instructions appeared to depend, to some extent, on their trust in those responders managing the incident. Finally, it was clear that those members of the public involved in the Grenfell Tower emergency attempted to help each other, and that their friends and family also tried to help. These themes are further explored alongside some of the key literature below.

6.5.1 Uncertainty and Anxiety Discussion

The Grenfell Tower Fire presented a unique situation for those members of the public involved. Such an event was beyond the experience and knowledge of those living in the Tower, and consequently, it is no surprise to see that anxiety was common. This is in line with previous research which demonstrates the role of uncertainty in driving anxiety during emergency situations (e.g. Slovic, 2000). Interestingly, whilst members of the public often referred to themselves and others as 'panicking', in several instances it was clear from their responses that the behaviours they described, whilst representing fear

or anxiety, did not inhibit their ability to make cognitive decisions (e.g. phoning the emergency number 999, helping others, attempting to evacuate). This has previously been recognized with Fahy *et al* (2012) finding in a study of behaviour during fires that *"panic, in terms of irrational behaviour, is rarely seen in fires"* (p336) and that "*descriptions of 'panic' relate more to fear or heightened anxiety than any sort of behaviour leading to the death or injury of a person."* (p336).

"Real panic" in contrast describes behaviours that are affective in nature (Sheppard *et al*., 2006), and therefore members of the public described behaviours that did not actually represent panic. This finding is in line with a wealth of previous research that demonstrates that panic is rare during emergencies, and that people continue to behave in a normative and cooperative manner (e.g. Aguirre *et al* 1998, Johnson 1987, Johnson 1988, Quarantelli 1954). So, whilst the uncertainty of a situation such as Grenfell can be expected to cause anxiety, this does not mean that members of the public are incapable of making cognitively weighed decisions.

This is a crucial finding, as the members of the public involved in the Grenfell Tower incident maintained their ability to engage cognitively with the situation and with the advice and instructions of the emergency services. This highlights the importance of ensuring that such behaviours during emergencies are well understood in order to ensure planning, training and strategies that embrace this learning.

This is supported by Carter and Amolt (2016) and Carter *et al* (2020) who identify the potential impact on guidance, training and operations. They identified how beleif in more affective approaches to public behaviour during mass emergencies can lead to strategies

which may at best be unhelpful for the management of an incident and in fact may actively inhibit operations and be counterproductive to engaging a supportive public response.

6.5.2 Environmental Factors in Evacuation Decision Making Discussion

The transcripts revealed that environmental cues and barriers played a key role in the decisions made by members of the public regarding whether to evacuate or stay in place. The presence of smoke or flames was often a driver of the decision to evacuate, though conversely, too much smoke was often given as a reason for not evacuating and for staying in place instead. As the physical cues of the fire intensified, so too did the activities to attempt to gather information or take protective actions, with members of the public weighing up the risk of either staying in place or risk evacuating. This is in line with previous research which highlights that the presence of smoke, flames and debris affect the evacuation of people from high-rise buildings for example Gershon *et al* (2007). Interestingly, at times members of the public appeared to weigh the perceived risk from the threat (i.e. the fire) against the perceived risks of evacuating (i.e. falling from a ladder). When the former outweighed the latter, this resulted in members of the public taking action.

6.5.3 The Role of Trust in Casualty Compliance Discussion

Many of those interviewed reported that they took advice directly from the Fire Fighters (FFs) they encountered or from Fire Control Operators (FCOs) to whom they spoke over the phone. Most people initially expressed trust in responders and the information they provided and expected that they would help them. This trust revolved around both competency and legitimacy, in line with Eiser *et al* (2012) suggestion that when

understanding who is trusted in relation to public responses to expert advice during natural disasters, *"research suggests that we need to distinguish between trust in others knowledge or expertise on the one hand, and their motivation, honesty and integrity on the other hand"* (p11).

However, as it became apparent in some instances that they unable to help, in this case due to the nature of the incident, consequently there was a reduction in trust in emergency responders and in their handling of the incident. This agrees with previous research which has shown that the way in which emergency responders manage an incident affects the perceived legitimacy of emergency responders (e.g. Carter *et al*., 2014). This reduction in legitimacy has been shown to reduce the willingness to comply with responder instructions by members of the public (e.g. Carter *et al*., 2014; Carter *et al* 2015). It is therefore essential that responder actions are perceived as legitimate, in order to enhance any compliance.

There are two major issues relating to trust that need to be considered. First, trust appears to be crucial in determining the relationship between members of the public involved in an emergency and members of the emergency services responding to it. Trust has been suggested by other fields of risk management to guide decision making, especially where there is little knowledge of a subject, which of course is most likely in emergency situations for most of the public involved (Siegrist and Cvetkovich 2000; Luhmann 2018). Secondly, trust appears to assist in facilitating decision making and when positively held can help promote public compliance with recommended protective behaviours (Rubin *et al* 2012; Gaunlett *et al* 2018).

Hence, understanding how trust is built and maintained by emergency services appears crucial in order to facilitate co-operation with instructions provided to the public to assist in the ability of the emergency services to perform their operations.

Questions surrounding trust therefore need to be addressed including: what levels of trust do emergency services hold within different communities? Should different emergency services provide communications and instructions at different emergencies or to different communities? Such questions require further research and consideration to ensure the concept of trust especially in relation to emergencies and the emergency services is more fully understood.

6.5.4 Helping and Co-operative Behaviours Discussion

The transcripts also identified that people were willing to help and cooperate with others. This is in line with Drury *et al* (2009), who found that during the London bombing attacks of 7 July 2005, members of the public demonstrated a willingness to help others around them regardless of any prior connection, and even at considerable risk to themselves. This also provides support to 'more cognitive' approaches to emergency behaviour, demonstrating that rather than behaving in an affectively driven or self-seeking way, members of the public will help others and tend to the welfare of their neighbours.

Drury *et al* (2009) also highlighted helping and co-operative behviours and suggests that resilience during an emergency is not just reliant on the emergency services but can develop rapidly in communities themselves. The importance of such findings is that it identifies the need to consider and include the public in policies and strategies for dealing with emergencies. This consequently allows the public to participate in their own safety

and wellbeing and therefore there is a need to consider how the public can be effectively informed during an emergency to facilitate such participation.

6.5.5 Practical Application

This Chapter finds that trust in emergency responders is essential in facilitating co-operation, and that it influences a casualty's engagement with the emergency responders and co-operation with the advice given. This understanding of trust will be crucial for informing the approaches and training taken by emergency responders in dealing with members of the public during emergency situations and most pertinently for this Thesis with Hazmat/CBRN incidnets which require mass deconamntion.

The analysis of the Grenfell enquiry transcripts also identified the various factors that contribute to a casualty's decision to either: evacuate, shelter in place or take another form of protective action. Physical cues appeared to play a very important role in the decision-making process with smoke and signs of fire promoting evacuation. Members of the public also looked to engage with others in the building to understand which course of action to take whilst many were also influenced by the advice given by emergency services. In most cases, a combination of all these elements played a factor in influencing perceptions of members of the public of both the threat being faced (the fire) and the behaviour being asked (evacuation, stay in place or other risk mitigating behaviours). Hence, these transcripts show how members of the public had the ability to receive information and advice and utilise this effectivity to weigh various options relating to the perceptions of the risks facing them.

Overall, the findings presented here indicate a variety of factors may affect the behaviour of members of the public during major incidents. These findings support the view that the behaviour of those involved in such incidents will be largely normative (despite high levels of anxiety and uncertainty). Those involved demonstrated that they would weigh up the risks of different behaviours before acting, would listen to and act upon advice from emergency responders, and would want to help others. Of particular interest is the finding that the way in which emergency responders managed the incident affected the trust of members of the public in responders and the information they provided, which may have impacted their behaviour. It would therefore be beneficial for future research to explore what actions and communications from emergency responders could be used to ensure perceptions of responder legitimacy and competency. It may also be beneficial to explore how pre-existing levels of trust in different response agencies (i.e. FRS, Police, Ambulance) may contribute to the behaviour exhibited by members of the publics during a major incident.

6.6 Limitations

The transcripts from the Grenfell Tower inquiry provide valuable first-hand accounts of the experiences of those involved, and therefore represent a unique resource from which to learn directly from such an incident. However, there are some limitations of this research, which should be considered when interpreting the findings.

With this study using a secondary data analysis there are some limitations associated with these findings.

As the interviews were conducted by another researcher, in this case the Grenfell Tower Inquiry, it was not possible to fully explore areas that arose during the interviews. As the goal of this research was different to the aims of the inquiry those performing the interviews did not examine in depth the areas which would have been most interesting to this study limiting the pertinent information available for this studies aims.

The data was also collected retrospectively following the event. The interviews occurred up to a year and a half after the incident happened. The incident was also a highly stressful event and attracted a great deal of media attention. The effects this will have had on respondent's recollection of events must also be considered as must the fact that those choosing to give interviews with the Inquiry and were therefore self-selecting.

Another limitation was that it was not possible to establish the interview approach that was used such as what types of questions were asked or the methodology applied in the interviews.

It was also not possible to establish if any form of emergency response training has been given to residents nor what prior experiences or knowledge, they may have had relating to emergency situations beyond that which they disclosed in their transcripts.

Finally, it was also not possible to capture the characteristics of the sample (e.g. age, gender etc.) and therefore not possible to compare the characteristics of the sample with those of the available transcripts.

6.7 Conclusions

The tragic events at the Grenfell Tower that unfolded during the night of 14 June 2017 resulted in the loss of 72 lives, eliciting shock and ultimately leading to a public inquiry. This Chapter, by systematically analysing a sample of the transcripts of that inquiry, has identified that casualties during that fire remained rational in their decision making and were unlikely to panic. Whilst uncertainty and anxiety were common, panic did not occur and casualties both maintained social norms and co-operated. Consequently, emergency services were able to effectively engage with casualties and, as such, casualty behaviour was not an inhibitor of operations.

Another finding of this Chapter is that trust in emergency responders is essential in facilitating this co-operation, in that it influences a casualty's engagement with the emergency responders and co-operation with the advice given. This understanding of trust will be crucial to inform the approaches and training taken by emergency responders in dealing with casualties during emergency situations.

The analysis of the Grenfell enquiry transcripts also identified various factors that contributed to casualties' decisions to either evacuate, shelter in place or take another form of protective action e.g. physical cues and advice given by emergency services. In most cases, a combination of elements played a factor in casualties' decisions regarding what protective actions to take including the casualties' perceptions of both the threat being faced (the fire) and the behaviour being asked (evacuation, stay in place or other risk mitigating behaviours). Hence, these transcripts show how casualties had the ability to receive information and advice and utilise this effectivity in order to weigh various options relating to the perceptions of the risks facing them.

Finally, critically this Chapter views the need to understand human behaviour with regards to the role trust plays in the decision-making of casualties and their willingness to follow responder advice as essential. The public will generally be active in support of emergency responders as long as trust is maintained and the FRS need to further understand and fully accommodate this[7].

[7] This work has been published in the International Journal of Disaster Risk Reduction – Long, F., Majumdar, A. and Carter, H., 2023. Understanding levels of compliance with emergency responder instructions for members of the Public involved in emergencies: Evidence from the Grenfell Tower fire. *International Journal of Disaster Risk Reduction*, *84*, p.103374.

Chapter 7 – Casualty Behaviours During Incidents Involving Hazardous Materials

The review of the Grenfell Tower Fire in the last chapter identified that the behaviour of members of the public involved in an emergency has a direct and significant impact on an emergency response, and therefore needs to be better understood. The choice of the Grenfell Tower Fire in this thesis provides a real-life incident where casualty decision making, and associated drivers of behaviour have been captured in post incident interviews as part of a public inquiry. This thesis now looks to expand on this learning by utilising another real-life incident, the fire in an Ocado distribution centre, in Andover, Hampshire, which involved a hazardous material and is therefore more closely related to the type of incident which may require a mass decontamination response.

A survey was undertaken to capture the experiences of those who were required to evacuate their homes or places of work as a result of the fire and associated hazardous material risk. This survey was then analysed, with path analysis utilised in order to further explore behaviours and develop a behavioural model of what influences these behaviours.

7.1 Introduction

When incidents involving hazardous materials occur, it is imperative that members of the public follow emergency responders' instructions in order to protect themselves from any potentially harmful effects. Actions taken by emergency responders to reduce casualties' risk during Hazmat/CBRN incidents, e.g., decontamination, evacuation or

shelter in place, may be highly stressful for casualties (Holloway *et al.,* 1997) given the unfamiliarity and uncertainty of the situation for those involved. During such incidents it is therefore essential to answer the following questions:

i) how are members of the public likely to behave?

ii) what factors influence their behaviour during such situations? and

iii) what impact will different behaviours have on effective emergency response operations?

It has been suggested that Hazmat/CBRN incidents have the potential to create disorderly (Bhardwaj, 2010; Clarke *et al.,* 2008) or aggressive behaviours (Koenig *et al.,* 2008), which would present significant challenges for emergency services responding to the incident. However, there is considerable research which demonstrates that disorderly behaviour is likely to be rare, and that the public are likely to behave in a helpful and cooperative manner (Aguirre *et al.,* 2011; Cornwell, 2003; Johnson, 1987; Johnson, 1988). Research into public behaviour during Hazmat/CBRN incidents suggests that the behaviour of members of the public is likely to be impacted by how emergency responders manage such incidents (Carter, 2013c; Carter *et al.,* 2015a). For example, during incidents in which the public are treated with respect and provided with sufficient information, they are more likely to behave in an orderly and cooperative way. Such research has therefore been used to inform some limited guidance and training for emergency responders in the management of these types of incidents. In particular, this has resulted in increased training for emergency responders on the psychosocial aspects associated with these incidents. However, a recent review of guidance for Hazmat/CBRN incidents highlighted that it is still largely based on outdated assumptions about public behaviour during these types of incidents (e.g. disorder, mass panic) rather than on evidence (Long *et al.,* 2020). This outdated

thinking is also used to inform planning assumptions, particularly those associated with the placement and deployment of specialist resources.

The two approaches described in the previous paragraph can broadly be defined as the affective' or 'cognitive' models of human behaviour.

The more affective models are based upon the idea that behaviours during emergencies are more irrational and suggests that decision making during emergency contexts is inherently different from decision making during other contexts. Kahneman and Tversky (1979) identified two systems used in decision making: 'fast think' and 'slow think. Slow think is a measured process involving a conscious cognitive process whilst fast think is a quick automatic reflexive process which doesn't require any conscious effort (Kahneman and Tversky, 1979). Emergency situations are characterised by a lack of control, unfamiliarity and uncertainty and this results in the primacy of an emotional, anxiety driven response (Bhardwaj, 2010; Cornish, 2007; Finucane *et al.,* 2000; Loewenstein *et al.,* 2001).

Behaviour during emergencies is therefore viewed as emotional and instinctive, occurring due to anxiety and as such it is a mainly pre-determined response that cannot be influenced by emergency responders.

Alongside the more affective model are the more cognitive approaches. These approaches views behaviour of casualties during emergencies as being driven by rational thinking and as such casualties can be trusted with information (Proulx and Sime, 1991) and able to think logically in order to participate and assist in helping themselves and others.

Normative approaches, in particular, have been used to describe these more rational pathways. Normative theories of behaviour have developed over time from Turner and Killian's (1957) initial Emergent Norm theory with numerous studies exploring the factors identified through the development of the 'rational' approach (Carter *et al.,* 2015b; Turner and Killian, 1957; Turner and Killian, 1972; Turner and Killian, 1987; Aguirre *et al.,* 1998; Carter *et al.,* 2013c; Pangi, 2002) most notably Carter's (2014) seminal work, which explored the roles of legitimacy and communications based on the social identity approach in relation to compliance and co-operation. With Carter *et al* (2013c) the focus is on legitimacy in relation to trust, Carter *et al* (2013c) however did not further examine the drivers of anxiety.

This Chapter aims to extend this understanding by exploring a broader understanding of trust and the drivers of anxiety and their interaction with risk perceptions and co-operation. It will also look to add in the more affective or irrational pathway in order to gain a better understanding of how the variables identified in this approach interact with the more affective or rational approach in informing risk perceptions and co-operation.

Furthermore, in contrast to previous studies that have used field exercises or visualisation techniques to explore behaviour (Carter, 2013a; Carter *et al.,* 2015a; Carter *et al.,* 2013c; Carter *et al.,* 2014), this Chapter uses data from experiences of a "real world" emergency incident.

It is also worth mentioning Klein's (1993) Recognition-primed decision (RPD) model. The model has been developed to show how fast and effective decision making occurs during complex situations like those discussed in this Chapter.

This model has traditionally been associated with military, emergency medical and rescue personnel who are required to make decision under conditions of time pressure, incomplete information and poorly defined objectives.

The limitations of RPD centre around the need for decision makers to hold extensive experience of a particular incident or situation in order to be capable of correctly recognising critical cues in order to inform their rapid and effective decision making.

As such whilst this model does relate to decision making in emergency situations the author does not judge that it is fully suitable in situations involving members of the public with no prior experience of an emergency situation.

In order to explore how social and psychological variables influence public cooperation during Hazmat/CBRN incidents, a carefully designed questionnaire was utilised to survey members of the public who were evacuated from their homes and places of work during a large fire at an Ocado distribution centre in Andover, Hampshire, in February 2019. The incident began at 02:51 on the 5th of Feb 2019 and was declared a Major incident by Hampshire Fire and Rescue Service at 23:15.

At this time the decision was made to order the evacuation of a kilometre squared area upon the discovery of an ammonia tank on the roof of the facility which was threatened

by fire. The message went out to those affected via social media channels alongside door-to-door foot patrols by the Police.

The evacuation itself was uneventful with no issues recorded and those affected leaving under their own powers either by foot or private vehicles.

This incident is particularly relevant to this Chapter since evacuation was necessary due to the risks of explosion and the leaking of this hazardous material. This Chapter presents the findings from this survey and develops a better understanding of the social and psychological factors, including their interactions, in promoting public cooperation with responders' instructions during Hazmat/CBRN incidents.

The Chapter begins by reviewing the literature on the various social and psychological factors that may affect public behaviour during a Hazmat/CBRN incident and hypothesises how these may interact.

7.2 Review of the Literature on Psychosocial Factors

7.2.1 The Role of Uncertainty, Unfamiliarity and Lack of Control During Hazardous Materials Incidents

There is a substantial body of research into risk perception which has shown that human beings do not judge risks equally. Numerous pieces of research (Alexander and Klein, 2006; Bleich *et al.,* 1992; Sheppard *et al.,* 2006) have identified a series of risk counterparts, which make people view a risk as more or less acceptable regardless of its

true likelihood or severity to them. Lack of control is viewed through the voluntary versus involuntary risk framework, whereby voluntary risks are more readily acceptable to people than risks which they find imposed upon them, and personally controlled risks or those controlled by a group in which an individual identifies are more readily accepted than risks controlled by 'others', that is to say people outside of a group within which an individual closely identifies. Here the level of control held over the risk is a crucial defining element of risks perceptions. Familiar risks are more accepted than unfamiliar, while risks with potential benefits or potential reduction of understood harms are better abided than risks with little or no perceived benefit or reduction of harm, that is to say where there is a greater level of certainty around outcomes (Gray and Ropeik, 2002). Here then the risk perception literature shows the role that unfamiliarity, uncertainty and lack of control will have upon risk perceptions (Adeola, 2009).

Uncertainty, unfamiliarity and lack of control are likely to be highly prevalent during incidents that involve hazardous materials, as the agents and substances involved may take a significant amount of time to be fully identified by emergency services and so it may take time to determine appropriate further interventions which casualties will likely not have a choice but to comply with. All of this will be beyond the experience and knowledge of most casualties involved. It is therefore likely that members of the public will be anxious in the face of these uncertain and unfamiliar risks. It is likely that the unfamiliarity, uncertainty and lack of control will generate high levels of anxiety.

7.2.2 The Role of Anxiety During Hazardous Materials Incidents

Anxiety can be understood as a *"tense, unsettling anticipation of a threatening but vague event; a feeling of uneasy suspense"* (p. 3) (Rachman, 2013). Carter (2014) defines anxiety as distinctly different from fear or panic with the difference being drawn by identifying fear as the response to a '*identifiable threat*' (p. 29), whereas anxiety was denoted as occurring in response to a perceived threat which may or may not be present or as severe as perceived. There are two types of anxiety identified in the field of psychology: trait anxiety (feelings of stress, worry or discomfort that people will feel across normal everyday situations); and state anxiety (a temporary feeling of fear or nervousness during a moment of perceived threat) (Spielberger and Sydeman, 1994). State anxiety is therefore the type of anxiety relevant to understanding public behaviour during Hazmat/CBRN incidents.

Members of the public are likely to experience anxiety during hazardous material incidents as people will have little to no experience or understanding of such situations and therefore will have minimal knowledge with which to make choices (Long *et al.,* 2020; Bhardwaj, 2010; Cornish, 2007). Pangi (2002) highlights several aspects of these types of situations that may create anxiety, including: lack of control over the situation; potential restrictions on casualties leaving the scene; and lack of understanding about actions that need to be taken. As can therefore be seen, Hazmat/CBRN incidents can create a mix of both uncertainty and a lack of control in an unfamiliar setting. On top of this, the types of agents that could be involved have the potential to generate anxiety out of proportion to the actual scale of the incident (Alexander and Klein, 2006; Bleich *et al.,* 1992) as it will be an opaque risk being faced which will increase the already high

levels of uncertainty and unfamiliarity that are likely to be being experienced by casualties.

During incidents involving hazardous materials, Carter *et al* (2013a) identifies the role of anxiety and the need to focus on understanding communication and management strategies, which are likely to prove effective in assisting to manage anxiety and improve the behaviours of those affected. It is important to note that Carter *et al* (2013a), alongside a wider body of literature indicates that anxiety is likely to occur, as opposed to panic, which is distinct and will involve fear or anxiety about a real or perceived threat. The crucial difference between anxiety and panic is that panic involves a level of irrationality in the behaviour displayed (Sheppard *et al.,* 2006), that has been shown to be rare during mass emergencies and disasters (Johnson, 1987; Johnson, 1988; Quarantelli, 1954).

However, while casualties may be expected to remain relatively calm and rational, to what degree will anxiety, identified by Carter *et al* (2013a) as highly likely during such incidents and currently omitted from any modelling and most training preparations, impact the willingness of casualties to co-operate with responders?

7.2.3 The Role of Affect as Information During Hazardous Materials Incidents

When considering how people process information, Kahneman (2011) identified two systems by which information is processed by the brain; these he labels the 'fast think' and 'slow think' systems. 'Fast think' is described as a reflexive or automatic process that occurs very quickly and without the need for any conscious effort to be taken by a

person in order to achieve its action, while 'slow think' is described as a slower and more measured process involving a conscious cognitive process.

Traditional risk communication theory has often understood 'slow think' cognitive processing to be the key to how individuals make risk-based decisions (Fischhoff, 1995; Fischhoff and Scheufele, 2013). Within this approach, behavioural decisions were seen as the result of the careful weighing of the advantages and disadvantages presented through risk communication. However, this idea is been challenged with many theorists now exploring and developing an understanding of how feelings and emotions, or 'affect', influence risk-based decision-making (Slovic *et al.,* 2013; Chaiken and Trope, 1999; Kahneman and Frederick, 2002). Slovic *et al* (2013) define affect as "fast, instinctive and intuitive reactions to danger" (p.24), aligning closely with the concept of 'fast think' proposed by Kahneman (2011). The role of affect must therefore be taken into account when understanding how people make risk-based decisions.

7.2.4 The Role of Perceived Levels of Risk Associated with a Threat / Perceived Levels of Risk Associated with a Behaviour During Hazardous Materials Incidents

How the public perceive the risk facing them at a Hazmat/CBRN incident will be crucial in determining their behavioural choices. A higher perception of risk, both in relation to the threat being faced and any behaviours being recommend by responders, will occur as the result of negative affective judgments and will therefore be more likely to result in non-compliant behaviours (Carter *et al.,* 2013c). However, conversely it may also be that a higher risk perception of a threat will actually decrease the perception of risk associated with the behaviour(s) recommend by emergency responders. As such it is

crucial to explore the role of risk perception both in relation to a threat facing members of the public and their perceptions of any behaviours being asked of them by responders and how these two elements relate to each other.

7.2.5 The Role of Communication During Hazardous Materials Incidents

Communication between responders and casualties will play a key role in shaping the relationship between the two groups, with previous research demonstrating that effective communication from emergency responders will engender trust in emergency responders (Carter *et al.,* 2013a; Carter *et al.,* 2015a).

Carter *et al* (2013a) explored communication during mass decontamination field exercises and found that communication was perceived as more effective if casualty volunteers were provided with: i) health-focused explanations about the need for decontamination; ii) information about actions emergency responders were taking; and iii) sufficient practical information about actions they should take during decontamination. This type of communication resulted in increased perceptions of responder (Carter *et al.,* 2015a; Carter *et al.,* 2013a), increased compliance (Carter *et al.,* 2015a; Carter *et al.,* 2013c) and reduced public anxiety (Carter *et al* 2015a).

These findings support previous research which has identified the importance of effective responder communication at Hazmat incidents (Glass and Schoch-Spana, 2002; Proulx and Sime, 1991; Seeger, 2006).

7.2.6 The Role of Trust During Hazardous Materials Incidents

Trust is a crucial concept for explaining the relationship between casualties and responders and has been identified in the literature as critical in situations where people are not familiar with the risks facing them as Siegrist and Cvetkovich (2000), Earle and Cvetkovich (1995) and Luhmann (2018) identify decisions and judgments made by people without the necessary knowledge will be guided by trust. Trust acts as a way of reducing the complexity faced by people in their decisions and judgements and so instead of needing to make rational judgments based on knowledge, they can employ trust as a mechanism of choosing which expert to listen to. A wide range of evidence demonstrates the importance of trust in promoting public compliance with recommended protective behaviours and reducing public anxiety (Rubin *et al.,* 2012; Gaunlett *et al.,* 2018).

It has been suggested that trust can be broadly separated into two distinct dimensions; legitimacy and competence (Carter *et al.,* 2013c; Siegrist *et al.,* 2012). Various literature has pointed to numerous different elements that make up trust and affect the level of trust with which entities are held. Das and Teng (1998) suggest that trust develops as a concept of shared values, with the confidence element of trust being dependent upon performance whilst legitimacy was seen as responsibility and honesty of those in authority coupled with a belief that those in positions of authority should be there and that their instructions should be followed (Carter *et al.*, 2013c).

7.2.7 The Role of Legitimacy During Hazardous Materials Incidents

To better understand the role of legitimacy in enhancing trust and facilitating public cooperation, it is helpful to consider the social identity approach (Turner *et al.,* 1979; Tajfel *et al.,* 1979; Turner *et al.,* 1987). The social identity approach has been applied to understand crowd behaviour during various different crowd events (Drury *et al.,* 2003a) including mass emergencies (Drury *et al.,* 2009b) and can contribute to an understanding of the role of legitimacy in facilitating trust and public cooperation. The social identity approach suggests that in order to enhance public compliance with recommended protective behaviours during mass emergencies, the actions taken by authorities and emergency responders must be perceived to be legitimate (Carter *et al.,* 2015a; Drury *et al.,* 2003b). If actions are taken by authorities which are perceived to conflict with a crowd's own desired actions (e.g. forcibly containing a crowd or forcibly moving people from an evacuation zone), crowd members may perceive that the actions taken are illegitimate, thereby reducing trust in authorities, and legitimising attempts by crowd members to challenge responders' authority. In this instance, compliance with recommended protective behaviours (e.g. evacuation, decontamination) is likely to be low, and the potential for disorder is likely to increase.

7.2.8 The Role of Competence During Hazardous Materials Incidents

While legitimacy is necessary for those affected to trust authorities, it is also important that those affected understand the role of authorities and believe they are capable of effectively managing an incident. For instance, a person involved in a Hazmat/CBRN incident might view the FRS as legitimate, perceiving their role and motives as positive

and in line with their own view of what is a positive in the world. However, they may not have any understanding of the role the FRS holds in dealing with hazardous materials and decontamination of casualties and so may not deem them capable of assisting at such an incident. Equally the response of the FRS may be such that the view of that individual is that the responders are unable to offer the level of service expected and wanted and so they will view those responders with low confidence.

This value of confidence in determining trust governs whether an agent is seen to have sufficient capability to provide that which is expected in an interaction (Earle and Siegrist, 2006). In relation to FRS' this idea suggests that for individuals to trust the FRS to effectively manage an incident, they must both: believe that the FRS are a legitimate agency who are working to protect people; and have confidence in the FRS to effectively manage a particular incident. The actions taken by the FRS during a Hazmat/CBRN incident (including communicating effectively, respecting public needs etc.) can influence both perceptions that they are managing the incident legitimately, and confidence that they can manage an incident effectively. Both of these factors enhance trust, which in turn enhances public compliance and cooperation.

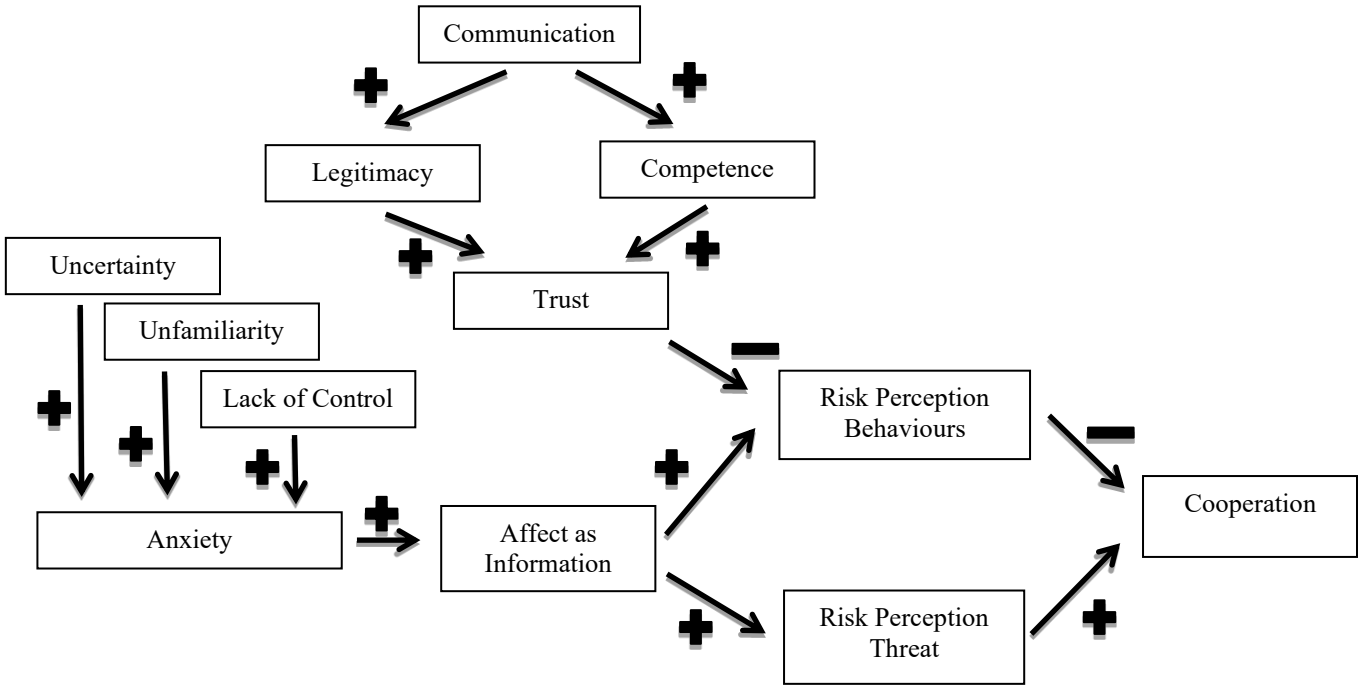
7.2.9 The Role of Co-operation During Hazardous Materials Incidents

Co-operation refers to members of the public following the instructions given by emergency responders. Ultimately, it is the cooperation of members of the public involved in a Hazmat/CBRN incident which is needed in order for a successful operation to occur.

7.3 Hypothesised Behavioural Model

Findings from relevant literature, presented above, facilitated the development of a hypothesised model of factors influencing casualties' co-operation during a hazardous materials incident, as outlined in Figure 8.

Figure 9 Behavioural Model of Casualty Engagement with Emergency Responder Instructions



Legend

Arrow = The arrows indicate the direction of influence a variable is having.

+ = A plus indicates an increase in a variable's influence as result of the preceding variable.

- = A minus indicates a reduction in a variables influence as result of the preceding variable.

7.4 Methodology

7.4.1 Ethics

This study was led by Hampshire Fire and Rescue Service who provide ethical approval and took responsibility for data collection.

All participants provided consent to their participation in the study and had the right to withdraw from the study at any time. This was achieved through the use of an informed consent sheet at the start of the online survey. The informed Consent Sheet is shown if Figure 9 below and the full informed consent document can be seen in Appendix III.

Figure 10 Casualty Behaviours During Incidents Involving Hazardous Materials

Informed Consent Sheet

Consent Form for Participants Able to Give Consent

Full Title of Project: Casualty Behaviours During Incidents Involving Hazardous Materials

Name of Principal Investigator: Hampshire Fire and Rescue Service

Please initial box

1. I confirm that I have read and understand the participant information sheet version 1.1dated 01/03/2020 for the above study and have had the opportunity to ask questions which have been answered fully.	
2. I understand that my participation is voluntary, and I am free to withdraw at any time, without giving any reason and without my legal rights being affected.	
3. I give consent for information collected about me to be used to support other research in the future, including those outside of the European Economic Area (EEA).	
4. I consent to take part in the above study.	

_____ _____ _____

Name of person taking consent (if different from Principal Investigator) Signature Date

_____ _____ _____

Principal Investigator Signature Date

All participants data will be anonymised and stored securely for 10 years.

7.4.2 Participants

A survey was conducted of 118 individuals evacuated as a consequence of a fire at the Ocado distribution centre in Andover on 5th February 2019. Of these, 102 participants were evacuated from their homes, whilst 16 were evacuated from their place of work. The main demographic data of those surveyed were as follows:

i) Thirty-two participants (27%) were female, 85 (72%) were male, with the remaining participant (1%) transgender.

ii) With respect to age, thirteen participants (11%) were aged 18 – 24, 54 (45%) were aged 25 – 34, 33 (29%) were aged 35 – 44, 10 (8%) were aged 45 – 54, 7 (6%) were aged 55 – 64, and one (1%) was aged over 75.

In the absence of any records kept of the actual number of people evacuated from this incident, the sample of individuals surveyed cannot be considered as a representative sample of the evacuees but instead are all those with whom this study was able to engage.

All recruitment of participants was done utilising an opportunistic recruitment strategy. Participants were invited to participate via Hampshire Fire and Rescue Services Social Media channels from where they could access the survey to participate if they met the research participant criteria.

7.4.3 Materials

The survey itself contained 30 items covering 12 variables requiring responses using a 7-point Likert scale (See Appendix IV), which was chosen because of the common use of such a scale in many other surveys in this field, including those which influenced this study (Carter *et al.,* 2013c; Harmon-Jones *et al.,* 2016). The items were designed to capture data relating to the variables included in the hypothesised model (Figure 10):

i) Control (e.g. 'I felt in control of my situation') (2 x items α= .727);

ii) unfamiliarity (e.g. 'I felt the situation was unfamiliar to me') (2 x items α= .578);

iii) uncertainty (e.g. 'I felt uncertain about what was happening to me') (2 x items α= .731);

iv) anxiety (e.g. 'I felt worried by my situation') (2 x items α= .857);

v) affect (e.g. 'I felt scared about my situation') (6 x items α= .838);

vi) threat risk perception (TRP) (e.g. 'I felt in danger from the fire') (2 x items α= .871);

vii) behaviour risk perception (BRP) (e.g. 'I felt it was dangerous to evacuate') (2 x items α= .234);

viii) trust (e.g. 'I trusted those asking me to evacuate') (2 x items α= .780);

ix) co-operation (e.g. 'I did all that those asking me to evacuate told me to do') (2 x items α= .808);

x) competency (e.g. 'I believed those asking me to evacuate were able to help me') (3 x items α= .777);

xi) legitimacy (e.g. 'I believed that those asking me to evacuate were acting in my best interests') (x items α= .937);

xii) communication (e.g. 'Those asking me to evacuate explained clearly what was happening during the evacuation') (3 x items α= .856).

7.4.4 Survey Development and Validation

Prior research provided guidance as to the appropriate questions to ask in order to elicit valid responses from the respondents. Carter (Carter *et al.,* 2013b; Carter *et al.,* 2013c; Carter *et al.,* 2014) considered a number of similar variables during mass decontamination field exercises and the questions used in that study have shaped the questions in this Chapter as they have been validated as effective for understanding this area of inquiry.

The questions relating to anxiety were based upon those from the STAI-6 form, a validated method of measuring State anxiety (Spielberger and Sydeman, 1994).

In order to understand the affective state of respondents, questions relating to their perceived level of Anger, Sadness and Fear were asked. These questions represent the negative emotions identified by the Discreet Emotions Questionnaire (Harmon-Jones *et al.,* 2016) and aim to identify a positive or negative affective emotional state of respondents, which can then be compared with other variables.

All scales showed good reliability (Cronbach's Alpha; Range .578 - .937, Mean .876), except the scale designed to measure Behavioural Risk Perception. This scale originally contained two items: 'I felt at risk from being evacuated' and 'I felt it was dangerous to

evacuate'. Given the poor scale reliability (Cronbach's Alpha .234), the single item ('I felt it was dangerous to evacuate') was used as the measure of Behavioural Risk Perception.

A further step to validate the survey was taken in the form of consultation with researchers from Public Health England's Emergency Response Department Science and Technology Team who have considerable experience in researching similar areas. Those participating were asked to complete the questionnaire and comment on it. They were also asked what they understood the meaning of each question to be. Through this process the survey was assured and deemed ready to be put to respondents.

7.4.5 Analysis

Data were analysed using SPSS 25, and path analysis was carried out using AMOS 19.

7.5 Results

7.5.1 Between Subject's Analysis

An ANOVA was undertaken to examine any differences between demographic groups. After a Bonferroni correction was applied ($p < .004$) no significant differences between demographic groups for any of the variables measured were observed.

7.5.2 Path Analysis

Path analysis was selected to analyse the results of the survey as it provides the opportunity to go beyond regression and allow for the analysis of more complicated models. In this case it allowed for the examination of the multiple dependent variables in a chain of influence.

However, it should be acknowledged that whilst path analysis can reject models postulating causal relations among variables, it cannot itself prove casualty.

This type of analysis has also been used by Carter (Carter *et al.,* 2013b; Carter *et al.,* 2013c, Carter *et al.,* 2014) to explore similar areas of research and therefore has been proven both reliable and effective in this area of study.

Data were entered into a path model, and the hypothesised path model (Figure 10) was tested. To evaluate the fit of the model, four different fit indices were used: model chi-square; root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker–Lewis index (TLI). For a good fit, a model should have a model chi-square of greater than .05, a CFI of greater than .90, a RMSEA below .08 and a TLI of greater than .90.

The original behavioural model had a poor fit with the data. To improve the fit of the model, one path, between Risk Perception Behaviour and Risk Perception Threat was removed. Following this, an additional path was added to the model between trust and cooperation, as this is a relationship that might be expected, based on existing literature even without the expected mediation of RPB. This new model is shown in Figure 10

below. Chi-square indicated that this model also had poor fit with the data (Chi-square = 92.023, df = 51, p < .001). However, as chi-square is highly sensitive to sample size and number of variables (Drury *et al* 2009b), a number of other goodness-of-fit indices were used to evaluate model fit. These showed that the revised model had good fit with the data (CFI = .93, TLI = .91, RMSEA .08).

The model explains 49% of the variance in Legitimacy, 62% in Competence and 38% in Trust, 52% of Anxiety, 57% of Affect as Information, 21% of Risk Perception Behaviours and 23% Risk Perceptions Threat with 19% variance in Cooperation.

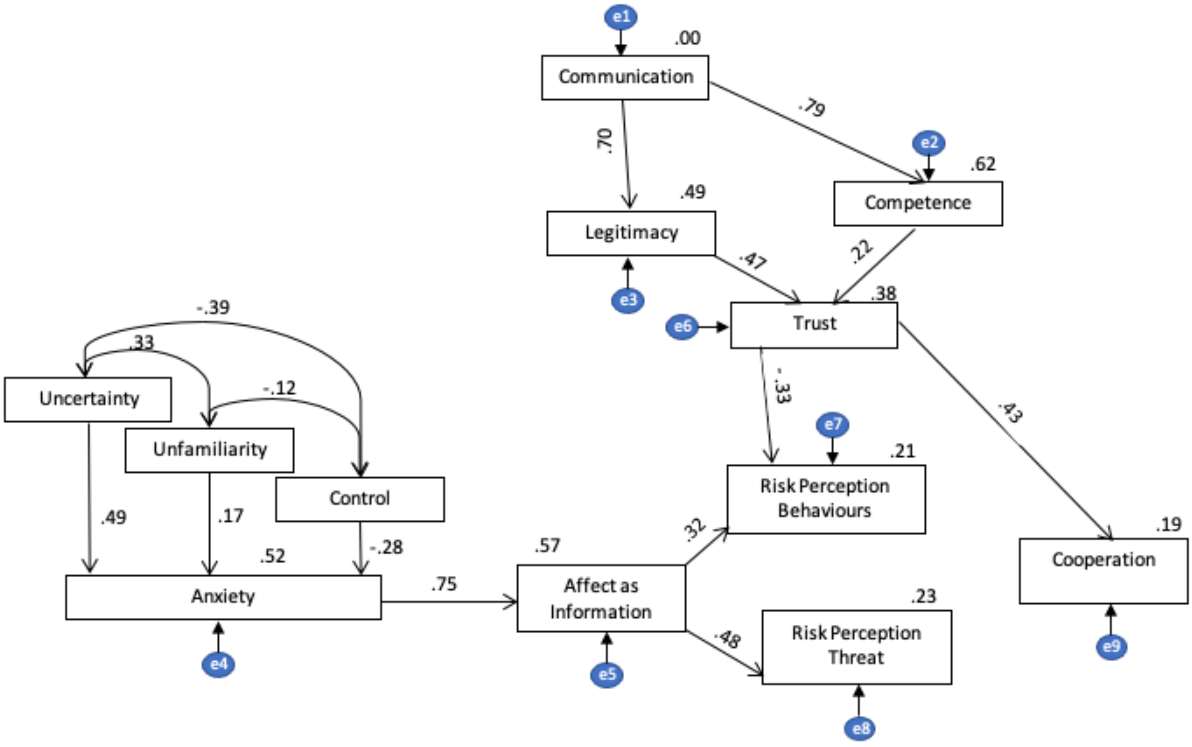
The model also showed significant relationships between all of the variables, as shown. There is a clear relationship between Communications and Competence (β=.79 p<.001) as well as Communications and Legitimacy (β=.70 p<.001). Legitimacy was also shown to have a significant relationship with Trust (β=.47 p<.001) as did Competence with Trust (β=.22 p<.012). While Trust was then shown to have significant relationship with Cooperation (β=.43 p<.001).

Trust also has a significant relationship with Risk Perception Behaviour (β=-.33 p<.001). Whilst Affect had significant relationships with Risk Perception Behaviour (β=.32 p<.001) and Risk Perception Threat (β=.48 p<.001).

Anxiety had a significant relationship with Affect (β=.75 p<.001), whilst Anxiety had significant relationships with Unfamiliarly (β=.17 p<.011), Uncertainty (β=.49 p<.001) and Control (β=- .28 p<.001).

Uncertainty had a significant relationship with Unfamiliarly (β=.33 p<.011) and Control (β=- .39 p<.001), whilst Unfamiliarly and Control both showed a significant relationship (β=- .12 p<.001).

Figure 11 Validated Behavioural Model of Casualty Engagement with Emergency Responder Instructions



7.6 Discussion

This study represented a unique opportunity to understand psychosocial factors associated with the willingness to evacuate during a real-life hazardous material incident.

The results of the path analysis support the majority of hypothesised relationships between variables. In particular, the model shows that uncertainty, unfamiliarity and lack of control are predictors of anxiety and the consequences of such anxiety on the subsequent decision-making of casualties utilising 'affect' during emergencies.

Given the high levels of the predictors of anxiety present during such an incident, it is crucial to understand the relationship between anxiety and affective decision making, in order to account for them in developing management strategies to manage casualties.

Of great significance, the model indicates that while anxiety is present, driven as it is by uncertainty, unfamiliarity and a lack of control over the situation, it does not overwhelm those involved who still utilise the cognitive or rational pathway in their decision making. The study's findings are in line with numerous studies which have also identified that casualties in emergencies utilise a more cognitive or rational approach and are not overwhelmed by anxiety or fear (Aguirre *et al.,* 2001; Cornwell, 2003; Johnson, 1987; Johnson, 1988; Quarantelli, 1954). More recently work by Drury *et al* (2009a) has demonstrated that not only can the public be expected to remain rational they will often look to help others during emergencies.

The model showed a clear relationship between communication and the perceptions of legitimacy and competency and that these in turn directly influence an individual's trust in emergency responders and, as such, their willingness to be cooperative. This highlights the critical importance of good communications, the building and maintenance of trust with the public and the importance of employing such strategies to ensure that casualties will not be overwhelmed by anxiety as suggested by the more affective or more irrationalist approach. Carter (Carter *et al.,* 2013b; Carter *et al.,* 2014) identified similar findings during mass decontamination field studies identifying the importance of legitimacy in engaging the cooperation of casualties.

While the presence of anxiety is fully acknowledged and must be considered, casualties still act rationally and therefore can be effectively engaged with to improve the outcomes of emergency situations.

However, there was no significant relationship between either 'Behavioural Perceived Risk' or 'Threat Perceived Risk' and Cooperation. The hypothesised model had presumed this would be present as previous literature relating to risk perception and communications (Seeger, 2006), had supposed that, as the threat risk perception increased and behavioural risk perception (the risk associated with a recommended action) decreased, compliance and co-operation would increase.

Interestingly, the model showed a significant and direct relationship between trust and co-operation, suggesting the key role the former plays in explaining the relationship between effective responder communication and increased casualty co-operation, over and above the role played by risk perception. This confirms the findings in the literature indicating the essential role that trust plays in driving public behaviour during situations in which unfamiliarity and uncertainty are high and the knowledge of decision-making is low (Siegrist and Cvetkovich, 2000; Gaskell *et al.,* 1999). Understanding the key role of trust in emergencies can therefore greatly impact the ability of agencies to conduct their operations effectively.

The findings demonstrate that in the event of a Hazmat/CBRN incident, casualties will be able to make use of information and instructions they are given, and that communicating effectively will enhance perceived legitimacy of responder actions, and perceived competence of emergency responders. These will in turn enhance trust in

emergency responders, and promote compliance and cooperation with responder instructions, thus validating the more cognitive approach.

7.7 Implications

Currently there is an absence of any form of public awareness about what to do in the event of a Hazmat/CBRN incident, which is a matter of great concern. This Chapter has shown the ability of casualties to make use of information and instructions during emergency situations and that this is crucial should such an event occur. Such pre-communications would likely enhance trust as members of the public would be aware of the roles undertaken by emergency responders, thereby increasing the legitimacy of responders. This would also help to set expectations of what responders would do when present at an incident, again assisting with trust through competency if responders meet set expectations.

There is already an understanding that developing the public's pre-existing knowledge and understanding of potential emergency incidents can be of benefit, seen for example with the 'Run, Hide, Tell' (National Counter Terrorism Security Office, 2018) messaging campaign. This is being further developed with the 'Remove, Remove, Remove' campaign for emergency responders responding to Hazmat/CBR incidents which is also available for the public, but not currently widely promoted for this audience (Carter *et al.,* 2019; Carter *et al.,* 2020a, Carter *et al.,* 2021).

Public education programmes endeavour to prepare members of the public for emergency or disaster situations so that they are more likely to behave in a manner

considered to be best for their own and others' well-being and furthermore, to reduce the pressures likely to be experienced by hospitals and emergency services (Paton and Johnston, 2001).

However, there can remain a belief that such preparations can create panic and fear in the public and have little effect with casualties believed to be likely to act irrationally during such incidents. Hence, the thinking is that such information pertaining as to what to do in during Hazmat/CBRN incidents shouldn't be widely spread as it will do more harm than good.

It is, however, the position of this Chapter that, in contrast, the findings demonstrate that casualties can utilise information and will not be driven by anxiety but by their trust in responders and their communications. Therefore, laying the foundation for this with effective public messaging appears to be an essential prerequisite. This has the additional benefit of reducing uncertainty (a major driver of anxiety) by increasing awareness and understanding.

This Chapter also emphasises the importance of effective communication in enhancing legitimacy, competency and therefore trust which ultimately enhances cooperation. This supports previous research in this area which has identified the crucial role of communication in effectively managing casualties at a Hazmat/CBRN incident (Carter *et al.,* 2013b, Carter *et al.,* 2015a; Long *et al.,* 2020).

This Chapter also clearly identifies a need for responders to be effective communicators themselves and be able to engage with casualties at the scene of a Hazmat/CBRN

incident in order to ensure that perceptions of legitimacy and competency are achieved and maintained.

Chapter 5 identified that there is currently a gap in the training of frontline responders concerning effective communication strategies and human behaviour. Whilst improvements in this area have occurred, including an increased focus by academics (Carter *et al.,* 2013a; Carter *et al.,* 2013b; Carter *et al.,* 2013c; Chilcott *et al.,* 2018), as well as the introduction of training for mass decontamination instructors, there is still a need for further measures. The findings of this Chapter reinforce the finding of Chapter 5 and reemphasise the crucial need for training in effective communication and engagement with casualties by responders as an essential component of this.

7.8 Limitations

The limitations of this study need to be acknowledged. Firstly, the study is retrospective in asking respondents to comment on events which took place a year earlier. However, given the nature of this highly unusual and exceptional event, it is nevertheless highly likely that those engaged would have a strong ability to recall the event well.

Secondly, the study also involved collection of self-report data, with respondents having the choice to participate or otherwise. Hence, some consideration should be given as to why respondents chose either to participate or not in this study. It is possible that those who chose to participate in the study differed in some way from those who did not. Additionally, no details were kept by the authorities of how many people were

evacuated during the Ocado fire and it is therefore not possible to identify how many of the potential participants chose to take part in the study.

Another potential limitation of the study was that all those asked to evacuate during the Ocado incident did so and, whilst some may not have been happy, there were no incidents of members of the public remaining within the cordon or being forcibly removed. Further research into this area is required to more fully understand the influence of variables on members of the public who are unwilling to voluntarily evacuate.

Finally, it must be acknowledged that the variables confidence and legitimacy in emergency services will vary across populations both locally, nationally and internationally. However, this model seeks to demonstrate the relationship between these variables which allows it to be valid across populations.

7.9 Future Research

Based upon the analysis conducted in this Chapter, there is a need for further understanding of this model in the following areas:

1. different emergency situations.
2. situations that witness a lack of co-operation or direct non-compliance.
3. between different population groups.

7.10 Conclusions

This Chapter has sought to understand how casualties are likely to behave in relation to instructions from emergency responders during incidents involving hazardous materials. To do this, a methodology was developed for exploring the variables which contribute to decision making during emergencies and used path analysis to understand the roles of multiple variables present in such incidents both individually and in combination. Consequently, this Chapter postulated a hypothesised model of behaviour which was then validated through engagement with evacuees of a real-world Hazmat incident, the Andover Ocado fire in February 2019.

It is interesting to note that while the hypothesised model, built from concepts identified through the literature, suggested that 'Risk Threat Perception' and 'Behaviours Threat Perception' would affect casualties' co-operation with emergency responders, this was not the case. Instead, the main driver of cooperation was trust in emergency responders, facilitated by perceptions of responder legitimacy and effective responder communication.

These findings again highlight the crucial role that the publics levels of trust in those giving emergency advice and managing emergency situations plays in emergency situations. There is therefore a need to explore the role of trust further across a range of emergency situations, from giving evacuation orders for natural hazards such as hurricanes or tsunamis through to more general advice for road traffic collisions or fires.

The evidence from this Chapter also clearly demonstrates that the rational pathway will be used by casualties in their decision-making during emergencies. Hence, casualties can and must be engaged by emergency responders to ensure. Guidance and training for responders must acknowledge these findings in order to prepare them to effectively engage with casualties[8].

[8] This work has been published in the Journal Safety Science – Long, F., Carter, H. and Majumdar, A., 2022. Casualty behaviours during incidents involving hazardous materials. *Safety science*, *152*, p.105758.

Chapter 8 – Hazmat/CBRN Mass Decontaminant Scenario Development

Having established the importance that the behaviour of casualties will have during an emergency and the ability of casualties' behaviours to be influenced by emergency responders, this thesis now builds on these finding to understand a crucial element of mass decontamination response planning which has so far been overlooked.

Chapter 5 of this thesis identified that the possibility of casualties leaving the scene of a Hazmat/CBRN incident prior to being decontaminated was a real concern, highlighting the concerns relating to the slow speed of response from specialist MDUs. This concern, coupled with the fact that currently no research has been undertaken to understand how long casualties would be willing to wait for decontamination to be provided, revealed that this crucial factor is missing from planning assumptions used to prepare for a mass decontamination event. Plans have not considered leaver rate and, as such, current strategies and resourcing arrangements have not been developed in consideration of this crucial casualty behaviour.

Therefore, this thesis will now look to develop an understanding of leaver rate and how emergency response efforts may affect it.

8.1 Introduction

The threat to the UK of a CBRN incident remains high (Cabinet Office, 2018). These weapons are often referred to as weapons of mass destruction due to the large impact even relatively small quantities of these materials can have, as seen during the 2018

Novichok incident in Salisbury (Dodd *et al.,* 2018). As a consequence, of a CBRN or hazardous materials incident, casualties affected may be required to undergo decontamination, whereby any agent or material which may have come into contact with their skin can be washed off.

The FRS hold the responsibility on behalf of the Department of Health for providing emergency decontamination to members of the public in the UK (The Fire and Rescue Service (Emergencies Order) (England) Order 2007) and there are a number of different methods by which decontamination of the public can be achieved. The main response from the FRS would come in the shape of Specialist Operational Response (SOR) which involves Specialist National Resilience assets which when deployed allow for up to 150 people per hour to be decontaminated by the UK FRS (FRS) (New Dimensions 2003).

During such large-scale incidents it will be crucial that casualties act in line with emergency responders' instructions, in order to facilitate a successful response; and the way in which emergency responders manage the incident will play a key role in promoting casualty compliance during the incident (Carter *et al.,* 2015a).

However, mass decontamination operations have often been seen as a technical issue, with very little attention being paid to the psychosocial and behavioural aspects of such incidents (Carter *et al.,* 2013a). Given the key role that casualty behaviour will play in shaping the outcomes from the incident, planning for incidents involving mass decontamination must take into account psychosocial and behavioural aspects.

One critical aspect of human behaviour at a Hazmat/CBRN incident requiring mass decontamination will be whether casualties are willing to remain at the scene of the incident. Should casualties choose to leave the scene of a Hazmat/CBRN incident before being effectively decontaminated, they will increase their own risk of serious illness or even death, as any contaminant they have been exposed to will continue to either affect them or risk exposing them, in case they have they not already been so exposed. They will also not have received any medical assistance. Furthermore, these casualties will risk spreading any contaminant they have on them, taking it away from the initial incident ground to any location they visit via their clothing, skin or even hair. This will therefore increase the contaminated area and may result in secondary contamination (contamination not caused by the original source) of anyone they come into close proximity with or who enters an area they have been present in, exposing these people to the same risks of serious illness or death.

The 1995 Sarin attacks on Tokyo demonstrated this risk well. Following the incident, contaminated casualties were transported or presented themselves at the nearest emergency hospitals. This resulted in the secondary exposure of emergency hospital workers and the critical infrastructure of the emergency departments, risking both the health of the medical workers and rendering this critical infrastructure out of use due to contamination. This therefore highlights the potential impact of casualties who leave the scene of a Hazmat/CBRN incident before being decontaminated (Nozaki *et al.,* 1995; Okumura *et al.,* 1998a; Okumura *et al.,* 1998b).

It is therefore essential that planning for incidents involving decontamination considers the potential impact that different factors might have on casualties' willingness to

remain at the scene of the incident in order to undergo decontamination. However, while research has examined the willingness of casualties to comply with decontamination instructions in general, or decontamination showering specifically (Carter *et al.,* 2013a; Carter *et al.,* 2014; Carter *et al.,* 2015b), there is very limited research examining the likelihood of casualties remaining at the scene of a Hazmat/CBRN incident requiring mass decontamination, or on the factors that affect this. It is an area that appears to have been overlooked both by previous research and operational planning as highlighted by Long *et al* (2020).

Previous Chapters in this Thesis have established that the public are very often co-operative and seek to assist in an emergency situation and that effective responder management and communications will help to maintain and facilitate these responses (Long *et al.,* 2022; Long *et al.,* 2023). This Chapter attempts to understand how the management of an incident and the communications used by emergency responders during a mass decontamination operation will affect the public response to such operations.

A major difficulty in studying casualty behaviour during decontamination operations is the very limited number of real-world incidents which have occurred. When such incidents do occur, they are often small-scale incidents (Vogt and Sorensen., 2002), and hence their findings are less applicable to understanding casualty behaviour during larger scale mass decontamination operations.

One way of overcoming this issue is to use scenarios to engage local emergency coordinators to make predictions regarding public behaviours in relation to emergency recommendations (Dombroski *et al.,* 2006). Dombroski *et al* (2006) used an adapted

Delphi method (Dalkey and Helmer, 1963) to develop a framework to predict likely levels of compliance for evacuate or stay in place orders issued during an emergency. Key variables were identified and inserted into a 'desktop emergency scenario', before asking experts from a wide range of associated fields to review the scenario for its plausibility. From this, a revised 'desktop emergency scenario' was developed and again presented to experts requesting review. This revision was subsequently used to form a structured survey, to extract predictions of likely compliance rates from emergency managers local and familiar to the context of the scenarios given.

Using a similar adapted iterative methodology, the current Chapter looks to develop a set of scenarios which take into account the key factors relating to public behaviours during an incident requiring mass decontamination. By doing this, this Chapter attempts to identify those factors that affect the willingness of casualties to remain at the scene and undergo decontamination. The scenarios developed within the current Chapter are designed to be used during subsequent research to examine the length of time that casualties are willing to remain at the scene and undergo decontamination.

This is essential, as currently planning assumptions do not consider this factor. There is therefore no understanding of how the length of time casualties may have to wait to be decontaminated may affect the rate at which they leave and as a result make any decontamination operation less effective, should large numbers choose to depart before being decontaminated.

By seeking to understand what will influence a casualty's decision to leave the scene without being decontaminated we can begin to understand those influences which emergency services can impact and those that are beyond their control. This helps to

build a picture of how many casualties can be expected to leave the scene of an incident over a period of time, thus potentially influencing resourcing strategies.

In summary, this Chapter aims to:

- Create a list of variables which will influence casualty willingness to stay at the scene of a CRBN incident and undergo decontamination.
- Develop a range of scenarios which can subsequently be used to investigate the amount of time that casualties will be willing to remain at the scene and their willingness to undergo decontamination.

8.2 Methodology

8.2.1 Ethics

This study is deemed to be an Evaluation and as such did not require ethical approval through Imperial College London (See Appendix I).

All participants provided consent to their participation in the study and had the right to withdraw from the study at any time. This was achieved at the start of the workshop via a briefing to all participants at the end of which they provided their consistent in order to continue with the workshop.

All participants data will be anonymised and stored securely for 10 years.

8.2.2 Design

This study used an adapted iterative design (Dombroski *et al.,* 2006; Dalkey and Helmer, 1963) to capture perspectives of emergency planners and responders during an expert workshop. The study utilised expert opinion in the iterative development of scenarios in a manner shown to be effective by Dombroski *et al* (2006) but with a change of emphasis on casualty behaviour during mass decontamination, rather than on evacuation/shelter in place compliance.

8.2.3 Participants

Expert participants came from several key organisations involved in the field of Hazmat/CBRN These organisations represent the civilian agencies responsible for the planning, resourcing and execution of an emergency response to incidents involving hazardous/CRBN materials and any mass decontamination operations in the UK. Each organisation was requested to provide a maximum of three representatives. Further details about these organisations and the number of participants actually provided in the workshops are outlined below.

- The three Public Health England participants were from the Emergency Response Department who have been responsible for much of the scientific research concerning the development of the mass decontamination capabilities within the UK.

- National Resilience provides specialist Hazmat/CBRN capabilities, personnel and resources in support of local FRS' to enhance their ability to respond effectively to large-scale or critical incidents be they natural disasters, industrial accidents or terrorist attacks. One such capability is Mass Decontamination. The two representatives present were the National Resilience leads for this capability.

- The National CBRN Centre, which provided a single representative, is responsible for bringing together the emergency services to protect and prepare the UK against CBRN threats and acts as a hub of expertise and co-ordination for all civilian CRBN response.

- The Home Office is the Government Department responsible for the Police, FRS' and National Resilience in the U.K, and provided one participant. It is therefore the overarching Government Department for all civil CRBN response in the UK. It has also been responsible for commissioning and managing much of the research performed in relation to Hazmat/CBRN and Mass Decontamination preparedness.

- [9] Within the Cabinet Officer sits the Civil Contingencies Secretariate which is responsible for emergency planning within the UK ensuring that the country is resilient to disruptive challenges by anticipating, assessing and working to ensure the UK is adequately able to prevent, prepare, respond to and recover from emergencies that occur including CBRN incidents which have featured

[9] The Civil Contingencies Securitate no longer exists having been disbanded in 2022, three years after this workshop occurred.

prominently on the UK's National Risk Register. This organisation also provided one participant.

- The FRS (FRS) have a duty under The Fire and Rescue Services (Emergencies) (England) Order 2007 (The Fire and Rescue Service (Emergencies Order) (England) Order 2007) to have the capability to remove chemical, biological, radiological and nuclear contaminants from people at an emergency. The two FRS representatives present where both Tactical Officers and Hazardous Materials Advisers who would provide specialist expertise for an FRS operational response to a Hazmat/CRBN or mass decontamination incident.

- The Police will be present at any CBRN or mass decontamination incident where they will most likely be the primary responding agency. The sole representative from the Police was a CRBN qualified Officer in the CRBN lead role for their regional force.

- The Ambulance Service provides the emergency response element of the Department for Health who hold responsibility for decontaminating members of the public. The decision on whether to decontaminate people will be taken by the Ambulance Service, in consultation with the FRS and the Police. As such the Ambulance Service will be a crucial agency to any Hazmat/CRBN or Mass Decontamination Incident. The two representatives present where from the Hazardous Area Response Teams (HART) which is the ambulances unit comprising specially trained and equipped personnel capable of responding to high-risk and complex emergency situations within the 'inner cordon' (or 'hot zone'). They are specifically trained in Hazmat/CBRN response and would be

central to the ambulance response to a Hazmat/CBRN or mass decontamination incident (National Ambulance Resilience Unit, 2022).

8.2.4 Procedure

Experts within the field of Hazmat/CBRN and Mass Decontamination, from the organisations outlined above, gathered together for a workshop, three-hours in duration, to develop a series of scenarios which aimed to capture the factors likely to affect the willingness of casualties to remain at the scene and undergo decontamination. The workshop was set at three hours for practical reason to give participants enough time to hold in depth discussions but within what participants were willing to give of their time.

Firstly, participants where split into small groups with all agencies mixed, as far as practical. They were asked to discuss freely what variables they felt would influence a casualties' decision to stay in place or leave the scene. Once they had established what these influences were, they were then asked to specify a 'best case' and 'worst case' scenario for each. This detailed how a variable would positively or negatively influence a casualty's willingness to either leave quickly, or to remain for longer to await decontamination.

For example, an initial theme of 'weather' was identified as a factor affecting casualties' decisions to remain at the scene. This was further refined to a 'best case' (e.g. good weather) and 'worst case' (e.g. bad weather) scenario.

Following the discussion within their small groups, these small groups then provided feedback relating to their thinking to the wider group and a further open group

discussion developed. There was no requirement for consensus, however, in this case this was achieved with variables and their best and worst iterations identified by the group as shown in Table 6.

Feedback was captured during the discussions through note taking by the researcher and through participants recording their thoughts and ideas onto A3 sheets of paper which were then kept supporting further analysis and the development of the scenarios.

8.2.5 Scenarios Development

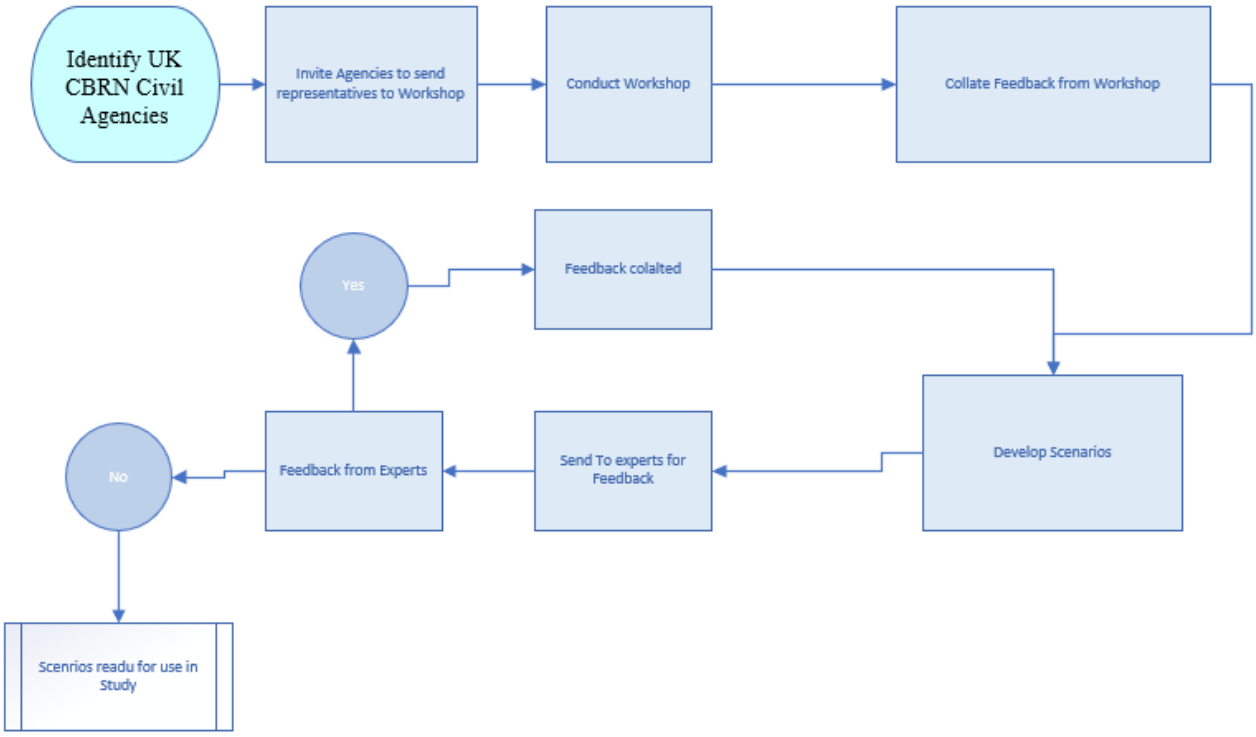
Following the workshop, the researcher, utilising their training and experience in both mass decontamination and Hazmat/CBRN response, collated findings from the workshop to develop five scenarios ranging from a 'best case' to a 'worst case' scenario.

Best and worst case was terminology developed by this study to describe factors which would influence casualties at the scene of a CRBN incident to wait for a greater or lesser amount of time to undergo decontamination, rather than leave the scene. It does not refer to the worst or best case in relation to a casualty's risk of injury, illness or death.

Worst case scenarios refer to a situation where all variables likely to impact upon a casualty's willingness to wait at the scene of the incident are aligned to make it as likely as possible that casualties would want to leave, whilst best case referred to all variables being optimal to keeping casualties in place.

These scenarios were then sent (via email) back to the experts for review. They were given one month to perform this review before feedback was required. The feedback highlighted the need to enhance focus on the role of communications, re-structure the scenarios to add clarity in relation the variables being considered (this led to the reduction from 5 scenarios to 4 scenarios) and refine information about the mechanism of how the incident occurred. The updated scenarios were then re-sent to participants with another month timeframe for feedback. No further comments were received and so the scenarios were finalised, and Figure 11 outlines the scenarios development process.

Figure 12 Scenario Development Process



8.3 Results and Discussion

The variables identified as likely to drive casualty behaviours at a Hazmat/CBRN incident are detailed below in Table 6, along with what the experts deemed would make them a best case or worst case for the likelihood of casualty remaining at the scene.

Table 6 Variables effecting casualty behaviour during a Hazmat/CBRN incident with best, intermediate and worst cases identified.

Variable	Best Case	Worst Case
Location	No Consensus	Enclosed and Unfamiliar
Communications by Responders	Good Clear and Consistent with Casualty's Understanding the Situation	No Communications
Public Awareness and Knowledge	Good Awareness and Knowledge	No Awareness or Knowledge
Agent Effect	No-Effect or Severe Reaction	Some Mild Painful Reaction
Weather Conditions	Dry and Warm	Wet and Cold
Dependants	No Dependants Involved	Dependants
Confidence in Responders	High Confidence	Low Confidence
Crowd and Other Casualty's Actions	Remain	Leave

Each of these variables will now be explored in turn. The first section explores those variables previously discussed in the academic literature whilst the second section discusses those variables which appear to be newly identified with no or little previous literature relating to them.

8.3.1 Variables with Previous Associated Literature

8.3.1.1 Communications by Responders

Communications by the emergency responders to any casualties was identified by the experts as a crucial element of how the latter perceive the former, and as such, their likelihood of remaining at the scene following instructions.

The experts identified that good and effective communication would involve emergency responders giving casualties timely and accurate information. Accuracy was of particular importance since if the messages from responders kept changing, it was believed this would reduce confidence in the response and indeed increase the likelihood of casualties leaving the scene to obtain assistance.

Furthermore, if no information was available then it was agreed that this fact should be communicated truthfully to casualties and that even in a very serious situation this reality should be shared rather than trying to play down any risk. Simply offering reassurance may appear disingenuous as responders in hazardous materials protective equipment arriving at the scene and beginning their operations would be a matter of concern. Such actions, it was agreed, would reduce trust and inhibit any ongoing operations.

Effective communications were highlighted as vital in helping to reduce any anxiety experienced by the casualties. This was felt to be a responsible action undertaken for the wellbeing of casualties helping to gain trust, which would assist with co-operation.

The experts also believed that the information provided must explain what was going to happen and why. By this means, sufficient practical information would be provided for casualties to be able to follow the instructions alongside the rationale of why they were required. This, it was felt, would gain the compliance and co-operation which would be necessary to keep people at the scene to undergo decontamination. It was also agreed that explaining to casualties the risk of leaving the scene both to their own health and also to the safety of others they may come into contact with, would assist in keeping people in place.

Expert respondents identified the crucial role that communications would have in allowing an effective operation through engaging with casualties to gain trust and co-operation. This analysis sits well with the literature. Lemyre *et al* (2010) highlight the importance of responders giving accurate information to casualties at a Hazmat/CBRN incident including when no information is available as a means of reducing casualties' uncertainty and increasing casualties' trust and consequently improving compliance with emergency responders' instructions.

Vogt and Sorensen (2002) reviewed incidents where decontamination was required regardless of an incident's scale or number of casualties and identified the importance of communication to both reduce anxiety and uncertainty as well as to improve trust in responders.

Carter (2014) summarised a lot of this research and validated it through field exercises and visualisation techniques, concluding that "*…overall, this study shows that communication strategies which are perceived by members of the public as the most effective are those which include health-focused explanations about the decontamination process, information about the actions responders are taking, and sufficient practical information. A communication strategy, which encompasses these aspects, is likely to increase the speed and efficiency of the decontamination process, by improving both public willingness, and ability, to take recommended actions. Increasing the speed and efficiency of the decontamination process may result in lives being saved during a real-life incident of this type."* (p. 293).

Clearly therefore communication is a critical component of a CRBN incident and one which is already being studied.

8.3.1.2 Public Awareness and Knowledge

The experts suggested that pre-existing knowledge or understanding of Hazmat/CBRN incidents and emergency responses would mean casualties would be more willing to stay at a scene and await the assistance of emergency services. In particular, they suggested that risk communications messaging akin to 'Run, Hide Tell' (National Counter Terrorism Security Office 2018) for the Marauding Terrorist Attack threat was deemed to be effective in supporting such awareness.

Such preparations benefit responders, as members of the public would have a better understanding of what is going to happen, what is required of them and why this is of

benefit to them, thereby reducing their uncertainty and unfamiliarity of the situation. There was discussion relating to whether such information could create and spread fear and anxiety in the population. However, this was seen as unlikely and outweighed by the benefits of having a more prepared population.

The idea of educating the public for what actions to take in the event of major incidents is not unprecedented and indeed the Run, Hide, Tell campaign (National Counter Terrorism Security Office, 2018) has recently sought to inform the public on what actions they should take in the event of a Marauding Terrorist Attack such as those seen in the Paris Batacalan (2016) or the London Bridge (2017) Attacks.

Indeed in 2004 a booklet entitled "Preparing for Emergencies" was developed by the British Government and designed to prepare the UK public for what to do in the event of a chemical attack. The booklet was distributed to all UK households but was criticised both for the limited content provided within the booklet and for perceived government scaremongering. Consequently, no further booklets were produced after the initial batch and by 2011 the accompanying website was also closed. However, this guidance was then re-introduced in 2018 covering a wider range of potential threats and actions to take, including in the event of a chemical, biological or radiological incident (Cabinet Office, 2018).

Israel has utilised public information successfully, creating a national education programme for chemical attack preparedness utilising a range of media and informing citizens on what actions to take in the event of such an attack (Home Front Command, Israeli Defense Forces, 2005).

Public education programmes endeavour to prepare members of the public for emergency or disaster situations so that they are more likely to behave in a manner considered to be both the best for their own and others' wellbeing and to reduce the pressures likely to be experienced by hospitals and emergency services (Jacobs *et al.,* 2003; Paton and Johnston, 2001).

The pressure that unwanted behaviours by members of the public can place upon the emergency services can be seen in the Tokyo Sarin attacks, where over 5000 people presented themselves at hospitals seeking medical treatment. The vast majority were the "worried well" and all had bypassed the emergency services and, in so doing, risked spreading the contaminant through those actually affected and for those unaffected by overwhelming the medical services of the city. Had they been made more aware of the processes and importance of waiting for emergency responders to assist them, such problems could have been reduced (World Health Organization, 2004; Tan and Fitzgerald, 2002; United States Army, 2005).

While not a new area it appears that there is potential for this to be an avenue worth further investigation. It's also clear that such approaches to informing the public are not well researched in relation to understanding what makes an effective public information campaign. However, given the levels of uncertainty and unfamiliarity that would be present during a Hazmat/CBRN incident together with the need for members of the public to be actively involved in a mass decontamination operation, the potential of improving such outcomes by educating the public and the best possible way this could be achieved requires much greater exploration.

8.3.1.3 Dependants

The presence of dependants at the scene or waiting upon a casualty, was seen as another driving factor in any casualty's decision-making. Their presence was suggested as being a key driver of behaviour, increasing the risk perceptions of those involved if the dependant is with them and encouraging the likelihood of casualties leaving the scene if a dependant was waiting for them.

The role played by dependants on affecting a casualty's evacuation decision-making was identified by the hurricane evacuation literature (Dash and Galdwin, 2007; Huang *et al.,* 2016) with Bateman and Edwards (2002) noting that the presence of children is a particular motivator in evacuation decision making. Dash and Gladwin (2007) write; "*For example, the presence of children in the household might influence parents to protect them from danger"* (p. 72).

This variable therefore needs to be explored in relation to Hazmat/CBRN incident to understand how it will affect the willingness to wait at the scene if dependants are waiting for them at a different location and also how it will affect behaviour should dependants be involved in the incident.

8.3.1.4 Confidence in Responders

The experts suggested that the perception of emergency responders held by the casualties plays a critical role. In particular, they felt it was crucial that casualties would need to believe that the responders could help them (confidence) and also hold a positive view of the emergency responders in general (legitimacy). They identified that this would be particularly important given how different communities may hold

different opinions of emergency services based on cultural background and prior experience.

The social identity approach can help to explain the role of legitimacy in the building of trust (Tajfel *et al.,* 1979; Hogg and Turner, 1987), as it attempts to explain how crowds behave during crowd events (Drury *et al.,* 2003a) including mass emergencies (Drury *et al.,* 2009b). The social identity approach suggests that if the actions of emergency service responders are perceived as legitimate, then the levels of public compliance with any recommended protective behaviours during an emergency will be correspondingly higher (Drury *et al.,* 2003a; Carter *et al.,* 2015a). However, if crowds feel in conflict with emergency responders in regard to required actions, then crowds may see emergency responders as illegitimate and consequently their trust in responders will be reduced with a subsequent drop in compliance with any recommended protective behaviours.

Alongside legitimacy, there is also a need for casualties to believe that emergency responders can help them at an incident. This may be based either on pre-held assumptions of the roles of emergency responders or upon the actions of responders at the scene of an incident. For instance, during a Hazmat/CBRN incident casualties may view the emergency responder's positively believing them to be trying to help and assist. Casualties are unlikely, however, to have an appreciation of the actions required by emergency responders to manage such an incident and hence may either fail to understand these actions or the ability of responders to carry these out. This would be especially true of Firefighters conducting decontamination activities. Hence casualties may not have confidence in the capability of responders to carry out such actions. Likewise, the actual response of the emergency service may be viewed by casualties as

incompetent for any number of reasons and as a result leave casualties believing that responders are unable to offer the level of response expected, resulting in low perceptions of competence (Earle and Siegrist, 2006).

Competence is central alongside legitimacy to the development of the trust held by any casualties involved in a Hazmat/CBRN incident. Especially, casualties must believe that emergency responders are legitimate actors working to protect them whilst also having confidence that they are able to do so effectively. This combination of legitimacy and competence will, in turn, enhance public trust and lead to increased compliance and cooperation.

8.3.1.5 Actions of Other Casualties

The experts also suggested that casualties will look at those around them to assist in their decision making. If large numbers of those around a casualty are seen leaving the scene, this will strongly influence that casualty to also leave the scene, with the converse true for remaining in place.

The influence that the behaviours of casualties would have on each other is supported by the literature. Self-categorisation theory (Turner and Killian, 1987) suggests that individuals will identify with a group if they believe themselves to hold a shared identity and common goals with that group in their current situation. Drury *et al* (2009b) identifies that in emergencies a shared identity, i.e. a 'shared fate', develops as a response to the common threats being faced.

This shared fate is also acknowledged by the Social Identity Theory, where a shared identity supports trust in those around us. Farmer *et al* (2014) identified that those whom we deem as "like ourselves", are more likely to be trusted. This is also supported by Eiser *et al* (2012) who found that in emergencies, people do not act on their own but will compare their interpretation of the situation with others to inform their decisions.

Hence, in a mass decontamination the role of a crowd formed as a function of social identify theory will be critical to informing decision-making.

8.3.2 Variables with No or Limited Previous Associated Literature

8.3.2.1 Weather Conditions

The experts believed that the weather would have an impact. In particular, they suggested that casualties would be influenced in their willingness to remain at the scene and undergo decontamination by weather conditions, with the example given of casualties being less inclined to remain at the scene and undergo decontamination if it was raining and/or cold. The additional discomfort that such weather would place upon casualties needing to disrobe and decontaminate increases the likelihood of their willingness to leave the scene, it was suggested.

The discussion amongst the experts focused upon cold and wet weather in relation to warmer and dryer conditions, though without exploring the role of the weather should it be very hot.

There is no published research concerning the role of weather conditions in influencing casualty behaviours concerning stay in place or evacuate, during a mass decontamination incident. Yet the expert respondents were agreed in their analysis that this would play an influencing role. As such, it appears this is an area requiring further investigation as it has thus far not been identified by the literature.

8.3.2.2 Agent Effect

The type of agent involved was identified as being of critical importance in assessing how people would react. The experts highlighted how both a severe physiological reaction and no reaction whatsoever can be tremendously problematic for responders. The former results in casualties immediately attempting to seek assistance and, as such, reduce the amount of time they are willing to wait at the scene of an incident for an emergency responder. Rather, casualties instead will seek out medical support at hospital or other health care facilities.

No reaction at all to the agent was seen as likely to encourage casualties to leave as they would fail to appreciate any need for decontamination to occur. Therefore, their willingness to stay at the scene and undergo decontamination would be lower, as it would appear unnecessary, and it is more likely that they will choose to continue with their day or return home to a perceived place of safety.

There appears to be little academic research attempting to understand how the effect of an agent will influence casualty behaviours. Expert respondents made it clear that the type of physiological reaction experienced would influence casualty behaviours. This varies across the spectrum from no visible or immediate effect caused by a radiological 'dirty bomb', making casualties more likely to leave and go home being unaware of any

risk, to exposure to a caustic agent leading casualties to immediately self-present to hospital. Hence further research to understand the role of this variable is required.

8.3.2.3 Location

The experts believed that the location of the incident was highly important, as it would play a role in driving the affective responses of casualties to an incident. Unknown locations, especially 'confined' places such as underground stations, were deemed to be places that would increase the likelihood of casualties leaving. Familiar locations for example were seen by some experts as likely to create a more positive affective response and increase compliance with the "stay in place" advice. However, others felt this could potentially increase the likelihood of casualties leaving the scene and either returning home or moving to other known 'safe locations' nearby, or to local medical facilities.

There is, however, little literature concerning the role of location in influencing such decisions. Research undertaken by Dombroski *et al* (2006), which considered the behavioural response to a Radiological Dispersion Device, suggested people would be 10% more likely to shelter in place if at home than at work and visa versa for compliance with an evacuation order, thus indicating the importance of location in such incidents.

However, beyond this no further research appears to have been conducted looking at the influence of location on casualty behaviours during a Hazmat/CBRN incident.

8.4 Scenarios

The four scenarios used varied in how they presented the communication by responders and the five environmental variables identified by responders as likely to influence casualty behaviours in relation to waiting at the scene of a Hazmat/CBRN incident and being willing to undergo decontamination (Location, Agent Effect, Weather Conditions, Dependants, Crowd and other casualty's actions).

'Public Awareness and Knowledge' and 'Confidence in Responders' were variables which the emergency service had influence over and, as such, could be examined through pre- and post-scenario questions, but would not form part of the scenarios themselves.

Worst Case Scenarios: These scenarios laid out a cold, wet and unfamiliar environment with waiting dependants. The effects of the agent are clearly described as being felt and severe in nature, whilst other casualties are identified as beginning to leave the immediate area.

Best Case Scenarios: These scenarios laid out a warm, dry and familiar environment where there are no dependants involved. The agent's effects are described as being felt but do not appear to be having a serious effect, and other casualties remain in place.

Effective and Poor Communications: Communications were altered for the Best and Worst case scenarios. Effective Communications involved emergency responders providing considerable information about what needs to be done and why. Poor communication scenarios involved very limited communications from emergency

responders as to what was happening and provided no explanation of why actions where required.

8.4.1 Scenario 1: Worst Case Scenario, Poor Communication

First stage of scenario (general scenario)

On a cold, wet late evening, you are travelling with some close family members. As you are stood on the platform of an unfamiliar train station, an explosion occurs. Ears ringing, you look down to find that you and your family are covered in a fine powder. Quickly you feel your eyes start to sting and a cough rises in your throat. All around you, you can see your fellow passengers starting to suffer. Many are starting to head for the exits in order to leave the station.

Second stage of scenario (communication)

Emergency responders tell you, and others nearby, to follow them to a location outside the train station. They then tell you to remove the top layer of your clothes, down to your underwear. They give you some blue paper roll and tell you to use it to wipe the powder off your skin. While you are wiping the powder off your skin, emergency responders say that they are going to need to set up a large shower system in order to decontaminate you.

Emergency responders tell you and the others affected to form a queue and wait to enter the large shower system. You are all told to remove your underwear, and then enter the shower one by one.

8.4.2 Scenario 2: Best Case Scenario, Poor Communication

First stage of scenario (general scenario)

It's 9am on a warm and dry summer day and you are wandering alone down your local high street where you often shop. You're in no hurry and are enjoying the walk. Suddenly there is a loud explosion. Looking down, you see you are covered in a fine powder. The air around you smells and tastes slightly strange. But you feel fine. The people around you all seem to have stopped and are staying put.

Second stage of scenario (communication)

Emergency responders tell you, and others in your vicinity, to follow them to an empty car park nearby. They then tell you to remove the top layer of your clothes, down to your underwear. They give you some blue paper roll and tell you to use it to wipe the powder off your skin. While you are wiping the powder off your skin, emergency responders say that they are going to need to set up a large shower system, to decontaminate you.

Emergency responders tell you and the others affected to form a queue and wait to enter the large shower system. You are all told to remove your underwear and then enter the shower one by one.

8.4.3 Scenario 3: Worst Case Scenario, Effective Communication

First stage of scenario (general scenario)

On a cold, wet late evening, you are travelling with some close family members. As you are stood on the platform of an unfamiliar train station, an explosion occurs. Ears ringing, you look down to find that you and your family are covered in a fine powder. Quickly you feel your eyes start to sting and a cough rises in your throat. All around you, you can see your fellow passengers starting to suffer. Many are starting to head for the exits to leave the station.

Second stage of scenario (communication)

Emergency responders explain that you have potentially come into contact with a chemical agent, and to prevent further contamination, they ask you to follow them to a location outside the train station. They then ask you to remove the top layer of your clothes, down to your underwear. They explain that removing the top layer of your clothes will remove 80-90% of any contaminant which you may have come into contact with and will therefore help to protect you. They give you some blue paper roll and ask you to use it to wipe the powder off your skin. They explain that using this roll to wipe yourself down will remove any contaminant which may remain on your skin and will therefore help to reduce any risks from the contaminant. While you are wiping the powder off your skin, emergency responders begin to set up a large shower system, using hoses from their fire engines. Emergency responders explain that going through the shower will remove any contaminant which may remain on your skin.

Emergency responders ask you and the others affected to form a queue and wait to enter the large shower system. You are all asked to remove your underwear, as this will

help to ensure that all remaining contaminant is removed from your skin during the shower. People are asked to enter the shower one by one.

8.4.4 Scenario 4: Best Case Scenario, Effective Communication

First stage of scenario (general scenario)

It's 9am on a warm and dry summer day and you are wandering alone down your local high street where you often shop. You're in no hurry and are enjoying the walk. Suddenly there is a loud explosion. Looking down you see you are covered in a fine powder. The air around you smells and tastes slightly strange. But you feel fine. The people around you all seem to have stopped and are staying put.

Second stage of scenario (communication)

Emergency responders explain that you have potentially come into contact with a chemical, and to prevent further contamination, they ask you to follow them to an empty car park nearby. They then ask you to remove the top layer of your clothes, down to your underwear. They explain that removing the top layer of your clothes will remove 80-90% of any contaminant which you may have come into contact with, and will therefore help to protect you. They give you some blue roll and ask you to use it to wipe the powder off your skin. They explain that using the blue roll to wipe yourself down will remove any contaminant which may remain on your skin and will therefore help to reduce any risks from the contaminant. While you are wiping the powder off your skin, emergency responders begin to set up a large shower system, using hoses from their fire engines. Emergency responders explain that going through the shower will remove any contaminant which may remain on your skin.

Emergency responders ask you and the others affected to form a queue and wait to enter the large shower system. You are all asked to remove your underwear, as this will help to ensure that all remaining contaminant is removed from your skin during the shower. People are asked to enter the shower one by one.

8.5 Conclusion

This study has sought to do three things:

- Identify a methodology for identifying variables which will influence casualty behaviour at a Hazmat/CBRN incident
- To identify the variables which will influence casualty willingness to stay at the scene of a Hazmat/CRBN incident and undergo decontamination
- Develop scenarios capable of allowing further investigation of casualty behaviours during a Hazmat/CBRN incident

The careful selection and use of expert knowledge and experience can be used to effectively understand issues of casualty behaviour at a Hazmat/CBRN incident and in doing so effectively fill the void of knowledge surrounding this area of mass decontamination response. This approach was used to identify these variables and utilise them in the development of scenarios which can be used to inform further investigation into how casualties will behave during Hazmat/CBRN incidents requiring mass decontamination and how these behaviours will impact the effectiveness of operations and the wider impact such incidents may have.

As such this Chapter has contributed to the development of understanding surrounding casualty behaviours during mass decontamination by providing the resources required for further research in this area. This Thesis will now seek to utilise the scenarios developed to establish the rate at which casualties would likely leave the scene of a Hazmat/CBRN incident requiring mass decontamination, in order to provide this crucial, but so far missing, piece of information for mass decontamination emergency response planning.[10]

[10] Part of this work was published in; Hall, C., Weston, D., Long, F., O'Sullivan, F., Amlôt, R. and Carter, H., 2020. Guidelines and recommendations for mitigation and management of CBRNe terrorism. Deliverable D1, 3.

Chapter 9 – Stay in Place Compliance Times and Decontamination Willingness – A Visualisation Approach

This thesis has explored the impact of the behaviours of those involved in a Hazmat/CBRN incident have on any operation requiring mass decontamination. It has identified the crucial importance of the willingness of casualties to wait at the scene of an incident and undergo decontamination during such an incident requiring. The thesis has also identified how casualties during such emergencies can and will be influenced by the actions of emergency responders.

In particular, by using the scenarios developed in the previous chapter, this Chapter now seeks to determine the length of time, i.e. duration, that casualties are willing to wait at the scene of a Hazmat/CBRN incident, their willingness to then undergo decontamination and how various factors will influence this; most crucially emergency service response times and communications. This is a particularly timely question to ponder as the Global Britain in a Competitive Age: Integrated Review of Security, Defence, Development and Foreign Policy (2021) states that *"It is likely that a terrorist group will launch a successful CBRN attack by 2030"* (p. 32). Such weapons therefore pose a significant risk to the UK, as witnessed by the events of the Novichok incident in Salisbury (Dodd *et al.,* 2018).

9.1 Introduction

Following a Hazmat/CBRN incident those affected may need to undergo decontamination in order to remove any hazardous materials they may have come into contact with. Chapter 2 noted that should such an incident occur within the UK, the FRS

have responsibility for providing for the decontamination of members of the public as laid out in the Fire and Rescue Services (Emergencies) (England) Order (2007).

National Resilience was established as a local and national governmental collaboration in the aftermath of the 9/11 Terror attacks to prepare the UK for emerging threats for which no single fire and rescue service can prepare for. It covered a range of potential risks one of which was the development a mass decontamination capability capable of decontaminating up to 150 people per hour (Colins *et al.,* 2021).

To provide this capability MDUs were strategically located around the country. The number available was revised in 2015 with a reduction of 22 units (Fire Brigades Union, 2015) in a cost cutting measure meaning only half the original capability is still in place. It is worth noting that the number of units and their locations has been determined given population densities, however a crucial variable in the decontamination process is the duration of time individuals are willing to wait in order to undergo decontamination before they leave, and if they are going to leave the scene at what rate will this be? Unfortunately, these crucial factors have not currently been considered.

Should casualties leave a Hazmat/CBRN incident without undergoing decontamination, the risks to both themselves and others is increased as not only will no medical help will be forthcoming, but they are also likely to spread the contaminant more widely risking the exposure of others to the hazardous material.

Little consideration seems to have been given in the literature as to how long casualties will wait at an incident with the assumption being these casualties will remain at the scene either via their own willingness or with the use of force being applied via cordons

enforced by the Police (Egan and Amlôt, 2012). Such assumptions, however, suffer from several flaws. Firstly, it is highly unlikely that there will be a sufficient number of readily available Police Officers (PO) equipped to deal with a CBRN incident in order to provide such containment operations. Secondly, such containment actions are unlikely to be effective in support of a mass decontamination operation, and will likely negatively impact the co-operation of casualties in following the instructions of emergency responders to go through the decontamination showers. As Stott *et al* (2018) has shown POs actions can have the effect of causing a deteriorating of crowd behaviours and make such compliance unlikely, rendering it highly unlikely that any decontamination undertaken will be successful.

Stott *et al* (2018) demonstrated how if a crowd perceives the action of the police as fair, just, and legitimate, it is more likely to result in compliance and cooperation. However, if the police are seen as unjust, biased, or using excessive force, it can escalate tensions and lead to non-compliance or even increased aggression. Stott *et al* (2018) also showed how the use of effective communication strategies by the police helps to manage crowd behaviours. Open dialogue, clear instructions, and efforts to understand and address crowd concerns were shown to increase compliance and reduce the likelihood of deterioration in behaviour. Stott *et al* (2018) showed how crowd behaviour is influenced by group dynamics and the social identity processes, and that, when a crowd perceives a shared identity and solidarity, actions by the police that are perceived as targeting or threatening the group can lead to a defensive or confrontational responses potentially further escalating a situation and reducing the likelihood of compliance and co-operation.

It therefore appears crucial to consider how casualties can be convinced to stay put and undergo decontamination of their own volition and to understand at what rate people would leave. Having in place valid assumptions for how long most people will wait at the scene and be co-operative and at what rate they will leave is essential to enable planning to be informed and effective.

This Thesis has thus far identified the need for greater consideration of how casualties behave during a mass decontamination incident and has shown through investigation of the Grenfell Tower Fire and the Ocado public evacuation, both how members of the public can be effectively engaged with and how they will most commonly be co-operative and helpful if engaged with effectively. Furthermore, this Thesis has developed a set of scenarios with which to test waiting times and leaver rates at a mass decontamination incident.

This Chapter will therefore seek to utilise these scenarios to inform future resourcing and planning strategies in relation to how engagement with human behaviour during a decontamination incident will impact such operations.

In particular, the aims of this Chapter are to assess:

- how long casualties will be willing to wait at the scene of a Hazmat/CBRN incident to undergo decontamination.
- how communications by emergency responders may influence casualties' willingness to remain and undergo decontamination.

9.2 Methodology

9.2.1 Ethics

This study was given Ethical Approval by Imperial College London's' Science Engineering Technology Research Ethics Committee.

All participants provided consent to their participation in the study and had the right to withdraw from the study at any time. This was achieved through the use of an informed consent sheet at the start of the survey. The Informed Consent Sheet used the same format as seen in Figure 9 and the full Informed Consent for this study can be seen in Appendix V).

All participants data will be anonymised and stored securely for 10 years.

9.2.2 Participants

A representative sample of 1096 UK residents were engaged for this study. The market research company Prolific was used to recruit participants.

9.2.3 Design

The study used an experimental design. Participants were randomised and provide with one of four different scenarios based upon variables identified by experts in the previous Chapter as likely to influence casualty's willingness to remain at the scene of a Hazmat/CBRN incident and undergo decontamination. The scenarios related to Good and Bad environmental factors coupled with effective and poor communications by

emergency responders. As such this gave four scenarios: Good Scenario and Effective Communications; Good Scenario and Poor Communications; Bad Scenario and Effective Communications; Bad Scenario and Poor Communications. The full design is set out in Figure 12 below.

Figure 13 Methodological procedure for determining leaver rates and willingness to undergo decontamination.



9.2.4 Procedure

Firstly, participants were asked to read and sign an informed consent form identifying that they understood what the study would involve, that they understood their rights as part of the study and that they were happy to participate.

9.2.5 Demographics

Next demographic information was captured on respondents covering their Age, Gender, Ethnicity, Education and Household Income. These categories were chosen as common categories collected during research and which were deemed useful for examining the potential of demographics to impact upon results (Creswell, 2014).

Full Demographic details are shown in Appendix VI.

9.2.6 Pre-survey Intervention Questionnaire

The pre-scenarios questionnaire asked the respondents a number of questions to look to understand their prior knowledge of CBRN and mass decontamination incidents and their attitudes towards emergency responders. See Appendix VII for full participant survey.

These areas were identified by experts in the previous Chapter as being likely factors in influencing behaviours and therefore needed to be consider alongside the

environmental and communications variables within the scenarios to understand their level of influence.

The questionnaire asked the following questions utilising a 7-point Likert scale, with 1 being “Entirely disagree,” and 7 being “Entirely agree” to elicit responses:

The level of trust held by respondents for the emergency services: (“I trust the emergency services”).

The level of confidence held by respondents for the emergency services (“I have confidence in the emergency services”).

The level of understanding respondents had of CBRN incidents (“I feel I have a good understanding of emergency incidents involving chemical, biological, radiological or nuclear materials”).

Finally, respondents understanding of mass decontamination (“I feel I have a good understanding of emergency incidents requiring mass decontamination”).

9.2.7 Main Content

The main body of the survey provided participants with one of the four CBRN scenarios. These can be viewed in Appendix VII.

The first stage of the scenario provided participants with general information on the situation they were being asked to visualise. The information related to the environmental factors identified in the previous Chapter.

The first question then asked participants *"From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene"?* Participants were asked to answer this question in the number of minutes they would be willing to wait. This is referred to as Time Stamp 1.

The second stage of the scenario focused on the communication delivered by emergency responders.

Following this part of the scenario a second question asked, *"From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene"?* Participants were then asked to answer this question in the number of minutes they would be willing to wait. This is referred to as Time Stamp 2.

Participants were then also asked about their willingness to undergo decontamination. "How willing would you be to undergo decontamination"? This was measured on a 7-point Likert scale (1= Entirely Unwilling; 7= Entirely Willing).

The final question then asked, *"Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene"?* Again, Participants were asked to answer this question in the number of minutes they would be willing to wait. This is referred to as Time Stamp 3.

9.2.8 Post-survey Intervention Questionnaire

The post-communication questionnaire looked to ascertain the level to which participants engaged with the scenarios. These can be viewed in Appendix VII.

Participants were asked the following questions utilising a 7-point Likert scale, with 1 being "Entirely disagree," and 7 being "Entirely agree" to elicit responses:

Their level of engagement with the scenario ("I imaged this event well", "I felt emotionally engaged with the scenarios"). The two measures of engagement were selected having been used in previous research for the same aim (Ford and Ayres 2009).

How effective their communications had been ("If this situation had been real, I think I would have understood what actions were expected of me during the decontamination process", "If this situation had been real, I think I would have had enough information to take appropriate actions"). These questions were selected having been used in previous research for the same aim (Carter *et al.,* 2013a; Carter *et al.,* 2013c; Carter *et al.,* 2014).

The level of Anxiety felt by respondents whilst engaging with the scenarios (If this had been a real incident, I would have felt anxious, If this had been a real incident, I would have felt scared, If this had been a real incident, I would have felt stressed").

These question for Anxiety came from State Trait Anxiety Index (Spielberger *et al.,* 1994) and adapted to relate to decontamination.

Participants were also then asked again for the level of trust they held for the emergency services: ("I trust the emergency services") and the level of confidence they held for the emergency services ("I have confidence in the emergency services").

9.2.9 Survival Analysis

Finally, Survival Analysis was conducted to understand the rate at which casualties would leave the scene of a CBRN incident.

Survival analysis is used to analyse data in which the time until an event of interest occurs. The response is often referred to as a failure time, survival time, or event time.

Survival analysis has been utilised by a number of other papers concerning behavioural choices during emergencies. Roberson (2017) utilised survival analysis to investigate the evacuation timing behaviour of residents threatened by wildfires in order to understand why some people delay evacuating when given official warnings.

Shimada *et al (*2018) used survival analysis to examine mortality rates dependent upon the decision to evacuate or shelter-in-place during the 2011 Fukushima nuclear incident whilst Fu and Wilmott (2006) used survival analysis models in their research to estimate the probability of an evacuation occurring within a distinct time frame prior to a hurricane landfall.

All of these examples demonstrated the effective role which survival analysis can have upon determining casualty behaviours during emergency situations and provides the

basis for this approach being utilised to analyse the likely casualty leaver rate collected for this study.

Survival analysis was utilised to analyse leaver rates as it allows for the estimation of the probability of an event (in this case, leaving the incident) occurring over time. It assists in determining the likelihood of individuals leaving the incident at different points in time and is capable of identify factors that may be associated with the timing of their departure. This type of analysis is particularly useful when studying events that occur over a period of time, such as is the case with a mass decontamination incident where people may be waiting for extended periods of time before being decontaminated or leaving. By using survival analysis, insight was gained for how long people are likely to stay at the incident, and the leaver rate throughout the incident.

9.2.10 Survival Analysis Formulae

The Kaplan-Meier survival analysis, is a non-parametric method for estimating the probability of an event occurring at different time points when analysing time-to-event data. The formula for calculating the Kaplan-Meier survival curve at a specific time point is as follows:

$$S(t) = \Pi [1 - (d_i / n_i)]$$

Where:

- S(t) is the estimated survival probability of a causality remaining at the scenario a CBRN incident to undergo decontamination at time t.
- Π denotes the product over all time points (i) where $t_i \leq t$.

- d_i represents the number of events (e.g., those leaving the scene) that occurred at time t_i.
- n_i represents the number of individuals or subjects at risk (still under observation) just before time t_i.

The Kaplan-Meier estimator is useful for visualizing and comparing 'survival' curves between different groups, in this case external variables (Good/Bad) and communication interventions (Good/Bad). It provides a non-parametric estimate of the 'survival' function and allows an estimate to be made and compared of probabilities of willingness to remain at the scene of a CBRN incident over time.

9.3 Results

9.3.1 Demographics

Demographics were explored to understand how these may influence behaviours. Tables 7, 8 and 9 below show where significance existed between demographic groups. Full details of these differences are set out in Appendix VIII.

Table 7 Demographic Differences: Pre-Survey Measures

	I trust in the emergency services	I have confidence in the emergency services	I feel I have a good understanding of emergency incidents involving CBRN	I feel I have a good understanding of emergency incidents requiring mass decontamination
Age	x	x		
Gender			x	x
Ethnicity	x	x		
Education	x	x		
Household Income				

Table 8 Demographic Differences: Main Survey Measures

	Time Stamp 1	Time Stap 2	Willingness to undergo decontamination	Time Stap 3
Age				x
Gender			x	x
Ethnicity		x		x
Education				
Household Income			x	

Table 9 Demographic Differences: Post-Survey Measures

	I imaged this event well	I felt emotionally engaged with the scenarios	If this situation had been real, I think I would have understood what actions were expected of me during the decontamination process	If this situation had been real, I think I would have had enough information to take appropriate actions	If this had been a real incident, I would have felt anxious.	If this had been a real incident, I would have felt scared.	If this had been a real incident, I would have felt stressed.	I trust the emergency services.	I have confidence in the emergency services.
Age					x			x	x
Gender					x				
Ethnicity			x	x				x	x
Education		x	x	x					
Household Income					x				

9.3.3 Waiting Times

The first-time stage asked respondents how long they would be willing to wait at the scene of a CRBN incident until emergency responders arrived at the scene. The first stage of analysis was to remove any outliers for each of the time points (1, 2, 3). Time Stamp one had 63 outliers removed. Time Stamp 2 had 28 outliers removed and Time Stamp 3 had 24 outliers removed.

A between-subjects Anova with Bonferroni correction was then used to compare waiting times between each of the four scenarios. This was then supported by the use of a Student's T-Test between each of the four scenarios.

Table 10 "From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene"?

Scenario	Mean Waiting Times (Minutes)	Standard Deviation
Scenario 1 (bad scenario, bad comms)	16.98	16.692
Scenario 2 (good scenario, bad comms)	30.18	42.380
Scenario 3 (bad scenario, good comms)	19.71	25.775
Scenario 4 (good scenario, good comms)	32.40	42.687

There were significant differences between Scenario 1 and Scenario 2 (<.001), Scenarios 1 and 4 (<.001), and also between Scenario 2 and Scenario 3 (.002), and Scenarios 3 and 4 (<.001). The significance was the same for both the between-subjects Anova with Bonferroni correction and the Student's T-Test.

The results indicated that casualties were willing to wait significantly longer at the best-case scenarios over the worst case regardless of communications.

The second-time stage asked respondents how long they would be willing to wait at the scene of a CRBN incident from the time emergency responders arrived at the beginning of an incident to decontamination activities being commenced by a mass decontamination unit.

Table 11 "From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene"?

Scenario	Mean Waiting Times (Minutes)	Standard Deviation
Scenario 1 (bad scenario, bad comms)	67.63	77.289
Scenario 2 (good scenario, bad comms)	89.37	89.673
Scenario 3 (bad scenario, good comms)	58.31	64.273
Scenario 4 (good scenario, good comms)	88.58	86.525

There were significant differences between Scenario 1 and Scenario 2 (.010 between-subjects Anova with Bonferroni correction; .002 Students T-Test), Scenario 1 and Scenario 4 (<.012 between-subjects Anova with Bonferroni correction ; .007 Students T-Test), Scenario 2 and Scenario 3 (<.001for both between-subjects Anova with Bonferroni correction and the Students T-Test), Scenario 3 and Scenario 4 (<.001 between-subjects Anova with Bonferroni correction;.007 Students T-Test).

Like at Time Stamp 1 respondents reported a willingness to wait significantly longer at the best-case scenarios over the worst case regardless of communications.

The final time stage asked respondents how willing they felt to undergo decontamination and how long they would be willing to wait at the scene of a CRBN

incident from decontamination commencing until they themselves underwent decontamination.

9.3.4 Willingness to Undergo Decontamination

The willingness of casualties to undergo decontamination was also measured see table 12 for means and std deviations of each Group.

Table 12 "How willing would you be to undergo decontamination"?

Scenario	Mean Willingness	Standard Deviation
Scenario 1 (bad scenario, bad comms)	6.06	1.305
Scenario 2 (good scenario, bad comms)	5.74	1.537
Scenario 3 (bad scenario, good comms)	5.94	1.519
Scenario 4 (good scenario, good comms)	5.56	1.610

Significant difference existed between Scenario 1 (bad scenario, bad comms) and Scenario 2 (good scenario, bad comms) (<.033 between-subjects Anova with Bonferroni correction and <.001 Students T-Test).

Significance was also seen between Scenario 1 (bad scenario, bad comms) and Scenario 4 (good scenario, good comms) (<.001 for both the between-subjects Anova with Bonferroni correction and the Students T-Test).

Significance was found between Scenario 3 (bad scenario, good comms) and Scenario 4 (good scenario, good comms) (<.019 between-subjects Anova with Bonferroni correction, 0.11 Students T-Test).

Table 13 "Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene"?

Scenario	Mean Waiting Times (Minutes)	Standard Deviation
Scenario 1 (bad scenario, bad comms)	73.10	87.510
Scenario 2 (good scenario, bad comms)	92.33	99.029
Scenario 3 (bad scenario, good comms)	66.03	77.007
Scenario 4 (good scenario, good comms)	89.90	94.079

Significant difference existed between Scenario 2 (good scenario, bad comms) and Scenario 3 (bad scenario, good comms) (.002 between-subjects Anova with Bonferroni correction; <.001 Students T-Test) and Scenario 3 (bad scenario, good comms) and Scenario 4 (good scenario, good comms) (.005 between-subjects Anova with Bonferroni correction; <.001 Students T-Test).

Once again respondents' willingness to wait at the scene was significantly longer for the best-case scenarios over the worst case regardless of communications.

Overall, from the start of a CBRN incident emergency services would therefore have the following amount of time to decontaminate a casualty before the average person decided to leave the scene.

Table 14 Overall Waiting Times

Scenario	Mean Waiting Times (Minutes)	Standard Deviation
Scenario 1 (bad scenario, bad comms)	176	190.54738
Scenario 2 (good scenario, bad comms)	224	222.08414
Scenario 3 (bad scenario, good comms)	163	171.37210
Scenario 4 (good scenario, good comms)	223	208.54517

Significant difference existed between Scenario 1 (bad scenario, bad comms) and Scenario 2 (good scenario, bad comms) (.028 between-subjects Anova with Bonferroni correction; .006 Students T-Test).

Significance was also seen between Scenario 1 (bad scenario, bad comms) and Scenario 4 (good scenario, good comms) when the between-subjects Anova with Bonferroni correction was applied (.028), however, the Student T-Test did not show significant

(.087). The difference in statistical significance is likely due to the wide Standard Deviation for these variables which the Student's T-Test is sensitive to.
Significance was also seen between Scenario 2 (good scenario, bad comms) and Scenario 3 (bad scenario, good comms) (<.001 for both between-subjects Anova with Bonferroni correction and Students T-Test).

Significance was also seen between Scenario 3 (bad scenario, good comms) and Scenario 4 (good scenario, good comms) (<.001 for both between-subjects Anova with Bonferroni correction and Students T-Test).

9.3.5 Survival Analysis

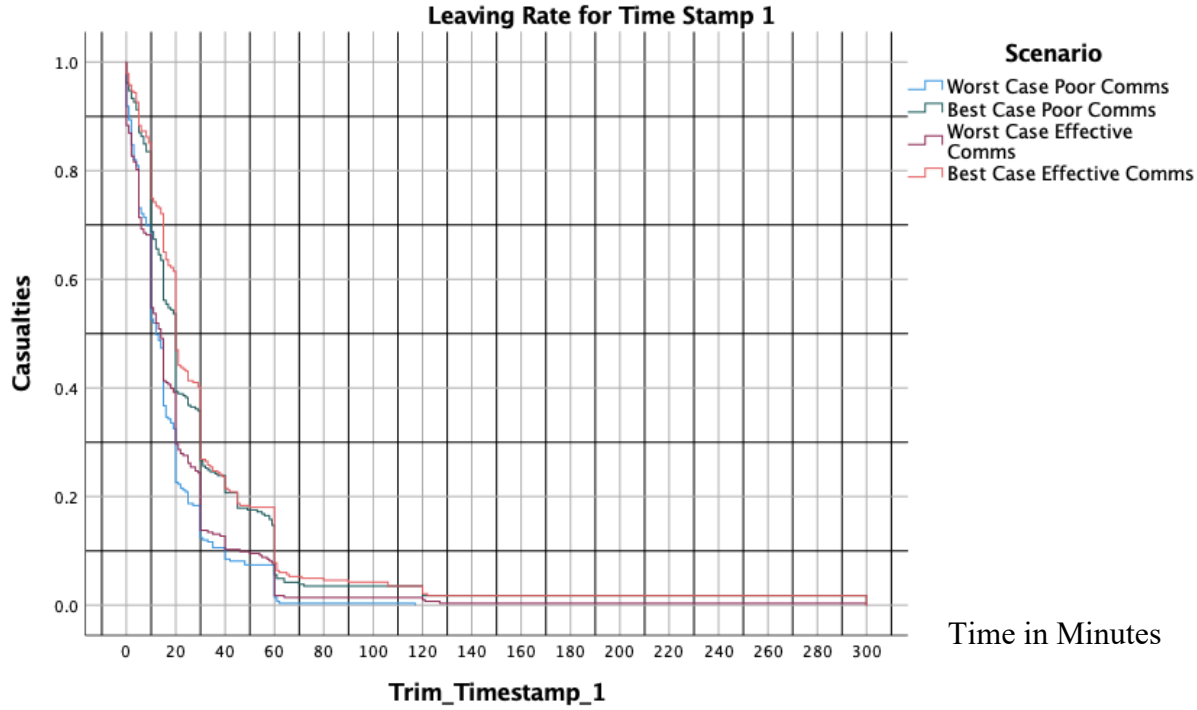
Finally, Survival Analysis was conducted to understand the rate at which casualties would leave the scene of a CBRN incident.

Figure 13 shows the leaver rate during the first-time stage of an incident from the incident occurring to the first emergency responders arriving. Figure 14 shows the leaver rate during the second-time stage of an incident from the first emergency responders arriving to decontamination operations commencing. Figure 15 shows the leaver rate during the third-time stage of an incident from decontamination operations commencing to an individual being decontaminated.

Using survival analysis to demonstrate the leaver rate provides a difference approach to utilising mean leaver time. As can be seen the leaver rate is not uniform with the fast-leaving rates earlier in an incident and slowing over time.

Figure 14 Leaver Rate from the incident occurring to the first emergency responders arriving.

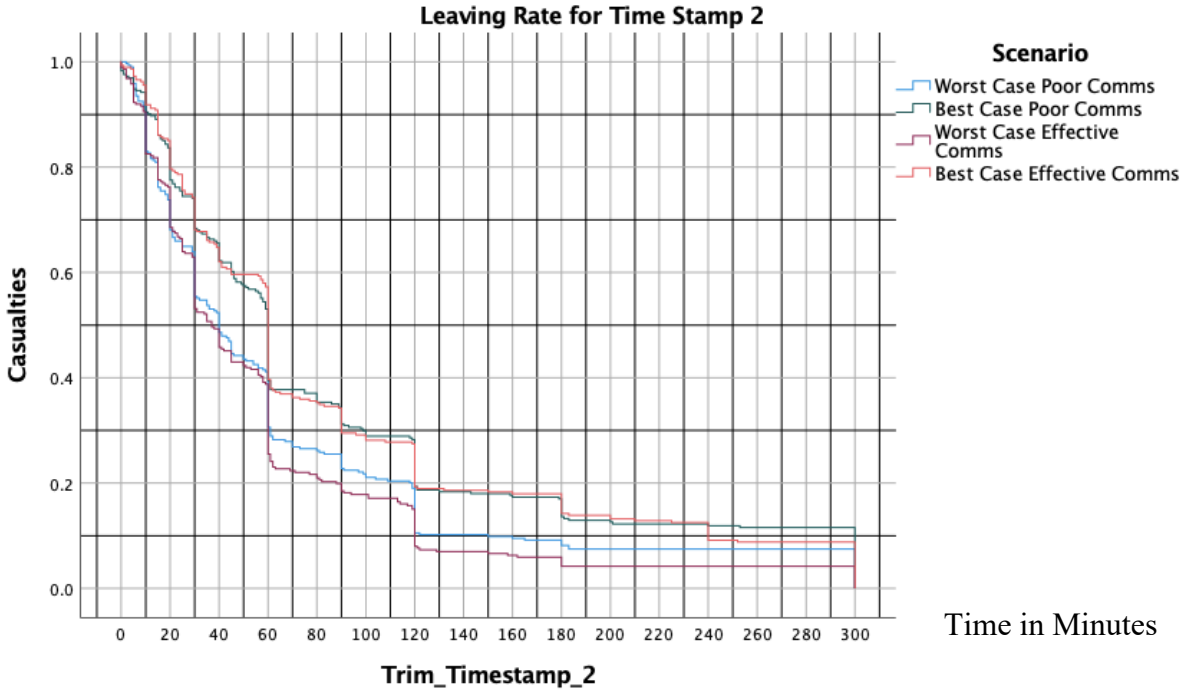
Percentage of Casualties at the scene



Time in Minutes

Figure 15 Leaver Rate from the first emergency responders arriving to decontamination operations commencing.

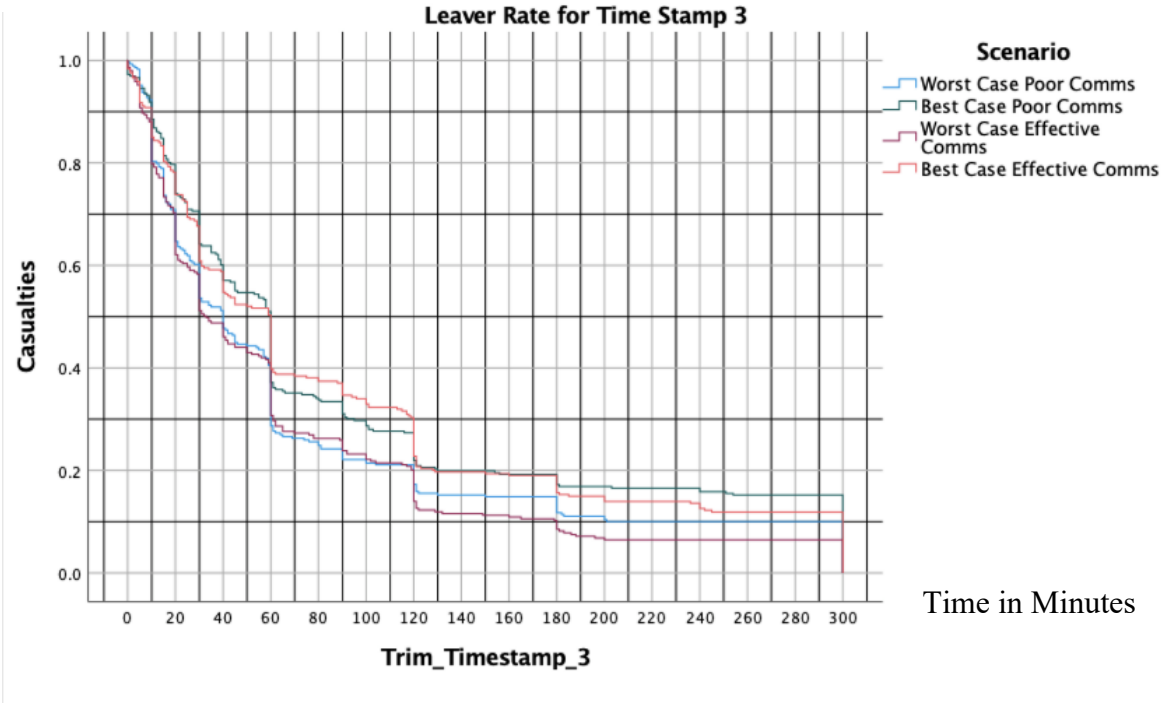
Percentage of Casualties at the scene



Time in Minutes

Figure 16 Leaver Rate from decontamination operations commencing to an individual being decontaminated.

Percentage of Casualties at the scene



Time in Minutes

9.3.6 Post Intervention Manipulation Checks

Manipulation checks were measured at the end of the survey to understand levels of engagement with the scenarios, how effective respondents felt communications would have been and the level of anxiety respondents believed they would have during an incident.

The post-survey intervention questionnaires utilised a 7-point Likert scale, with 1 being "Entirely disagree," and 7 being "Entirely agree."

Participants levels of trust and confidence in the emergency services ("I trust the emergency services"; "I have confidence in the emergency services") was also measured again post intervention, following these questions being asked before taking one of the studies.

Their level of engagement with the scenario (two items, $\alpha = .65$ "I imaged this event well", "I felt emotionally engaged with the") showed no significant difference between scenarios.

How effective emergency responder communications had been (two items, $\alpha = .71$ "If this situation had been real, I think I would have understood what actions were expected of me during the decontamination process", "If this situation had been real, I think I would have had enough information to take appropriate actions") showed no significant differences identified between scenarios.

The level of Anxiety felt by respondents whilst engaging with the scenarios (three items, $\alpha = .88$ "If this had been a real incident, I would have felt anxious. If this had been a real incident, I would have felt scared. If this had been a real incident, I would have felt stressed"). There was significant difference between the scenarios as shown below in Table 15.

Table 15 Significant differences between Post Intervention Anxiety measure

Scenario	Mean Anxiety Scores	Standard Deviation
Scenario 1 (bad scenario, bad comms)	6.58	.74077
Scenario 2 (good scenario, bad comms)	6.4	.86185
Scenario 3 (bad scenario, good comms)	6.57	.77585
Scenario 4 (good scenario, good comms)	6.31	.89651

Significant difference existed between Scenario 1 (bad scenario, bad comms) and Scenario 2 (good scenario, bad comms) (.036).

Significant difference existed between Scenario 1 (bad scenario, bad comms) and Scenario 4 (good scenario, good comms) (>.001).

Significant difference existed between Scenario 3 (bad scenario, good comms) and Scenario 4 (good scenario, good comms) (>.001).

There were no significant differences between Pre-Intervention Trust levels and Post-Intervention Trust levels or Pre-Intervention Confidence levels and Post-Intervention Confidences levels.

9.4 Limitations

A visualization approach was taken in this research in order to engage respondents with the scenarios presented and gain their insights into their willingness to remain at the scene of a CRBN incident and undergo decontamination.

Whilst the visualisation approach offers a number of advantages to this research, most prominently the ability to explore a topic where data from real world incidents is not available due to such an incident never having occurred in the UK. It does, however, also have a number of limitations which must be addressed.

The use of an online visualisation study does not involve respondents having to participate in a CBRN or mass decontamination incident. This therefore may have made it difficult for participants to accurately visualise such an incident as that which is described in the scenario. This may therefore have made it difficult for participants to have accurately imagined how they would feel and act during such a situation, and as such will have limited the ecological validity of this research.

In order to overcome some of these limitations future research will be need in order to triangulate the findings of this research with additional control measures for the issue of ecological validity. The use of additional research methods will help to support the inferences made in this research, helping to overcome the limitations of a visualisation approach.

Firstly, this thesis would suggest a place for the use of exercises, whereby participants are physically immersed within a scenario. However, it must be noted that even

exercises are not a truly ecologically valid environments and are very resource heavy operations to instigate, especially where mass decontamination is involved. This will therefore mean a small sample size of participants being available. Nonetheless, the use of exercises in combination with visualisation experiments can help to add further weight to findings.

The use of Virtual Reality is another potential option to support future research in this area. While careful consideration must be given to how it is utilised, if it can be shown to be an effective tool it will assist in bridging the gap between a visualization experiment and exercises, overcoming limitation of both around ecological validity whilst mitigating the heavy resource burden of exercises which limit available sample sizes.

This methodology, as well as the use of exercise or virtual reality would also benefit from the use of more validation methods to provide a more comprehensive understanding of their effectiveness. Greater use of observations and post engagement interviews can offer insights into respondent's perceptions and experiences of the visualization experiment (or exercise etc.), helping to support assertions around the levels of engagement by participants.

Finally, thought should be give not how to collect data should a real world incident of mass decontamination occur, especially in the UK. Such an incident will occur without warning and be relatively short lived-in nature. Therefore, options for how to capture necessary information should be pre-made to allow for any research to be put into action quickly and effectively. Whilst such an incident would of course be truly horrific, learning in order to prepare for any future such tragedies should not be missed.

9.5 Discussion

This Chapter attempts to identify the duration that casualties would be willing to wait at the scene of a CBRN incident in order to undergo decontamination. This is a crucial question in the planning for such emergencies, yet before the analysis in this Chapter, no serious attempt has been made to understand this problem. This Chapter also recognised the importance that communications has on influencing waiting times, in particular the effect of good communications, and how this, together with the speed of response and external variables, impact waiting times and what these wating times are likely to be.

Mass decontamination, in the event of an accidental hazardous material incident or a malicious CBRN attack, is crucial in order to ensure casualties affected by an agent can be effectively washed to reduce the impacts of the agent, allow medical assistance and to ensure they do not spread the agent more widely (National Operational Guidance, 2022c). If casualties leave the area of high contamination, known as the Hot Zone[11], before being decontaminated they will risk spreading any contaminants, even further escalating the incident and putting more people at risk. Furthermore, they will not receive any medical support themselves, thereby increasing their own risk.

As stated in the previous Chapter, in the UK, mass decontamination is undertaken by specialist resources. MDUs are National Resilience assets strategically placed around the country. Their geographic spread makes their response times much longer than that of

11 Hot Zone - The area where the initial release if a hazardous material occurs or where it disperses to. This is the area which will pose an immediate threat to the health and safety of all those located within it and is the area of greatest risk.

regular frontline fire appliances. Furthermore, it takes time to setup the specialist equipment once the asset arrives at the incident.

As such there is a need to understand what impact these delays may have upon the willingness of casualties to remain at the scene of the incident and undergo decontamination. The current strategy and asset distribution has been undertaken with little to no consideration of how response times will be affected and how this could impact the number of casualties leaving the scene of a CBRN incident.

The findings of this Chapter identified certain statistical significance between various groups as explained below.

Significance was seen between all four scenarios waiting times at each of the three-time stamps and in the total waiting times of casualties to remain at the scene of a CBRN incident. Those with the best-case scenarios were willing to wait a statistically significant amount of time longer than those with a worst-case scenario, irrespective of communication. This finding is interesting as effective communication is widely cited in the literature as being crucial in an effective response *(*Proulx and Sime, 1991; Seeger, 2006; Carter, 2014; Carter *et al.,* 2013a; Carter *et al.,* 2013c; Carter *et al.,* 2015a). Given the weight of literature supporting the importance of communications, it is likely that this is the case even if this is not reflected in this study. However, what this study does highlight is both the significant influence that environmental factors can have on an incident and the need for emergency responders to be prepared for a worst-case scenario, given the increased likelihood this may have on casualties' willingness to await decontamination.

As stated, this Chapter has for the first time identified the length of time casualties will be willing to wait to receive decontamination at the scene of a Hazmat/CBRN incident where mass decontamination is required. This figure is crucial in providing emergency planners with a basis from which to formulate tactics and resourcing levels. With an understanding of the waiting times of casualties, planners can make an assessment of both the likely number of casualties involved in such an incident and the percentage of casualties they wish to keep at the scene. This knowledge, coupled with the known response times based upon asset locations, setup times and the 150 casualties per hour throughput of an operating MDU, greatly assists planners to understand whether current arrangements are adequate or seek alternate strategies or additional resources.

Given the inability of emergency services to control many of the variables included in making something a 'good' or 'bad' scenario, it would appear wise to prepare utilising the worst-case scenarios which this study indicates is an average worst-case waiting time of 163 minutes from the start of an incident until leaving.

It is also however, worth considering each 'time stamp' independently. Time Stamp one worst case suggests that, on average, casualties would wait 17 mins for the arrival of an emergency responder who can communicate the need to wait at the scene. Most FRS' have approximately 10 minutes as a first response target for critical incidents, and it may be expected for Police or Ambulance to make it to such a serious incident event more quickly. Hence, it seems that this time stamp average is well within current capabilities to achieve.

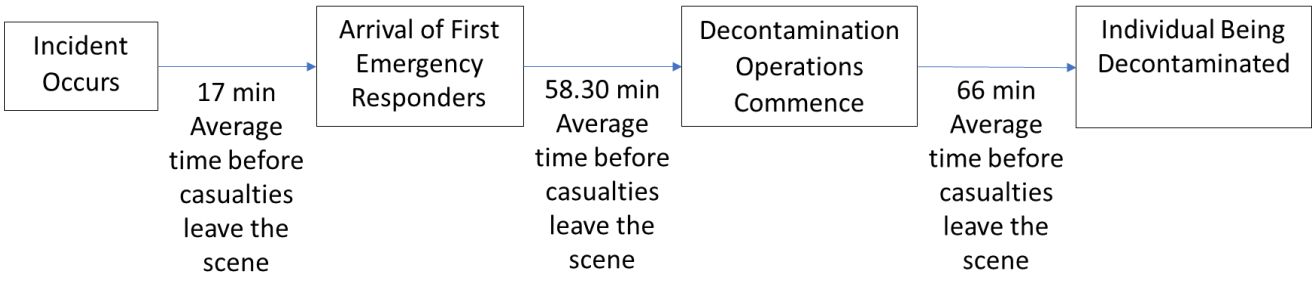
Time Stamps 2 and 3 should be considered to determine if MDUs could arrive and set up within the 58.30 minutes of the least waiting times (bad scenario, good comms) for time

stamp 2 and whether foreseeable casualty numbers could be fully decontaminated within the following 66 minutes of Time Stamp 3 (bad scenario, good comms).

This Chapter is the first attempt in the literature to identify the duration that emergency responders have to arrive at a scene, initiate decontamination and complete decontamination of casualties. This is summarised in Figure 16 below.

This finding allows for a comparison to be made against current standards to assess how viable current plans are.

Figure 17 Overview of Mass Decontamination Operation Timeline



9.5.1 Significant Demographic Differences

While the majority of demographic measures showed no statistical significance, there were nonetheless significant differences in relation to Gender and Ethnicity demographics.

In particular, Males in general were significantly more willing to undergo decontamination and responded to having significantly lower anxiety levels than Females.

White Males in particular show:

i) greater trust in emergency services than Mixed or Multiple Ethnic Groups, Asian or Asian British or Any Other Ethnic Group,

ii) greater confidence in emergency services than Asian or Asian British or Any Other Ethnic Group, and

iii) are willing to wait significantly longer at time stamps 2 and 3 than the Black African Group.

Such differences have been a concern to those planning mass decontamination, with the potential barriers to decontamination present in various ethnic, cultural and religious groups featuring in policy and training materials (National Operational Guidance, 2022c). However, thus far no research has been conducted to understand what such barriers are, why they exist, to what extent they would inhibit mass decontamination nor what actions can be undertaken to mitigate such barriers. Instead, the practice has been to rely upon conjecture, and various ideas relating to cultural and religious barriers to decontamination have been advocated. However, the absence of the necessary research to effectively support such ideas means that any of the pertinent questions around this topic remain unanswered and therefore of little use in the support of operational planning and preparations.

Hence, this Chapter highlights this area as one requiring further research.

9.5.2 Willingness

All four scenarios had high mean results for willingness to undergo decontamination, with no statistically significant difference between the scenarios. This interesting finding suggests a general willingness amongst casualties to undergo decontamination, if they are still at the scene when decontamination becomes operational.

9.5.3 Survival Analysis

Survival analysis, a technique used to assess the leaver rates, indicates that across all three time stamps these rates aren't uniform. The implication of this is that consideration needs to be given to the leaver rate beyond simply the mean times for leaving. Utilising survival analysis alongside the use of means (averages) provides a more effective measure to help determine the required response times in order to meet the desired stay in place levels. For instance, whilst the worst-case overall scenario indicates a mean leaver time of 163 minutes, survival analysis suggests that at this stage approximately 70% of the casualties will have left the scene. Hence, the use of survival analysis may provide a more accurate form of analysis with which to undertake realistic planning.

9.6 Conclusion

The unique findings of this Chapter provide a critical information set for mass decontamination emergency planners. These results can inform future resourcing and planning strategies in relation to how engagement with human behaviour during a decontamination incident will impact such operations. These findings can support

future modelling analysis to provide the key pieces of information to allow for greater understanding of both the efficacy of current arrangements in varying CBRN incidents and whether current arrangements are sufficient to meet desirable results in relation to the number of casualties receiving decontamination against the number who would leave the scene.

These findings would then support far more reliable planning regarding alternate strategies for providing mass decontamination and ensuring the appropriate resourcing of all mass decontamination response methods.

Chapter 10 – Mixed Methods Appraisal

The purpose of this Chapter is to reflect upon the use of mixed methods as a research approach to studying human behaviour during mass decontamination incidents, in order to inform future research in this area. This Thesis establishes an epistemological research philosophy utilising a pragmatic approach. This led to the use of a mixed methods research design in order to achieve the aims of the Thesis. Consequently, this Thesis has demonstrated the efficacy of the use of mixed methods in answering questions relating to human behaviour during mass decontamination events.

Quantitative and qualitative research methods are used to answer different research questions, each having its own strengths and weaknesses. A mixed methods approach offers the advantage of allowing for a comprehensive understanding of the complex issue of casualty behaviours by employing the strengths of both approaches to provide a more complete understanding of the phenomena (Choy, 2014).

Positivism is the foundational philosophy underlying most quantitative research. The basic tenet of this research approach is that there exists a single objective reality and that this can be measured through empirical observations and statistical analyses (Arghode, 2012). For any study looking at mass decontamination this may include understanding the effectiveness of certain detergents or hose pressures in cleaning a casualty or how many persons can be decontaminated in an hour. It may also answer such questions as how many casualties are likely to leave the scene and at what rate following an incident. These technical elements, as Carter *et al* (2014) highlights, have often been the focus of much of the attention of planners concerning mass decontamination preparation.

However, other considerations concerning casualties' perceptions and experience of mass decontamination incidents have also been shown to be critical, e.g. how to communicate with them or their pre-existing perceptions of emergency responders (Carter *et al.,* 2014). It is here that qualitative research, with its roots in interpretivism, can be effective in providing required insights. Interpretivism assumes that people will perceive and experience the world in diverse ways. Such understanding leads qualitative research to examine and analyse these diverse interpretations and perspectives of individuals within a studied sample (Chowdhury, 2014).

Mixed methods bring together these two philosophies, allowing a broader set of research choices and therefore can be more adept at answering more complex research questions such as those posed by human behaviour during an emergency (Choy, 2014). The research concerning casualty behaviour during mass decontamination needs to consider the situation, as well the meaning, norms and values of those involved within a single piece of research. In order to do this the combined strength of qualitative and quantitative approaches are needed in order to offer multiple ways of looking at the research question effectively. This then allows a more robust set of conclusions and more accurate and nuanced descriptions and interpretations of a phenomenon than would be possible using only a single method.

The mixed-methods approach is therefore essential for researching the topic of casualty behaviour during mass decontamination especially given the lack of real-world data with which to understand the topic. It was therefore necessary and will continue to be necessary for future research to first formulate theories of what behaviours would be

likely during such an incident and then test these theories in the absence of a real mass decontamination incidents.

It is also worth reflecting here on how the use of mixed methods can also offset some of the issues that can occur between positivism and post- positivism.

Mixed methods, including interpretivism, address limitations of both positivism and post-positivism. While positivism focuses on empirical data and objectivity, incorporating interpretivism as part of a mixed methods approach allows for the inclusion of subjective experiences and perspectives, acknowledging the need for both objectivity and subjectivity.

By utilising a mixed methods approach which includes interpretivism alongside positivism, research data can be triangulated from multiple quantitative and qualitative sources and perspectives. A significant advantage of this is its ability to mitigate the limitations of a purely positivist approach by being capable of acknowledging the importance of subjective experiences and context in understanding complex phenomena. It also addresses the discussions concerning post-positivism. Incorporating empirical evidence alongside an acknowledgement of the role of interpretation and social context in shaping knowledge allows for a more comprehensive understanding of research problems to be developed bridging the gap between objectivity and subjectivity.

10.1 Advantages of Mixed Methods Research

Through undertaking a mixed methods approach in the study of human behavioural factors during mass decontamination operations there are several advantages which have stood out and are worth reflecting on.

10.1.1 Triangulation

Mixed methods research excels in triangulating findings, and this enabled a more thorough understanding of the complex research questions in this Thesis by integrating diverse sources of information. Employing methods like surveys, interviews, and visualisation experiments across the Thesis, it was possible to capture multifaceted perspectives on mass decontamination, which a single qualitative or quantitative approach would have been incapable of achieving.

The mixed methods approach doesn't simply blend different types of data; it allows for the triangulation of findings. The varied sources and data types gained through the mixed methods approach enables the conclusions drawn to be corroborated or challenged. This triangulation approach was essential in enhancing the reliability and validity of conclusions. This is especially necessary when studying mass decontamination, where there are fortunately very few real-world incidents and triangulation of data is needed to provide the enhanced reliability and validity needed in place of real-world data.

10.1.2 Comprehensiveness

A major strength of the mixed methods research approach used lies in its comprehensiveness. This approach allowed the research to achieve a more comprehensive understanding of the intricate phenomena of human behaviours at a mass decontamination incident by harnessing the strengths of each method, while compensating for their individual limitations.

Qualitative data was able to provides nuanced descriptions and insights into human experiences, attitudes, and behaviours, aspects which are often unattainable or severely limited through quantitative surveys or experiments alone. Conversely, quantitative data delivers robust statistical analyses and generalizable outcomes, aiding in research concerning validation of the behavioural model in Chapter 7 or the leaver rate identified in Chapter 9. Here patterns and relationships among variables could be identified and reported.

The synergy between both data types enabled the research to facilitate a holistic comprehension of the phenomenon of human behaviour during mass decontamination which is impossible using a single method approach.

10.1.3 Diverse Data Collection

Utilising diverse approaches in the data collection stands out as strength of the research strategy. The mixed methods research approach was capable of amalgamating both quantitative and qualitative data, facilitating a more exhaustive comprehension of casualty behaviour during mass decontamination. Employing a spectrum of techniques

including surveys, interviews, visualisations and thematic analysis enabled this Thesis to capture varied facets of the mass decontamination phenomenon. The use of diverse data collection also further supported the validity of data captured by mitigating the potential for bias or the errors inherent in a single method.

10.2 Disadvantages

However, undertaking mixed methods research also posed challenges. Numerous factors demand consideration when integrating qualitative and quantitative methods in the research, including:

i) decisions regarding data collection and analysis techniques,

ii) ensuring coherence across diverse data types,

iii) efficient management of voluminous data, and

iv) addressing potential biases resulting from methodological integration.

Another crucial challenge encountered in developing this study was the necessity for expertise across both qualitative and quantitative research methodologies. This complexity extended the timeline of the research and required additional resources, such as specialized analysis programs for the quantitative elements and recording equipment to allow qualitative interviews to be undertaken.

During the analysis phase, a further limitation emerged. Mixed method studies present a greater analytical challenge than single-method approaches. Effectively, creating a narrative between the different data types demanded proficiency in both statistical analysis and qualitative coding techniques. Additionally, amalgamating diverse data

forms holds the possibility of introducing subjectivity into result interpretation, impeding research from drawing definitive conclusions.

10.3 Conclusion

Throughout this Thesis, the use of mixed methods has proved instrumental. Initially, qualitative inquiries through interviews with mass decontamination operatives and officers, combined with transcript analysis from the Grenfell Tower Fire, laid the theoretical groundwork. These theories were then scrutinized using quantitative methods involving the Ocado fire and visual simulations of mass decontamination incidents. This comprehensive approach underscores the significance of mixed methods in this domain, showcasing its indispensable role in generating comprehensive insights unachievable with a solitary methodological approach.

However, despite its merits, the mixed methods approach also possessed several challenges. The use of both qualitative and quantitative approaches meant that some studies, particularly the qualitative studies, took a lot of time to undertake and analyse. Additionally, analysing diverse data required a wider skill set than would have been need if only a single qualitative or quantitative approach had been adopted.

However, overall, the mixed methods research approach surpasses what can be achieved using the single method approach. It is well adapted to support future research into mass decontamination due to its ability to provide multifaceted insights into mass decontamination operations. This is essential for an area of research where real-world incident data is not available to support findings and where therefore additional robustness and validity is required.

Chapter 11 – Recommendations

This thesis has identified numerous elements of casualty behaviour during Hazmat or CBRN incidents that would impact the effectiveness of emergency services response in relation to mass decontamination being carried out. Primarily this relates to the psycho-social influences on casualties and on their ability to remain rational and engaged with emergency responders and as a result how the actions of responders can and will influence their behaviours. Secondly, this has seen exploration of the impact that can be had by responders on casualties' willingness to await and undergo decontamination. As a result of these findings this thesis will now set out below the following five recommendations which through an improved understanding of casualty behaviour will assist emergency services response should a Hazmat/CBRN incident requiring mass decontamination occur within the UK:

- Recommendation 1: Utilisation of Interim Decontamination.
- Recommendation 2: Mass Decontamination Units to be deployed directly to Hospitals.
- Recommendation 3: Development of a model of mass decontamination response utilising the leaver rates identified in this thesis.
- Recommendation 4: Development of the public's awareness of Hazmat/CBRN risk and Mass Decontamination capabilities.
- Recommendation 5: Development of training for all frontline responders on human behaviour and effective communications for Mass Decontamination operations.

Furthermore, these recommendations are subsequently partially validated by means of a survey with experts in the field.

11.1 Pathways

In order for the recommendation set out below to have real world impact and value it is important to consider how these can best be implemented. Table 16 below sets out the organisations responsible for mass decontamination delivery in the UK. This sets the background for who would need to be engaged with for each recommendation and how the recommendations can most effectively be implemented.

Table 16 Organisational Responsibilities for Mass Decontamination in the UK

Organisation	Overview
Home Office	The Home Office plays a significant role in mass decontamination preparedness. The Home Office has responsibility for overseeing and coordinating national strategies and policies relating to emergency management during a chemical, biological, radiological, and nuclear (CBRN) incidents. The Home Office aims to ensure a coordinated and effective response to CBRN incidents, safeguarding public safety and minimizing the impacts of any event.
Health Security Agency	The UK Health Security Agency (UKHSA), is an executive agency of the UK Department of Health and Social Care. UKHSA's role in mass decontamination preparedness involves several key responsibilities.

	Firstly, UKHSA provided guidance and advice to emergency services, healthcare professionals, and other relevant stakeholders on the planning and response to mass decontamination incidents. This includes the development of protocols and best practices based upon scientifically evidenced information. The UKHSA also have the capability to undertake training programmes and exercises to assist in assuring that emergency responders and healthcare workers are adequately prepared to respond to mass decontamination incidents. UKHSA conduct the research and development activities relating to mass decontamination, including evaluating decontamination techniques, studying the effectiveness of different products and equipment, and exploring innovative solutions for decontamination processes.
National Fire Chiefs Council	The UK National Fire Chiefs Council (NFCC) represents the professional voice of UK FRS'. The primary focus of the NFCC is on improving and co-ordinating the efforts of the fire and rescue-related sector.

	The NFCC's role in mass decontamination preparedness relates to the development of guidance and standardization through the National Operational Guidance (NOG) programme. NOG develops guidance and promotes best practices for operations by the FRS'. This includes developing procedures and training materials to ensure a consistent and effective response to emergency incidents across a range of areas, including mass decontamination.
National Resilience	National Resilience is the organisation responsible for a range of specialized capabilities, resources, and personnel that enhance the ability of the UK FRS' to effectively respond to large-scale or critical incidents, including mass decontamination incidents. National Resilience plays a crucial role in mass decontamination preparedness and response. National Resilience provides the specialist capabilities that are specifically designed to handle mass decontamination incidents. This includes equipment, resources, and expertise that go beyond the standard capabilities of individual FRS'.

	National Resilience works closely with relevant government bodies, emergency response organizations, and stakeholders to develop national-level plans and strategies for mass decontamination incidents. They contribute to the development of response frameworks, protocols, and standard operating procedures to ensure a coordinated and effective response across the country. National Resilience also conducts training programmes and exercises to enhance the readiness and capabilities of emergency responders involved in mass decontamination incidents. National Resilience also has responsibility for the management and maintenance of critical resources required for mass decontamination incidents. This may include specialized decontamination units, personal protective equipment (PPE), detection and monitoring equipment, and other necessary resources. They ensure these resources are available and ready for deployment when needed.

	Finally, in the event of a mass decontamination incident, National Resilience provides support and coordination to the affected areas and local emergency response agencies. This can include deploying specialized teams, providing technical advice, and coordinating the allocation of additional resources from across the country to support the local response efforts.
Joint Emergency Services Interoperability Principles (JESIP)	The Joint Emergency Services Interoperability Principles (JESIP) is a framework established in the United Kingdom to improve coordination and interoperability among emergency services during major incidents, including mass decontamination events. JESIP works to enhance the overall coordination, communication, and interoperability among emergency services during major incidents, including mass decontamination. It helps ensure a more efficient and effective response, minimizing the impact of the incident and maximizing the safety of responders and the public.

11.2 Mass Decontamination Recommendations

11.2.1 Recommendation 1: Utilisation of Interim Decontamination.

Recommendation Pathway: This recommendation would be applicable to National Resilience and the National Fire Chiefs Council.

Recommendation Overview:

This Thesis has identified potential behavioural difficulties associated with incidents requiring the decontamination of large numbers of casualties and, in particular, the likelihood of those casualties choosing to leave the scene of an incident prior to receiving decontamination due to the slow response times of specialist MDUs and, in doing so, increasing the risk to both themselves and the wider public.

This recommendation, therefore, looks to propose an operational solution to the issue of slow response times associated with current Mass Decontamination strategies and the problem of casualties leaving the scene as a consequence as identified by this Thesis.

Responders interviewed in Chapter 5 of this Thesis felt that given the limited number of MDUs and their wide geographical spread it could take several hours or more to decontaminate a few hundred casualties. Responders felt that these long-time frames would see people leave the scene and go home or self-present at hospital if an effective cordon was not quickly established, and, if such a cordon was established, non-compliance could be expected.

This was then reinforced through the scenarios-based survey of the public undertaken in this Thesis, which found that casualties would be willing to wait in a worst-case scenario 163 minutes on average from the time of an incident occurring to undergoing decontamination. Considering a minimum setup time for an MDU can be adjudged as 30 mins plus travel times to the scene, this would not leave much time until most people would look to leave. As such, a method which reduces the number of casualties leaving the scene by speeding up the timeframes within which decontamination can occur would be advisable.

This PhD recommendation therefore argues for the use of interim decontamination as a supplement to MDUs in the management of Hazmat/CBRN incidents. Interim decontamination provides immediate and on-site decontamination measures, ensuring the rapid reduction of contamination levels and enhancing the efficiency and effectiveness of subsequent mass decontamination efforts. This recommendation is supported by evidence from the literature, case studies, and expert opinions, highlighting the benefits of interim decontamination in improving response capabilities and reducing the risks associated with Hazmat/CBRN incidents.

Interim decontamination consists of a structured decontamination process, utilising FRS equipment available on all front-line fire appliances (National Operational Guidance, 2022j). The usual method for this as pictured in Figure 17 below is to construct a gantry between two fire appliances with ladders laid between the two vehicle and hoses suspend from these ladders creating an improvised shower for casualties to move beneath. However, there are numerous other variations which can be employed to achieve the same result (see Figure 4). Given that such a method can be

completed by any two front line appliances (or even one appliance in some iterations of interim decontamination), the number of showers that can be made available rapidly at an incident is far greater than if reliant on MDUs, and although these showers will not be able to decontaminate as many people per hour as the specialist MDUs, the sheer number of showers which can rapidly be brought online means a significant increase in the number of persons being able to be decontaminated. This allows for a vastly improved response in comparison to current strategies, which are reliant solely on specialist response in the guise of the MDUs.

Figure 18 Interim Decontamination Setup



It is also interesting to note that whilst in the UK current practice relies heavily upon specialist assets, in the USA what the UK FRS would term interim decontamination is fully utilised as a primary response strategy with the Ladder-Pipe system as it is referred being identified as crucial with the time element of a decontamination operation recognised as critical (United States Army, 2005).

The are several key benefits of utilising interim decontamination at Hazmat/CBRN incidents. Firstly, it allows for rapid intervention, minimizing the potential for casualties

to leave the scene and further spread contamination. As interim decontamination would utilise frontline fire appliances it could be set up far more quickly due to the nature of interim methods and the fact that there a far more fire appliances than MDUs.

Secondly, as demonstrated by the Sarin attacks in Tokyo, a potential limitation of MDUs is their mobility and flexibility. Once MDUs are set up, they are challenging to move due to the time and effort required for packing and re-deployment. Moreover, if any decontamination takes place, the units themselves become contaminated, further complicating their movement.

During the Sarin attack in Tokyo, casualties emerged at multiple locations across the city, rather than a single centralized location. This situation poses a challenge when relying solely on MDUs, as their limited numbers and difficulties in redeployment make it challenging to respond effectively to multiple sites. In contrast, interim decontamination methods offer greater flexibility and ease of movement. Fire appliances, readily available in larger numbers, can perform interim decontamination, enabling a more efficient response to multiple sites requiring decontamination assets.

Finally, it offers far greater scalability as, due to there being far more fire appliances, interim decontamination stations can be scaled to meet the needs of the incident by bringing in additional fire appliances from further afield.

By implementing interim decontamination, response capabilities in Hazmat/CBRN incidents can be significantly enhanced. The associated lower response times provided by interim decontamination will reduce the number casualties leaving the scene, thus reducing the risk of them transferring hazardous materials to healthcare facilities,

thereby reducing the risks faced by medical personnel and preventing the contamination of critical infrastructure. Interim decontamination also allows for more efficient triage and prioritization of casualties, ensuring that those with the highest level of contamination receive immediate attention.

The use of interim decontamination complements the efforts of MDUs. While interim decontamination provides a fast and flexible response, MDUs can focus on decontamination of non-ambulant casualties, which interim is not equipped to do, or in providing decontamination facilities capable of offering greater privacy than interim methods. This division of such responsibilities would optimize the utilisation of resources and streamline the overall decontamination process.

The successful implementation of interim decontamination requires careful planning, coordination, and training. Key considerations include establishing standard operating procedures, providing adequate training to all FRS responders, ensuring the standard availability of appropriate decontamination equipment and supplies, and coordinating with other response agencies and healthcare facilities. Regular drills, exercises, and evaluation processes would need to be developed by National Resilience in co-ordination with the NFCC's National Operational Guidance (NOG) programme to ensure the effectiveness and readiness of interim decontamination protocols across all services.

Several real-world incidents, in conjunction with the opinions of mass decontamination experts interviewed as part of this Thesis in Chapter 5 support the use of interim decontamination. Case studies, such as the 2001 anthrax attacks and the Tokyo Sarin

incident, highlight the importance of immediate and flexible decontamination measures in reducing contamination risks and improving overall response.

Based on the evidence presented, this PhD recommendation strongly supports the utilisation of interim decontamination as a supplement to MDUs in Hazmat/CBRN incidents. Interim decontamination provides immediate and flexible decontamination measures, reducing risk of casualties leaving the scene of an incident, enhancing response capabilities, and improving overall safety. Integrating interim decontamination into response protocols requires careful planning, coordination, and training, but the benefits justify the investment. By implementing this recommendation, emergency response systems can optimize their decontamination efforts, minimize the risks associated with Hazmat/CBRN incidents, and protect both victims and responders.

Further research and development in this area are crucial to refine interim decontamination protocols, assure interim decontamination efficacy, evaluate its effectiveness in various scenarios, and promote best practices. Continuous collaboration between emergency management agencies, healthcare providers, and researchers will contribute to the ongoing enhancement of Hazmat/CBRN incident response capabilities, ensuring the safety and well-being of affected individuals and communities.

11.2.2 Recommendation 2: Mass Decontamination Units to be Deployed Directly to Hospitals

Recommendation Pathway: The implementation of this recommendation should be jointly led by the Home Office and National Resilience with the support of local FRS utilising JESIP.

Recommendation Overview:

This PhD recommendation argues for the need for National Resilience, with the support of the NFCC, to develop plans and procedures for the deployment of MDUs directly to hospitals in the event of large-scale Hazmat/CBRN incidents in conjunction with decontamination efforts at the scene of the incident. Currently, MDUs will be sent directly to the site of an incident to provide decontamination to casualties who remain at the scene.

This recommendation, that MDUs be sent directly to hospitals, is supported by both the current literature concerning mass decontamination in particular case studies of real-life incidents and also by the qualitative interviews used in this Thesis.

The findings in this Thesis support this recommendation as they emphasize that casualties leaving the scene of Hazmat/CBRN incidents are likely to seek help at hospitals. As such by sending MDUs to hospitals, critical infrastructure can be protected, and contaminated casualties can be efficiently and effectively treated. The recommendation also highlights the need for pre-planning and coordination between MDUs and hospitals to optimise response efforts.

Both the available literature and the qualitative interviews conducted in Chapter 5 identified a recurring theme that casualties leaving the scene of Hazmat/CBRN incidents are highly likely to seek help at hospitals. This finding aligns with what occurred during the 1995 Sarin attacks in Tokyo, where casualties contaminated in the attack bypassed decontamination points and headed directly to hospitals, exposing hospital workers to hazardous substances (Nozaki *et al.,* 1995; Okumura *et al.,* 1998a; Okumura *et al.,* 1998b).

Hospitals serve as trusted places where individuals can seek medical attention, making them a natural destination for casualties who choose not to remain at the scene of an incident for emergency service assistance. Given the critical role of hospitals in normal conditions and their increased significance during emergencies or disasters, such as Hazmat/CBRN incidents, it is essential that they are prepared for decontamination and treatment of casualties.

Hildebrand and Bleetman (2007) identify several implications of casualties heading directly to hospitals, particularly questioning whether Accident and Emergency (A&E) departments are adequately prepared for such events. They suggest considering the provision of mass decontamination facilities at hospitals in addition to those provided at the scene of a chemical release. This recommendation highlights the need to enhance hospital preparedness for decontamination and the effective management of contaminated casualties.

Given the likelihood of casualties seeking assistance at hospitals, a prudent use of MDUs would be to deploy them directly to local hospitals. By doing so, critical infrastructure can be protected, and contaminated casualties can receive timely and appropriate

decontamination and medical care. This approach complements the recommended use of interim decontamination, as it would free MDUs to focus on hospitals and efficiently meet the needs of contaminated casualties.

Effective deployment of MDUs to hospitals requires pre-planning and coordination. MDUs should engage in proactive communication and collaboration with hospitals to identify suitable sites for deployment. This pre-planning ensures an effective and efficient response in the event of a Hazmat/CBRN incident, as MDUs can be strategically positioned to provide timely and appropriate decontamination services.

Based on the findings throughout this PhD, this recommendation supports the deployment of MDUs to hospitals. This recommendation would allow for immediate decontamination of casualties upon arrival, minimizing the risks of further contamination and ensuring prompt medical intervention. Additionally, hospitals have existing infrastructure, trained personnel, and medical resources that can be leveraged during the decontamination process, leading to streamlined resource allocation and improved patient outcomes.

Pre-planning and coordination with hospitals led by National Resilience with the support of local FRS' and utilising the principles of JESIP would facilitate efficient deployment, ensuring an effective and coordinated response.

Further research and development in this area are crucial to refine deployment strategies, enhance hospital preparedness, and assess the effectiveness of hospital-based MDUs. By implementing this recommendation, emergency response systems can

enhance their capabilities to effectively manage Hazmat/CBRN incidents, safeguard public health, and minimize the impact of such events.

11.2.3 Recommendation 3: Mass Decontamination Model

Recommendation Pathway: This recommendation would be applicable to the Home Office, National Resilience and the Health Security Agency.

Recommendation Overview:

This recommendation highlights the crucial need to develop a comprehensive Mass Decontamination model that takes into account the rate at which casualties will leave the scene of a Hazmat/CBRN incident.

It is recommended that the development of this model be led by the UK Health Security Agency, with its specialist capacity for such work, and that it should be assisted by National Resilience, who will then be able to utilise the model in the development of strategies and resourcing in preparation for a mass decontamination incident.

The Home Office, with overall responsibility for the resourcing of mass decontamination capabilities, will be a key stakeholder in facilitating the use of such a model.
It is essential that the dynamic nature of casualties departing the scene of a Hazmat/CBRN incident before being decontaminated is considered. This crucial aspect must be included in future models to enable emergency responders to effectively plan and manage mass decontamination operations.

Currently, MDUs are strategically positioned throughout the UK, based on modelling and planning assumptions regarding expected casualty numbers and the adjudged highest risk locations. Notably, the human behavioural aspect of a mass decontamination operation, particularly the waiting time at the incident scene, has not been taken into consideration.

Previous work by Albores and Shaw (2008) which utilised discrete event simulation (DES) played a vital role in the development of mass decontamination capabilities within the New Dimension programme. However, the model did not account for human behaviour, which, as argued throughout this Thesis, is a critical factor in influencing cooperative behaviours required for a successful mass decontamination operation. In particular the crucial factor of willingness to wait at the scene of a Hazmat/CBRN incident and undergo decontamination has not been previously considered.

This recommendation, therefore, emphasizes the importance of utilising the leaver rate identified by this Thesis in informing simulation modelling which can then more robustly inform the development and implementation of a Mass Decontamination Model.

However, until the work in this Thesis no attempt has been made to try and quantify the likely rate at which casualties would leave the scene of a Hazmat/CBRN incident and there has been no data to inform likely departure rates.

Mass decontamination operations during Hazmat/CBRN incidents require the efficient management of casualties, including considering the rate at which they leave the scene.

This PhD recommendation aims to underscore the need to develop a Mass Decontamination Model that accounts for casualty departure rate.

Casualty departure rates plays a crucial role in mass decontamination operations. Failure to account for this factor can lead to misguided resourcing, ineffective decontamination processes, and ineffective response strategies. Understanding the dynamics of casualty departure rates is essential for developing an accurate model that aligns decontamination capacity with the desired levels of on scene decontamination.

With this data now available simulation modelling can be used to provide a powerful tool which can incorporate casualty departure rate dynamics into a mass decontamination simulation, allowing National Resilience to more effectively assess different scenarios, optimize resource allocation, and identify potential problems in the decontamination process. The model can help determine the optimal number of decontamination units, staff allocation, tactical operating procedures and logistical requirements based on anticipated casualty departure rates.

In conclusion, the development of a comprehensive Mass Decontamination Model, utilising the data and methodology pioneered in this Thesis to consider casualty departure rates in Hazmat/CBRN incidents, is of utmost importance. Incorporating this simulation modelling can significantly enhance response capabilities, optimize resource allocation, and improve overall preparedness. The research conducted in this area will contribute to the advancement of knowledge, facilitate evidence-based decision-making, and ultimately ensure more effective mass decontamination operations in Hazmat/CBRN incidents.

This Thesis strongly recommends further research and development in this field to refine the Mass Decontamination Model, validate its effectiveness, and integrate it into emergency response frameworks. By addressing the dynamics of casualty departure, responders can better plan and manage mass decontamination operations, thereby improving the overall response and minimizing the impact of Hazmat/CBRN incidents.

11.2.4 Recommendation 4: Public Awareness Campaign

Recommendation Pathway: This recommendation should be led by the Home Office with the support of the Health Security Agency.

Recommendation Overview:

This Thesis recommends that the Home Office with the support of the UK Health Security Agency undertakes the design and implementation of a public awareness campaign to prepare the general public for the potential need for mass decontamination operations in response to Hazmat/CBRN incidents.

Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy (2021) acknowledges the realistic possibility of increased state-sponsored terrorism and the use of proxies, making it *"likely that a terrorist group will launch a successful CBRN attack by 2030"* (p. 32). It seems therefore unrealistic to hide or downplay the risk posed by CBRN weapons. Therefore, the Thesis argues that pre-communications regarding Hazmat/CBRN incidents and mass decontamination would inform the public about the role of emergency responders, particularly the FRS in providing decontamination. This approach would enhance the

public's perception of the legitimacy of these responders' role, thereby increasing trust and cooperation by casualties.

Concerns have been raised by authorities that public awareness campaigns regarding CBRN threats could lead to alarm and panic among citizens, leading to a downplaying or avoidance of highlighting this potential risk. As identified by Sheppard *et al* (2006) in Viewpoint: Terrorism and Dispelling the Myth of a Panic Prone Public *"Governments and commentators perceive the public to be prone to panic in response to terrorist attacks – conventional or involving chemical, biological or radiological weapons."* (p. 1). However, this study by Sheppard *et al* (2006) concluded that *"Evidence from five such incidents suggests that the public is not prone to panic, although people can change their behaviours and attitudes to reduce the risk of themselves being exposed to a terrorist incident"* (p. 1). The public is therefore not prone to panic or overwhelming anxiety and fear and these influences are not the primary factors determining their response.

Extensive research has highlighted the importance of public awareness, education, and preparedness to ensure an effective response and minimize the impact of Hazmat/CBRN incidents.

Lindell *et al* (2016) has shown that raising awareness of risks and recommended actions correlates with higher levels of preparedness and increased willingness among individuals to behave in accordance with recommended measures.

The importance of preparing the public for emergencies is widely recognized. For instance, campaigns such as the "Run, Hide, Tell" initiative by the National Counter Terrorism Security Office (2018) aim to inform the public about appropriate actions

during a marauding terrorist attack. Similarly, Israel has utilised public information campaigns to prepare its citizens for potential CBRN attacks (Home Front Command, Israeli Defense Forces, 2005), with the intention of improving public behaviour during emergencies.

Pre-incident messaging, therefore, is not uncommon, and this is especially so for natural hazards like flooding, earthquakes, or wildfires. Carter *et al* (2020a) have shown that pre-incident information not only enables the public to protect themselves and others, but also increases their sense of self-efficacy. It also improves shared situational awareness between communities, emergency services, and authorities. Engaging communities in emergency and disaster planning, leads to increased community preparedness, understanding and trust in emergency responders, and consequently cooperation between communities and responders (Kenny *et al.,* 2017).

It is therefore critical for public awareness campaigns to prepare the general public for mass decontamination operations in response to Hazmat/CBRN incident in order to address the potential challenges associated with public response during such emergencies and to educate, inform, and empower individuals to effectively respond to potential incidents.

This Thesis has highlighted the potential challenges associated with how the public would respond during a Hazmat/CBRN incident requiring mass decontamination and how this may impact upon the ability of emergency services to effectively respond to such an incident.

These challenges have included how trusted responders will be by casualties and how this level of trust will impact co-operation. These factors, if not managed well, will hinder effective evacuation and decontamination by responders. Public awareness campaigns play a pivotal role in mitigating these challenges by providing accurate information, dispelling myths, and fostering trust in the emergency services.

In order to counter these issues, recognising, as research shows, that the public will remain rational, it is recommend that a public awareness campaign be used in enhancing preparedness, response capabilities, and public cooperation during emergencies, with studies demonstrating that well-designed campaigns significantly improve public knowledge, attitudes, and behaviours related to emergency preparedness. Such campaigns provide information on potential hazards, decontamination procedures, safety measures, and response protocols, empowering individuals to take appropriate actions during Hazmat/CBRN incidents.

Effective public awareness campaigns should be designed based on evidence-based practices and tailored to the needs of the target population (Carter *et al.,* 2020a). The campaigns should employ clear and concise messaging, accessible language, and culturally appropriate materials (Carter *et al.,* 2020a). Visual aids, demonstrations, and interactive platforms can enhance understanding and engagement (Carter *et al.,* 2020a). Collaboration with local authorities, emergency management agencies, and community organizations is essential for campaign success.

Campaign messages should convey accurate information, address public concerns, and inspire confidence in response efforts (Carter *et al.,* 2020a). They should emphasize the importance of early detection, prompt reporting, and following instructions from

authorities (Carter *et al.,* 2020a). Communication strategies should include multiple channels such as social media, websites, public service announcements, community workshops, and partnerships with local media outlets. Targeted messaging for vulnerable populations, including non-English speakers, elderly individuals, and people with disabilities, is crucial.

Public awareness campaigns play a vital role in preparing the general public for mass decontamination operations in response to Hazmat/CBRN incidents. By raising awareness, providing accurate information, dispelling myths, and fostering preparedness, these campaigns empower individuals to take appropriate actions during emergencies. The design, implementation, and evaluation of effective campaigns require evidence-based practices, tailored messaging, and collaboration with relevant stakeholders. Continuous improvement through evaluation and learning from successful case studies are essential for enhancing campaign effectiveness and ensuring public readiness.

This Thesis strongly recommends further research and development in this area to explore innovative approaches, evaluate campaign impact, and refine strategies for public awareness campaigns. By implementing comprehensive and targeted campaigns, we can enhance public preparedness, cooperation, and resilience in the face of potential Hazmat/CBRN incidents.

11.2.5 Recommendation 5: Mass Decontamination Casualty Behaviour and Communication Training

Recommendation Pathway: This recommendation should be led by the National Fire Chiefs' Council through National Operational Guidance whilst being supported by National Resilience and JESIP.

Recommendation Overview:

This fifth recommendation recognises the need to train mass decontamination operatives, in particular, and FRS personnel, in general, about casualty behaviour and communication in readiness for a Hazmat/CBRN incident requiring mass decontamination.

This Thesis has made evident that effective management of incidents such as those involving mass decontamination, requires not only the provision of appropriate infrastructure and resources but also the presence of well-trained responders who can navigate the complex challenges associated with casualty behaviour and communication. The Thesis has shown that these skills build and maintain trust, which in turn increases the willingness of casualties to cooperate with instructions given by responding agencies.

The importance of proper training in casualty behaviour and communication cannot be overstated. In the event of a Hazmat/CBRN incident, the psychosocial factors that come into play, relating to trust in particular, can significantly impact casualty behaviour and compliance. Without adequate training, responders may not be able to effectively engage with casualties which may result in non-compliant behaviour, hindering the

decontamination process and potentially compromising the overall response efforts. Furthermore, ineffective communication strategies can impede information dissemination, leading to confusion and delays in response coordination with casualties.

Research has consistently shown that comprehensive training programmes significantly improve the ability of responders to positively influence casualty behaviour during mass decontamination incidents (Carter and Amlôt, 2016). Studies have demonstrated that training initiatives that support operatives in effectively communicating with casualties about the decontamination process, its importance, and associated health risks, contribute to better compliance (Carter *et al.,* 2013a). By providing training on the need for clear instructions and guidance, operatives are able to better support casualties in gaining a better understanding of the decontamination procedures and, as a result, building trust and increasing their likelihood of cooperation during incidents.

Training programmes that focus on communication strategies for responders have been found to enhance information exchange and overall communication effectiveness (Carter and Amlôt 2016). Clear and concise instructions, active listening skills, and addressing casualties' concerns have been shown to increase cooperation and reduce confusion (Carter and Amlôt 2016). Training initiatives that emphasize the importance of effective communication can significantly contribute to the success of mass decontamination operations.

To implement effective training programmes for mass decontamination operatives the training curriculum should be evidence-based and tailored to address the specific challenges of Hazmat/CBRN incidents. It should also include comprehensive modules on casualty behaviour, communication strategies, and psychosocial aspects.

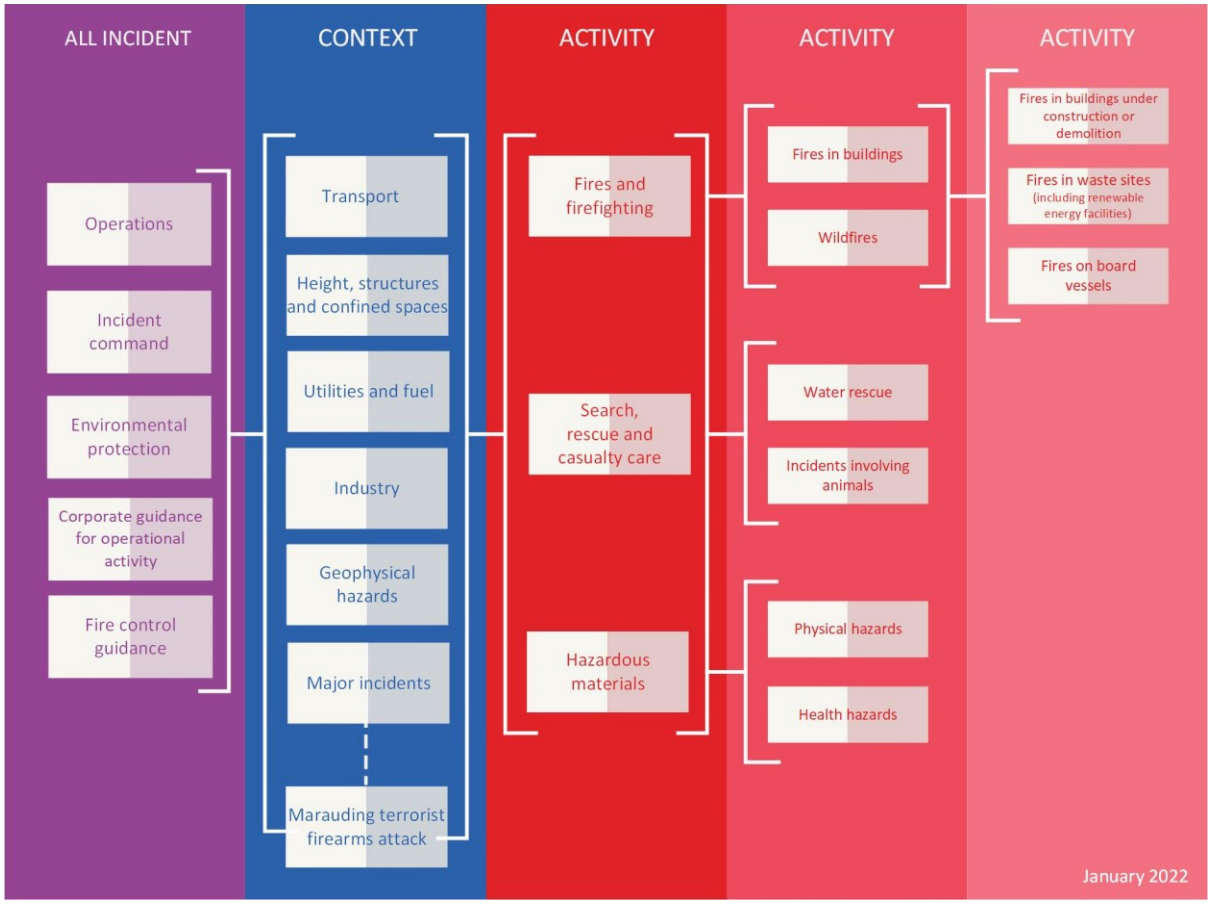
In recent years such a gap has somewhat been recognised in the training of mass decontamination instructors with the introduction of human behaviour training on the National Resilience Mass Decontamination Instructors course. These courses train FRS personnel to then deliver training to their respective mass decontamination crews.

However, a recommendation of this Thesis would be for casualty behaviour to be included in the training specifications for all crews to ensure such understanding is disseminated across all FRS personnel, as casualty behaviour and communications is essential in all emergency situations and will be needed to implement the interim decontamination approach proposed in this Thesis.

This should be achieved through the creation of a Casualty Psychology/Communications National Operational Guidance element within the All-Incidents category of National Operational Guidance.

National Operational Guidance has been set-up to a establish a common approach to dealing with emergency incidents for UK FRS' by introducing guidance made up of strategic, tactical and training actions (National Operational Guidance, 2022k). It utilises a hazard and control measures approach and the guidance is structured to cover all hazards likely to be encountered within particular areas and so starts with those elements that affect all incidents as show below in Figure 18.

Figure 19 National Operational Guidance Structure



(National Operational Guidance, 2022k)

The introduction of guidance on casualty or public psychology at emergencies into the 'all incidents' category, along with specific guidance relevant to the various areas including around decontamination, would ensure that any crews involved in a mass decontamination incident were aware of the likely casualty behaviours they will encounter and the importance of good communication in allowing them to contribute alongside specialist responders.

Incorporating realistic casualty behaviours into simulation-based exercises as part of any ongoing the training programme should also be implemented and would allow

operatives to practice their skills in realistic scenarios. These exercises should simulate various Hazmat/CBRN incident scenarios and replicate the challenges faced during mass decontamination. This is something which National Resilience and the UKHSA are well placed to support.

All training programmes must also involve collaboration between the various relevant stakeholders who will be involved in a mass decontamination response, including other emergency services such as the Police and Ambulance, healthcare professionals, and public health agencies. This collaboration ensures a coordinated approach and effective integration of training efforts and helps ensure the consideration of human behaviour and communications with casualties is disseminated widely to increase effectiveness. Here again the principles of JESIP should be utilised to facilitate efficient sharing of casualty behavioural considerations.

In conclusion, the available literature strongly supports the need to train mass decontamination operatives in casualty behaviour and communication for Hazmat/CBRN mass decontamination incidents. Comprehensive training programmes that address casualty compliance, communication strategies, and public awareness are essential for effective response efforts. Simulation-based exercises and collaboration among stakeholders further enhance the training's efficacy. By implementing these recommendations, mass decontamination operatives can equipped with the necessary skills to navigate the complexities of casualty behaviour and communication during Hazmat/CBRN incidents, ultimately improving the overall response and ensuring the safety and well-being of the affected population.

11.3 Expert Validation

In order to validate the recommendations, put forward by this Thesis and provide assurance that these recommendations are both realistic and feasible a survey was conducted of experts within the field of mass decontamination to seek their professional views.

11.3.1 Methodology

This survey utilised a quantitative questionnaire to collect the opinions of the identified experts. The survey contained 5 questions for each of the 5 recommendations with responses collected utilising a 7-point Likert scale (See Appendix IX).

Space was also provided for a free text responses to each question.

5.2.2 Ethics

This study is deemed to be an Evaluation and as such did not require ethical approval through Imperial College London (See Appendix I).

All participants provided consent to their participation in the study and had the right to withdraw from the study at any time. This was achieved through the use of an informed consent sheet at the start of the survey.

The Informed Consent Sheet used the same format as seen in Figure 9 and the full Informed Consent for this study can be seen in Appendix X).

All participants data will be anonymised and stored securely for 10 years.

11.3.3 Participants

Those organisations which were engaged as part of Chapter 8 to develop CBRN Mass Decontamination Scenarios where again contacted to provide feedback on the realism and feasibility of the recommendations put forward. These organisations are:

- Fire and Rescue Service
- Police
- National Resilience
- Health Security Agency (formerly Public Health England)
- The National CBRN Centre
- The Home Office
- Ambulance

The one exception being the Civil Contingencies Secretariate which has been disbanded since the work in Chapter 8 was undertaken (United Kingdom Government, 2022).

11.3.4 Procedure

Each participating organisation were provided with the full recommendations Chapter of this Thesis to read and consider.

They were then asked to complete the survey answering the 5 questions for each of the 5 recommendations made.

Each organisation was given 1 month to respond.

11.3.5 Results

Only limited replies were gained with responses only coming from the FRS and Ambulance Service who provide 2 survey responses.

The feedback received however, was very supportive of the recommendation made. This Thesis has not undertaken any statistical analysis of the response due to its limited nature however, the full scores given for each question are provided in Appendix XI. Table 17 below sets out the average for each question across all 5 recommendations.

Table 17 Summary of Expert Validation Results

Recommendation	Q.1	Q.2	Q.3	Q.4	Q.5
R1	6.66	6.66	7	7	7
R2	6.66	6.66	5.66	6.66	5.66
R3	5.66	6.33	6.33	6.33	5.33
R4	6.66	6.66	6.66	6.66	6.66
R5	6.66	7	6.33	6.66	6.66

The high scores clearly indicate strong levels of support from those surveyed for the proposed recommendations.

Open text responses provide in the survey also reinforce this strong level of support with some examples provided below.

Recommendation 1 suggests the primary use of Interim Decontamination techniques.

"Yes, a realistic and practical measure."

"People will not remain on scene."

Recommendation 2 suggests the deployment of Mass Decontamination Units directly to Hospitals in the event of a Hazmat/CBRN incident.

"Footprint size will vary within the hospital grounds (look at Watford General Hospital), though agree with the data from Tokyo and the idea."

"Taking the risk off the hospital could be seen as both positive and negative."

"Skills need to practice regularly and effective, not a capability that sits in a box which is never realistically practices. For example, dark, middle of the night, resourcing levels…"

Recommendation 4 suggests development of strategies to increases the public's awareness of CBRN risk and Mass Decontamination capabilities.

"100%, I think this needs to be done to get the public on side. The complexities of the incident need to be communicated, though also some simple measures like education can break these barriers down and aide the emergency services."

Recommendation 5 suggests developing training for all frontline responders on human behaviour and effective communications for Mass Decontamination operations.

"Yes, agree, I'm not convinced people understand the complexities and challenges of these incidents."

11.3.6 Summary

This Chapter has reflected on the findings of this thesis and developed five recommendations. Whilst there has only been a limited response to the survey, due in a major part to time constraints, what has been communicated has been overwhelmingly supportive of those recommendations put forward. Such validation is, however, essential as it ensures that the recommendations proposed are reliable and accurate and helps to confirm that they are based on sound reasoning, evidence, and comprehensive analysis. It will also help to ensure that they are effective and are practical, feasible, and capable of achieving the desired outcomes.

Table 18 Recommendations Summary Table

Recommendation	Organisation Involved	Evidence from Thesis
Recommendation 1: Utilisation of Interim Decontamination	• National Resilience • The National Fire Chiefs Council	Chapter 5's interviews with responders revealed a concerning challenge: the scarcity of MDUs across wide areas, which would mean significant delays in decontamination. This delay could prompt casualties to leave the scene or seek self-treatment elsewhere. This assertion is further supported by the work of Chapter 9 which showed that, on average, casualties were willing to wait 163 minutes before leaving an incident scene. Considering setup and travel times for MDUs, this leaves minimal time before most people consider leaving the scene. Therefore, expediting decontamination timeframes to prevent casualties from dispersing though the use of interim decontamination is recommended.
Recommendation 2: Mass Decontamination Units to be Deployed Directly to Hospitals	• The Home Office • National Resilience • Local FRS' • JESIP	Both the literature review conducted in Chapter 3 and the qualitative interviews conducted in Chapter 5 identified a recurring theme that casualties leaving the scene of Hazmat/CBRN incidents are highly likely to seek help at hospitals. Therefore, developing plans to protect these vital assets and prepare for the likely self-presentation of contaminated casualties is recommended.

Recommendation 3: Mass Decontamination Model	• The Home Office • National Resilience • The Health Security Agency	Chapter 2 discuses modelling utilised in the planning and preparation of mass decontamination capabilities. It identifies how existing modelling focuses on environmental and technical requirements and how human behavioural aspects are often overlooked. Chapter 2 highlights the absence of human behavioural factors in modelling as a potentially major gap in operational preparedness. The work of Chapter 5 and Chapter 9 then supports these findings. Chapter 5 identifies through interviews with responders that there is significant concern regarding how speed of response will influence casualty compliance and willingness to wait at the scene to undergo decontamination. This is then complemented through the findings in Chapter 9 which provides data for how response times would affect the leaver rate of casualties at a CBRN incident. However, modelling of this crucial consideration is missing. As such it is clear there is a need for mass decontamination modelling capable of considering human behavioural factors to be developed.
Recommendation 4: Public Awareness Campaign	• The Home Office • The Health Security Agency	Chapters 6 and 7 emphasized the possible hurdles regarding public response during emergencies, especially in Hazmat/CBRN incidents necessitating mass decontamination. These challenges revolve around the level of trust the public places in responders and how it affects their cooperation. If not handled properly, these factors can impede efficient decontamination efforts by emergency responders. Addressing these challenges is crucial, and public awareness campaigns play a vital role in this by offering accurate information, debunking misconceptions, and building trust in the emergency services. This finding is then backed up by the conclusions of Chapter 7 which identified casualties' capability to utilize information and instructions even during emergencies and that as such pre-incident awareness would be effective in boosting public trust by familiarizing them with emergency responders' roles, managing expectations about responders' actions during incidents and

		demonstrating the emergency services readiness and capability to effectively manage a mass decontamination incident. This is further supported by Chapter 8 where experts identify pre-incident messaging as crucial in supporting an effective response.
Recommendation 5: Mass Decontamination Casualty behaviour and Communication Training	• The National Fire Chiefs' Council (through National Operational Guidance) • National Resilience • JESIP	Chapters 6 and 7 underscore the critical role which responders can have in managing incidents involving mass decontamination. Beyond infrastructure and resources, effective response hinges on responders' abilities to navigate complex challenges related to casualty behaviour and communication. This Thesis emphasizes that such skills foster trust, enhancing casualties' willingness to cooperate with responding agencies' instructions. Chapters 6 and 7 support the recommendation for proper training in casualty behaviour and communication by detailing how during a Hazmat/CBRN incidents, psychosocial factors, especially trust, profoundly influence casualty behaviour and compliance. Inadequate training may hamper responder-casualty engagement, leading to non-compliance and disrupting the decontamination process, thereby compromising overall response efforts.

Chapter 12 – Conclusion

Hazmat/CBRN incidents can cause immense harm to individuals affected, as evinced with the few that have occurred such as in Tokyo in 1995 and Salisbury in 2018. Mass decontamination of such events is a crucial societal response, and this Thesis has sought to explore how understanding casualty behaviour can improve mass decontamination response. This is an essential question because the ability of responders to effectively manage such an incident will to a large degree rely upon their ability to engage effectively with those affected.

The thesis has explored the question of human behaviour during such incidents as it is crucial to the success of mass decontamination efforts.

Throughout the research ethical integrity has been an important focus. The ethical standards of Imperial College London have been maintained throughout in recognition of the need to ensure that participants involved in the research were treated with dignity and respect. This included the use of informed consent, ensuring confidentiality and security of all participants details, and seeking to at all times to minimise the risk of any potential harm to any participants.

This adherence to ethical conduct also ensured the maintenance of the integrity of the research itself and included the honest and transparent reporting of methods, results, and any conflicts of interest.

The research began with a literature review, which was undertaken to explore mass decontamination processes as well as how human behaviour would influence such operations. The literature review utilised a Narrative approach which was essential for this area of research and something which is worth briefly reflecting upon for future research in this area.

The use of a narrative literature review in this area is crucial given the large amounts of materials which are not of an academic nature or which due to security considerations are not widely published. As a result, a more traditional systematic review would be unlikely to uncover the vital insights held within this material. A narrative review, however, is able to more freely search for pertinent literature and as such find insight for informing research which would be missed by a systemic review. It is therefore a conclusion of this thesis that future research in this area should strongly consider the use of a narrative literature either in place of or complementary to a systemic review.

With the literature review completed it was then reinforced by seeking out the current views and understanding of this area of mass decontamination response from FRS personnel involved in this area.

Chapter 5 analysed semi-structured interviews with these responders in order to build a picture of how human behaviour would impact a mass decontamination response. This highlighted several key areas particularly around the importance of human behaviour, the impact that speed of response would have on casualty's compliance and the difficulty of keeping casualties at the scene.

Following on from this, with the importance of human behaviour well established, the thesis to explored what these human behaviours would be and what drives behaviours during acute emergency situations.

A major difficulty of considering casualty behaviour during mass decontamination incidents is that such an operation has never occurred in the UK. The literature review made use of incidents worldwide, such as the Tokyo Sarin Attack or smaller scale incidents. This thesis therefore used another acute emergency incident, the 2017 Grenfell Tower fire, in order to seek to understand casualties' behaviours which could then be used to inform mass decontamination operations.

The public inquiry was held after the Grenfell incident interviewed those affected by the tower fire. From these transcripts of these interviews, this Thesis identified several important drivers of behaviours including the importance of anxiety, reasons for evacuation or staying in place, how casualty behaviours during the incident and that casualties were both helpful and co-operative with other casualties and emergency services and the importance of trust and how trust is constructed of both legitimacy and competency.

The understanding developed through reviewing the transcripts of the Grenfell incident and also further literature around human behaviour during acute emergencies led to the development of a hypothesised model of behaviour. This model was validated based on acute emergency incident, namely the Ocado Fire and the associated evacuation due to the hazards associated with an ammonia tank.

A survey of those evacuated was used to validate the model utilising path analysis. As a result, the model was able to further support the findings from the study of the Grenfell Fire transcripts review. The model highlighted the rational approach to decision making which casualties maintain during emergencies and how, whilst anxiety will occur, it will not commonly cause casualties to be overwhelmed and become irrational. Instead, the model highlighted the importance of trust in and communication by emergency responders would have in ensuring co-operation. This significant finding confronts the oft-mistaken belief that casualties during emergencies are prone to panic and therefore must be controlled rather than engaged with. As a result, the validated model highlights the need for emergency services to be cognisant of human behaviours and capable of engaging with casualties in a manner which effectively influences positive and co-operative behaviours.

The findings from this Thesis also clearly identify that casualties' behaviour at any emergency incident would be critical and that for an incident requiring decontamination it would be crucial given the need for casualties to remain and await decontamination as well as then co-operate in this process. The Thesis has also identified that casualties at emergency incidents are not likely to be overwhelmed by anxiety or panic and can be engaged with and influenced by emergency responders in order to improve compliance and co-operation.

This Thesis, therefore, identified the importance of understanding the factors influencing casualties to remain at the scene of a Hazmat/CBRN incident requiring mass decontamination and also how long they would be willing to wait. These are both crucial in informing planning for such an incident. Again however, with no real-world mass decontaminations to provide data, it was unclear how these issues could be

explored. This study therefore proposed a novel approach to this, by identifying the variables which would impact a casualties' willingness to wait for decontamination both positively and negatively and, for the first time, putting a time on how long this would be.

The implications of the findings within this thesis are crucial to inform future planning regarding mass decontamination strategies and capabilities within the UK. Currently, the basis for these strategies and resourcing of capabilities has been based upon technical judgments with very little consideration given to the role of human behaviour during operations and how this will influence desired outcomes.

In conclusion, this thesis has highlighted the importance of casualty behaviour and specifically the importance of communications and responses times. Putative response time are now available for the first time and can be included in planning.

This Thesis whilst proposing a number of findings and recommendations has also identified areas requiring further research.

1. Ocado Model Validation

   The behavioural model built from findings of the Ocado incident needs to be re-tested with different demographics and different incident types most especially any incident where there are refusals to follow responder instructions in order to validate it in other contexts.

2. Pre-Incident Information Campaign

Given the limited availability of people with any knowledge or experience of mass decontamination, pre-incident awareness messaging to prepare the public for a mass decontamination incident appears important and as other literature has shown has been successfully used to prepare for other threats. Therefore, there is a need to explore how best to deliver such pre-information for a Hazmat/CBRN incident requiring mass decontamination.

3. Mass Decontamination Modelling

   This Thesis has provided a crucial piece of information for modelling of mass decontamination operations by providing a leaver rate for casualties at a Hazmat/CBRN incident requiring mass decontamination.

As such it is critical that this new information be built into planning assumptions. It would therefore be hugely beneficial for a model of mass decontamination response to be developed in order to understand how current arrangements and resourcing would fare in various incident scenarios. It would also then allow exploration of what new resourcing requirements or strategies such as interim decontamination may be needed in order to meet the required (whatever this may be set as) level of response effectiveness.

Overall, this study has shown the importance of human behaviour during emergency situations and that these behaviours will not be irrational but rather are rational and can be influenced. The role of trust in such engagement is crucial, with trust compromising of both legitimacy and competency.

Building upon this understanding this Thesis has been able to identify the crucial need for responder training in the areas of human behaviour and particularly communication and has filled a previous gap in mass decontamination planning by providing a rate at which casualties will leave the scene. Finally, this Thesis has also identified areas requiring further research. As a result, this Thesis has contributed to a significant increase in planning potential for mass decontamination operations. This is essential given the current threat of a CBRN incident as recently identified *"Strategic Defence Review expressed stated "There is a realistic possibility that state sponsorship of terrorism and the use of proxies will increase. It is likely that a terrorist group will launch a successful CBRN attack by 2030"* (p. 32) (Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy, 2021).

Within Chapter 1 of this Thesis an overview was provided of the objectives of each Chapter. Table 19 below again sets out the objectives for each Chapter alongside a summary of how this has been achieved.

Table 19 Chapter Objectives

Chapter	Objectives	How the Objectives have been met
Chapter 1 – Casualty Behaviour During Hazmat/CBRN Incidents Introduction	To provide an introduction to the PhD, elucidating the rationale behind the Thesis's development and outlining the intended aims and objectives it seeks to achieve.	Chapter 1 provides an introduction for the Thesis and sets its aims and objectives.
Chapter 2 – Context of emergency decontamination in the United Kingdom	To establish the context for Mass Decontamination operations in the UK, detailing their governance, the legal framework, planning, and operational aspects.	Chapter 2 sets of the context for mass decontamination in the UK covering what decontamination is, how a mass decontamination incident is prepared for and organised during an emergency operation as well as the legal framework which supports it. It also covers the significance of casualty behaviour during a mass decontamination operation with particular focus on the role of casualty compliance during such incidents.
Chapter 3 – Casualty Behaviour and Mass Decontamination: A Literature Review	To analyse existing literature on casualty behaviours in Hazmat/CBRN and mass decontamination incidents, with the goal of identifying knowledge gaps and establishing a foundational understanding to address the PhD's research objectives.	Chapter 3 provides a comprehensive literature review of casualty behaviour during mass decontamination incidents setting out an overview of existing research and highlighting the current gaps which exist.
Chapter 4 – Methodological Overview	Provide a methodological overview of the Thesis.	Chapter 4 sets of the methodological approach of the Thesis as a whole as well as the methodological approach taken for each Chapter.

Chapter 5 – The Impact of Fire and Rescue Service First Responders on Casualty Behaviour During Hazmat/CBRN Incidents	Catalogue responder perceptions of casualty's behaviours during mass decontamination incidents. Catalogue how responders believe they would impact these behaviours. Catalogue how prepared responders feel about dealing with these behaviours.	Chapter 5 catalogued Mass Decontamination Operatives, Hazardous Material Advisers (HMA's) and Level 4 FRS Strategic (Gold Command) Managers regarding their views and perceptions on casualty's behaviours during mass decontamination incidents, how their actions as responders would impact such behaviours and how prepared they felt as responders to deal with the perceived behaviours. This resulted in six themes being identified by the Chapter. These themes have subsequently been published as part of a paper in the International Journal of Emergency Services.
Chapter 6 - The Role of Trust in Casualty Compliance with Emergency Responder Instructions During Emergencies	Catalogue and describe factors that affected the way in which those involved in the Grenfell Tower Fire behaved.	Chapter 6 produced four themes to summarise factors that affected the way in which those involved in the Grenfell Tower Fire behaved. These four themes were then utilised to inform the development of a behavioural model for casualty behaviours during a hazardous material incidents in Chapter 7. These themes were also published as part of a paper in the International Journal of Disaster Risk Reduction.
Chapter 7 – Casualty Behaviours During Incidents Involving Hazardous Materials	Develop a behavioural model of what influences casualty behaviours. Validate this model in a real-world incident involving hazardous materials.	Chapter 7 develops and validates a behavioural model of casualty behaviour and has been published in the Journal Safety Science.

Chapter 8 – CBRN Mass Decontaminant Scenario Development	Create a list of variables which will influence casualty willingness to stay at the scene of a CRBN incident and undergo decontamination. Develop a range of scenarios which can subsequently be used to investigate the amount of time that casualties will be willing to remain at the scene.	Chapter 8 delivers a set of variables which will influence casualty willingness to stay at the scene of a CRBN incident and undergo decontamination and then utilised these valuables to develop a set of scenarios. The variables identified have subsequently been used as part of a deliverable titled "Guidelines and recommendations for mitigation and management of CBRNe terrorism", which forms part of a European Union's Horizon 2020 research and innovation programme called PROACTIVE (PROACTIVE 2023a). The scenarios have also then been utilised by PROACTIVE to inform a Pre-Incident Public Information Materials publication (PROACTIVE 2023b). A full paper covering the development of the scenarios from Chapter 8 has also been submitted to the Journal *Fire* and is currently under review.
Chapter 9 – Stay in Place Compliance Times and Decontamination Willingness – A Visualisation Approach	Determine how long casualties will be willing to wait at the scene of a CBRN incident and how willing they would be to undergo decontamination. Determine how the roll of communications by emergency responders influences casualties' willingness to wait at the scene of a CBRN incident and undergo decontamination.	Chapter 9 provides for the first-time reliable figures for how long casualties will be willing to remain at the scene of a CBRN incident and undergo decontamination and how this figure will be influenced by both external variables as well as the communication and response times of responding emergency services. A Journal Paper on waiting times of casualties at a mass decontamination incident is currently under preparation.
Chapter 10 – Mixed Methods Appraisal	To reflect on the utilization of a mixed methods approach to comprehend human behaviour during	Chapter 10 provides a reflective assessment of the use of mixed methods in studying human behaviour during incidents requiring mass decontamination.

	mass decontamination incidents and articulate implications for future research within this domain.	
Chapter 11 – Recommendations	Present a set of recommendations to guide future planning, resource allocation, and training strategies for Mass Decontamination response and validate these findings with experts in the UK CBRN/Mass Decontamination field.	Chapter 11 sets out five recommendations to assist appropriate agencies and responders should a Hazmat/CBRN incident requiring mass decontamination occur within the UK.
Chapter 12 – Conclusion	Provide a conclusion to the Thesis.	A conclusion to the Thesis is presented in Chapter 12 offering a succinct recapitulation of the critical insights and findings presented throughout. Its purpose is to reaffirm and emphasize the central Thesis argument, emphasizing the most significant discoveries and outcomes, and their contributions to the field of study.

Through the delivery of these objectives this Thesis has been able to deliver real-world impact. It has been able to influence academic thinking through the publication of several Chapters. Chapter 5 being published in the International Journal of Emergency Services; Chapter 6 being published in the International Journal of Disaster Risk Reduction and Chapter 7 being published the Journal Safety Science. Furthermore, Chapter 7 is being presented at the UK Hazmat Conference in May 2024.

Both the variables identified as likely to drive casualty behaviours at a Hazmat/CBRN incident, which are set out in Table 6 in Chapter 8, and the Scenarios also from Chapter 8 were also published as part of the PROACTIVE Guidelines and recommendations for mitigation and management of CBRNe terrorism. Deliverable D1, 3. PROACTIVE stands for "PReparedness against CBRNE threats through cOmmon Approaches between security praCTItioners and the VulnerablE civil society". It is a Horizon 2020 European Union funded project that seeks *"to enhance preparedness against and response to a CBRNe incident through a better harmonisation of procedures between various categories of practitioners, and a better understanding of the needs of vulnerable citizen groups"* (PROACTIVE 2023a).

It is therefore well placed to utilise the work of this Thesis and is influencing operational strategies and practices. Indeed, this methodology and the scenarios used have continued to influence this European project and are being utilised as part of further research projects and operational guidance for emergency response agencies (PROACTIVE 2023b).

Word Count – 72413

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Appendices

Appendix I – Imperial Ethics Framework

	Research	Evaluation	Audit
Purpose	Derive generalizable new knowledge including studies that aim to generate hypotheses as well as studies that aim to test them.	Designed and conducted solely to define or judge current systems or policy implementation.	Designed and conducted to produce information to inform delivery of system or policy implementation
Approach	Quantitative Research – designed to test a hypothesis Qualitative research – identifies or explores themes following established methodology	Designed to understand the current state of a given situation	Designed to understand if a specific standard is being met in a situation
Outcome	Addresses clearly defined questions, aims and objectives	Measures the current state of a given context without reference to a standard	Measures against a standard
Research Activity	Quantitative Research – may involve evaluating or comparing various interventions, solutions, or prototypes. Qualitative Research – usually involves studying how interventions, solutions, prototypes and relationships are experienced.	Involves examining the world as it already exists (including policy interventions or pilots already implemented) and does not involve implementing and measuring new proposed interventions.	Involves examining the world as it already exists and does not involve implementing and measuring new interventions.
Data Source	May involve the use of existing or routine data but typically will involve collecting additional data to answer a specific question.	Often involves observation, questionnaire or interview in addition to the use of existing data.	May involve observations, questionnaires or interviews in addition to the use of existing data.
Study Design	Quantitative research may involve allocating participants to intervention groups. Qualitative research uses a clearly defined sampling framework underpinned by conceptual or theoretical justifications.	Participants are not asked to change what they would normally be doing. Instead, the researcher examines what is being done.	Participants are not asked to change what they would normally be doing. Instead, the researcher examines what is being done.
Example	Quantitative – measuring the effect of one design tool/technique over another Qualitative – exploring attitudes towards a product or prototype or behaviour change	Contextual observations and questions of a surgeon using a medical device to understand current use and limitations. Examining how things have changed following implementation of a policy measure/intervention or pilot scheme.	An assessment of if office seat, desk and monitor height match specified standards in an office.
Ethics Approval Required?	These studies will typically require approval from ICREC or SETREC or through appropriate means for student work.	Does not require ethical approval.	Does not require ethical approval.

Appendix II – The Impact of Fire and Rescue Service First Responders on Casualty Behaviour During Hazmat/CBRN Incidents: Quantitative Validation Questionnaire

Mass Decontamination Operative Questionnaire

For each of the following statements please give your professional opinion as a mass decontamination operative.

1 = Entirely Disagree

7 = Entirely Agree

How would you rate the following Statements?

1.) People leaving the scene before being decontaminated will be a major challenge.

1-2-3-4-5-6-7

2.) Those who do leave the scene are most likely to go to Hospital or to go home.

1-2-3-4-5-6-7

3.) Casualties not complying with emergency responders instructions will be a major difficulty.

1-2-3-4-5-6-7

4.) Currently the speed with which we would be able to decontaminate people is too slow.

1-2-3-4-5-6-7

5.) The training provided for crews regarding human behaviour is inadequate.

1-2-3-4-5-6-7

6.) Emergency responders are not well prepared for dealing with the human behavioural aspects of mass decontamination operations.

1-2-3-4-5-6-7

7.) The trust with which casualties hold emergency responders will be critical to them following instructions.

1-2-3-4-5-6-7

Thank you for your participation.

Appendix III – Casualty Behaviours During Incidents Involving Hazardous Materials: Informed Consent

Casualty Behaviours During Incidents Involving Hazardous Materials

Participant Information and Informed Consent

Invitation paragraph

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Take time to decide whether or not you wish to take part.

Purpose of the study

The study is looking to understand the experiences of members of the public involved in an emergency icnidnet relating to a hazardous material.

Why have I been chosen?

You have indicated via Hampshire Fire and Rescue Services social media channels that you were eaucted form your home or place of work as a result of the fire at the Ocado distribution cwnter.

Do I have to take part?

Taking part is entirely voluntary and you may refuse. You are also completely entitled to withdraw from the study at any time with no penalty or loss, now or in the future.

What do I have to do?

If you choose to take part, you will be asked 30 questions relating to your experience of the evacuation that occurred as a result of the fire at the Ocado distribution centre.

All that is expected of you is to give your opinion to the questions asked by selecting a number relating to that question. The meaning of the numbers will be explained.

Will my taking part in this project be kept confidential?

No identifying details will be taken during this study meaning there will be no way for your participation to be traced and therefore everything you answer in the study will be confidential.

What will happen to the results of the research project?

The results of the research will inform future planning for Hampshire Fire and Rescue Service and will also be used as part of a PhD project at Imperial College London.

Who is organising and funding the research?

The research is being organized by Hampshire Fire and Rescue Service with the support of Imperial College London.

Contact for further information

For further information please contact –

Hampshire Fire and Rescue Service

Email: Inquiries @hantsfire.gov.uk

Address: Leigh Road, Eastleigh SO50 9SJ

Alternatively, Please Contact –

Francis Long

Email: f.long16@imperial.ac.uk

Address: Skempton Building, Imperial College Rd, Kensington, London SW7 2BB

Consent Form for Participants Able to Give Consent

Full Title of Project: Casualty Behaviours During Incidents Involving Hazardous Materials

Name of Principal Investigator: Hampshire Fire and Rescue Service

Please initial box

5. I confirm that I have read and understand the participant information sheet version 1.1dated 01/03/2020 for the above study and have had the opportunity to ask questions which have been answered fully.	
6. I understand that my participation is voluntary, and I am free to withdraw at any time, without giving any reason and without my legal rights being affected.	
7. I give consent for information collected about me to be used to support other research in the future, including those outside of the European Economic Area (EEA).	
8. I consent to take part in the above study.	

_____ _____ _____

Name of person taking consent (if different from Principal Investigator) Signature Date

_____ _____ _____

Principal Investigator Signature Date

Appendix IV – Casualty Behaviours During Incidents Involving Hazardous Materials: Ocado Evacuation Survey

Andover Ocado Evacuees

Questionnaire

Were you evacuated from your home/place of work during the Ocado fire? Yes – Home Yes – Work No

Who were you evacuated by (Police, Fire Service)?

……..

Age – ……..

Gender – Male, Female, Non-Binary, Transgender, Other (Please Specify), Prefer not to say

Ethnicity – White British, Mixed or Multiple Ethnic Groups, Asian or Asian British, Black, African, Caribbean or Black British, Any Other Ethnic Group, Prefer Not to Say

Education – High School, Undergraduate Degree, Postgraduate Degree

Household Income – Below 10k, 10-20k, 20-30k, 30-40k, 40-50k, 50-100k, +100k

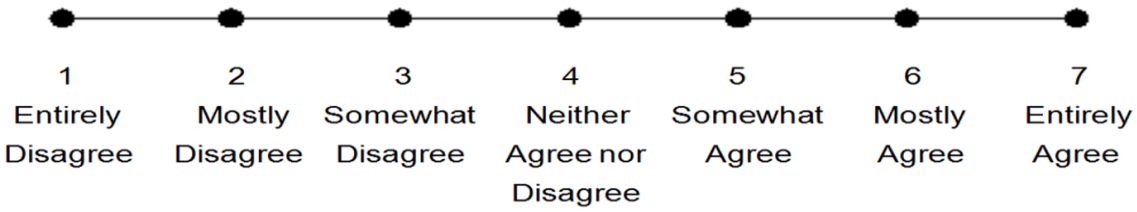
For each of the following statements please think about your experience and how you felt when being asked to evacuate during the Ocado Fire.

How would you rate the following statements?

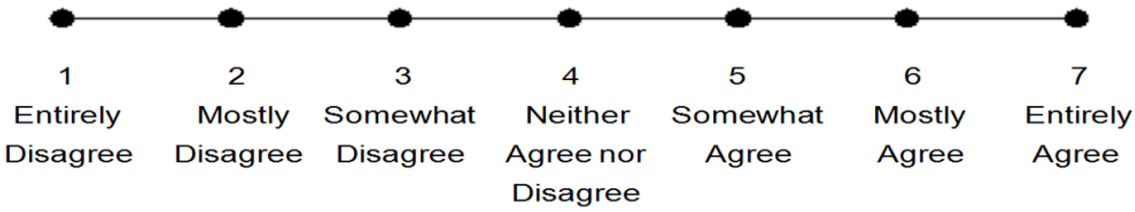
1 = Entirely Disagree

7 = Entirely Agree

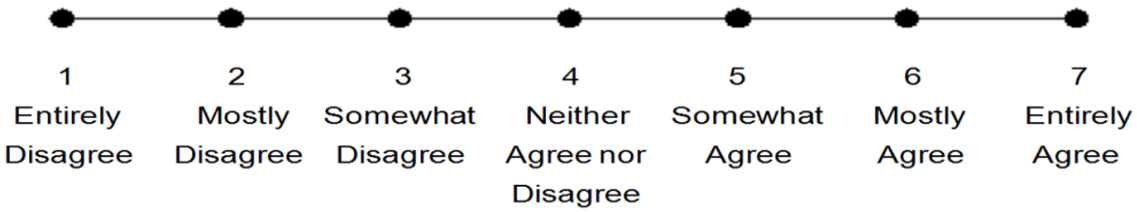
1.) I felt in control of my situation.



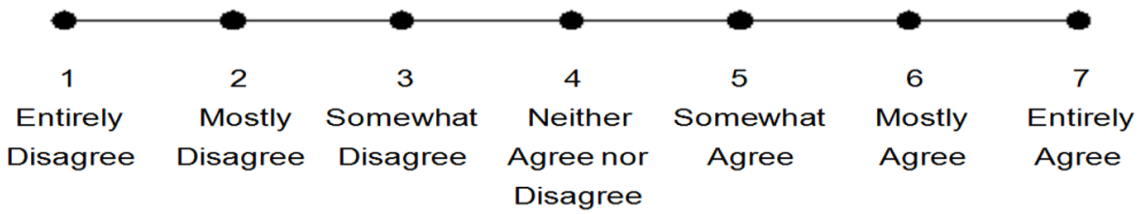
2.) I felt the situation was unfamiliar to me.



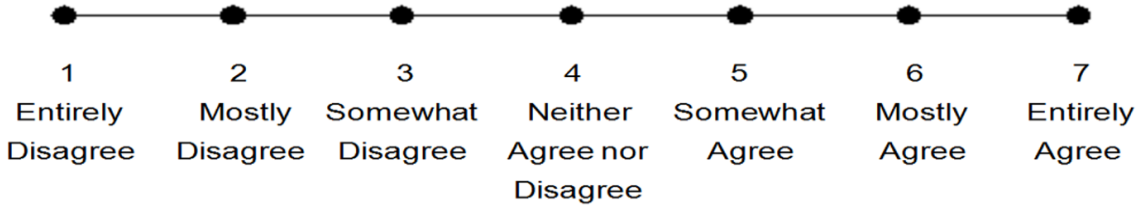
3.) I felt uncertain about what was happening to me.



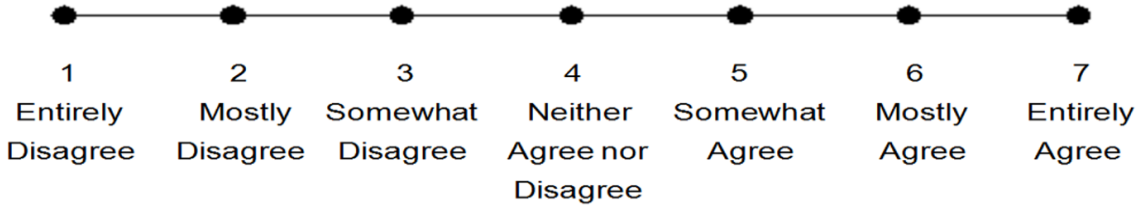
4.) I felt tense about my situation.



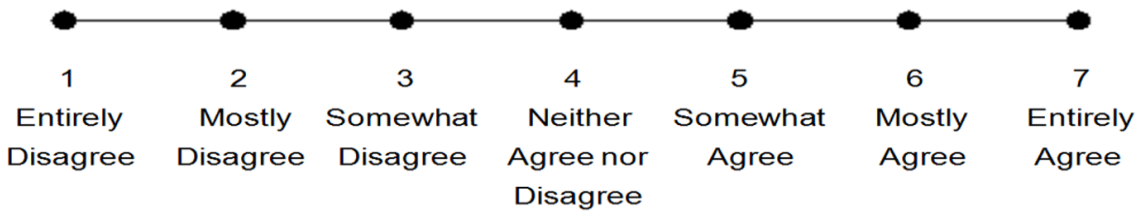
5.) I felt angry about my situation.



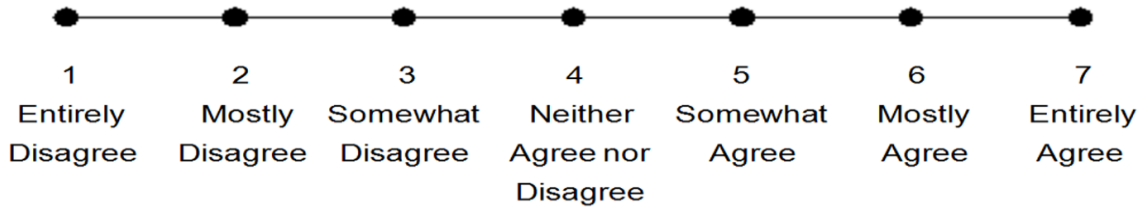
6.) I felt scared about my situation.



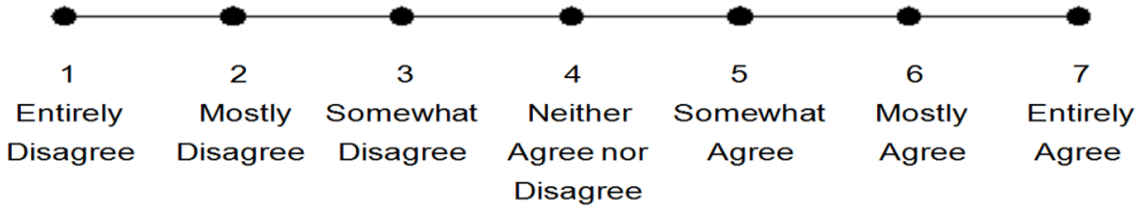
7.) I felt sad about my situation.



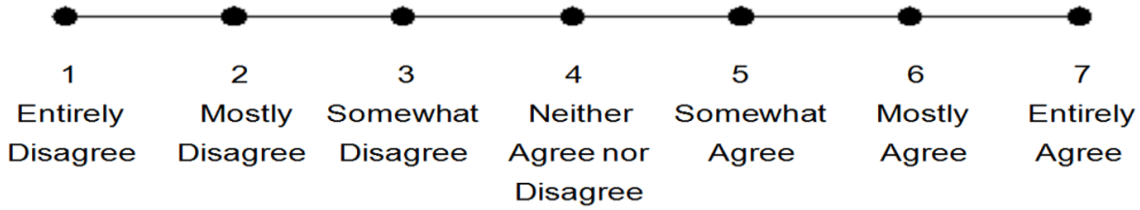
8.) I felt at risk from the fire.



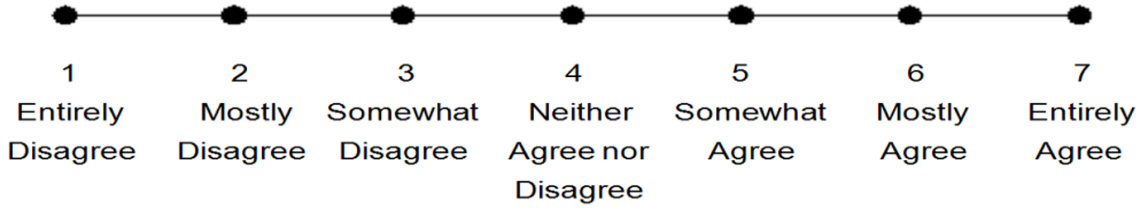
9.) I felt at risk from being evacuated.



10.) I trusted those asking me to evacuate.



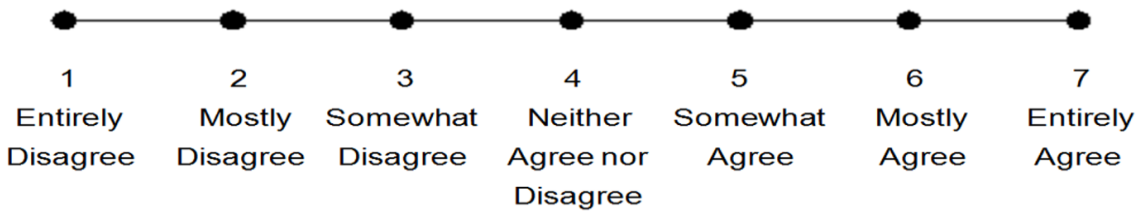
11.) I followed all the instructions of those asking me to evacuate.



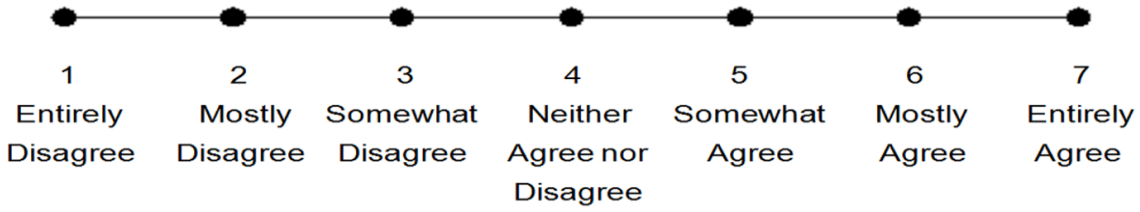
12.) I felt able to influence my situation.



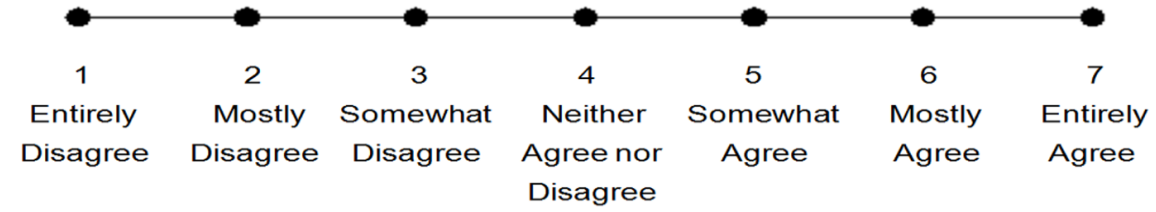
13.) I had not experienced a situation like this before.



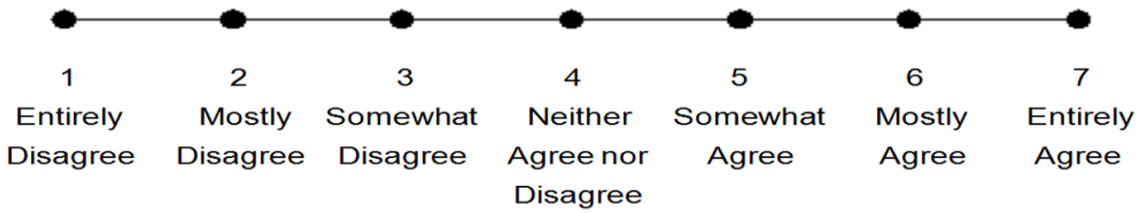
14.) I didn't know what was going to happen to me.



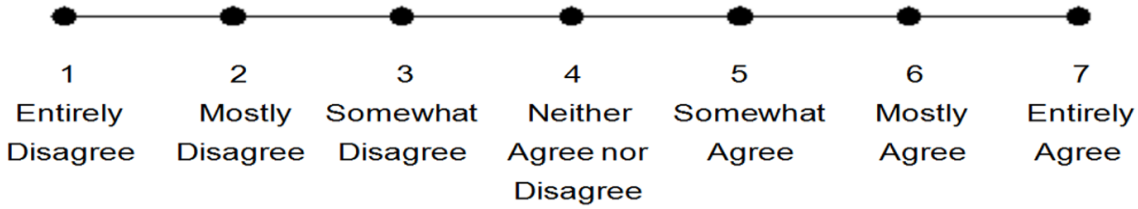
15.) I felt worried by my situation.



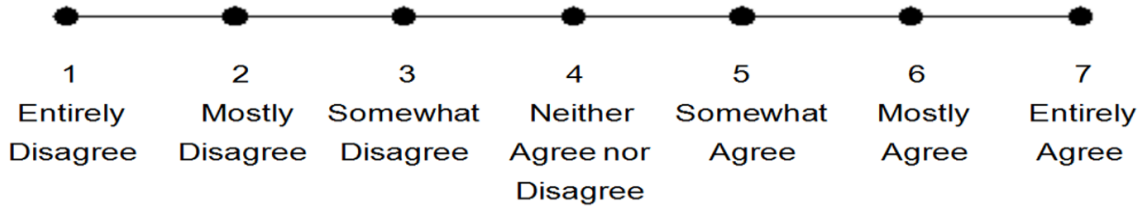
16.) I felt mad about my situation.



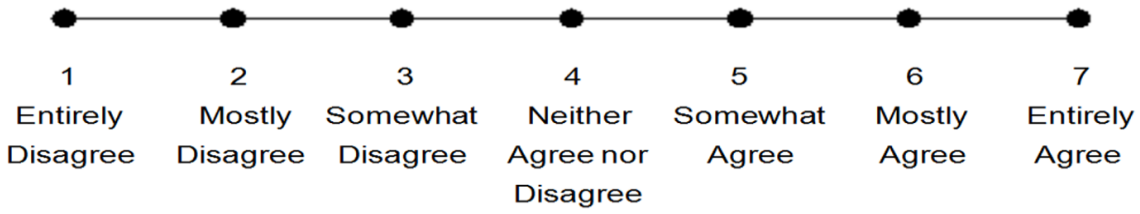
17.) I felt afraid due to my situation.



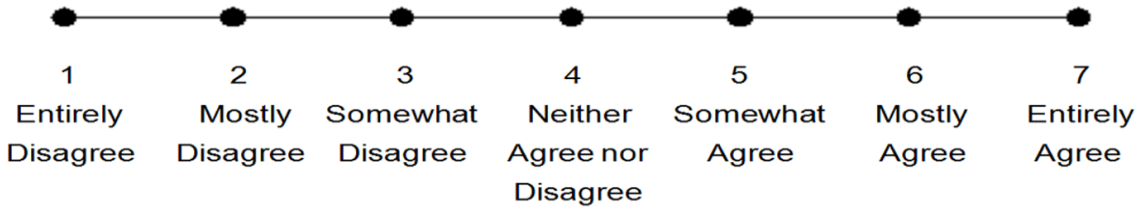
18.) I felt grief about my situation.



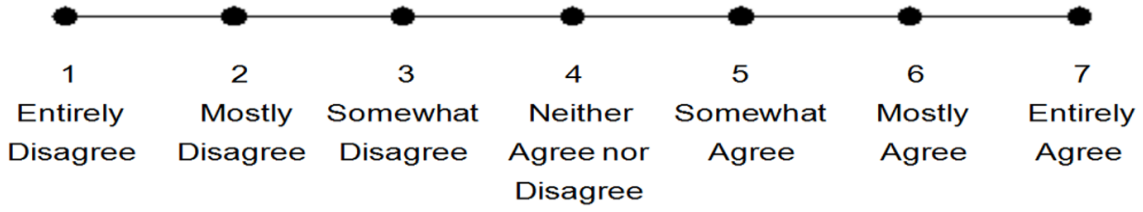
19.) I felt in danger from the fire.



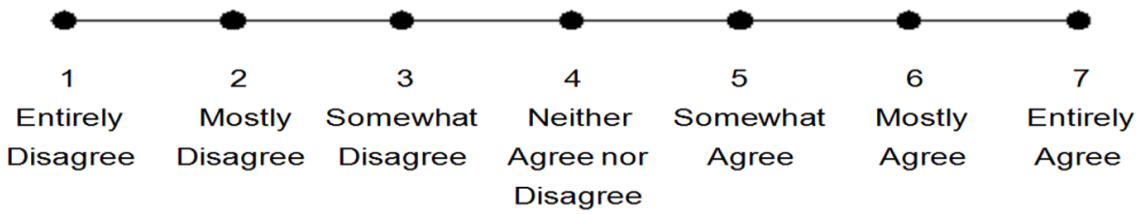
20.) I felt it was dangerous to evacuate.



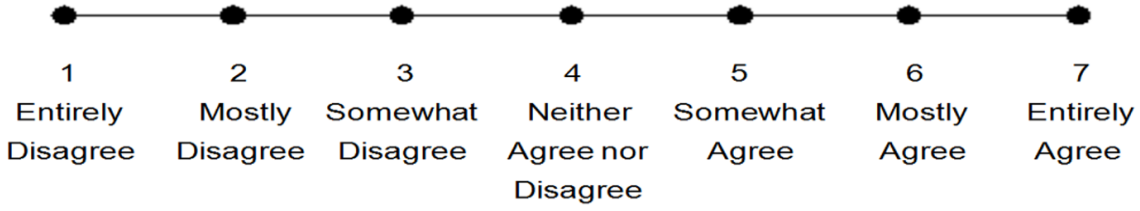
21.) I believed that those asking me to evacuate were acting in my best interests.



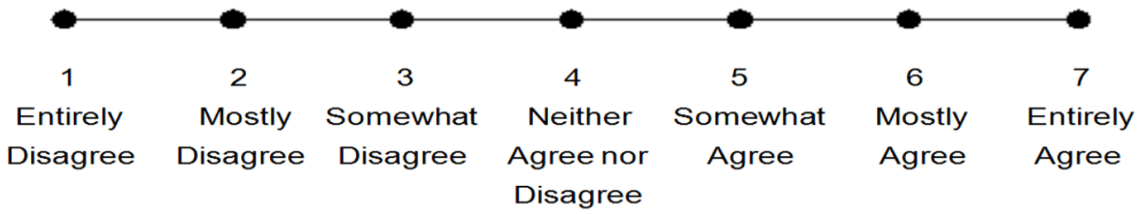
22.) I did all that those asking me to evacuate told me to do.



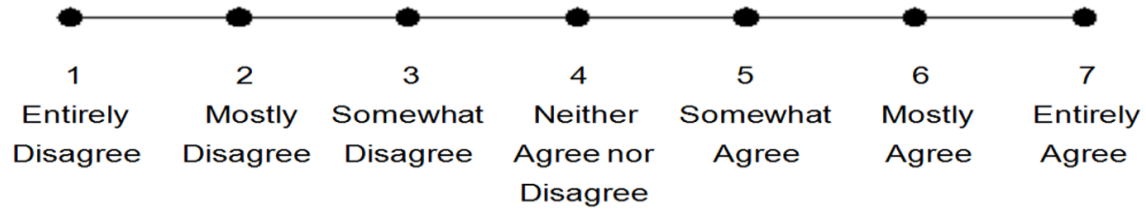
23.) I believed those asking me to evacuate were able to help me.



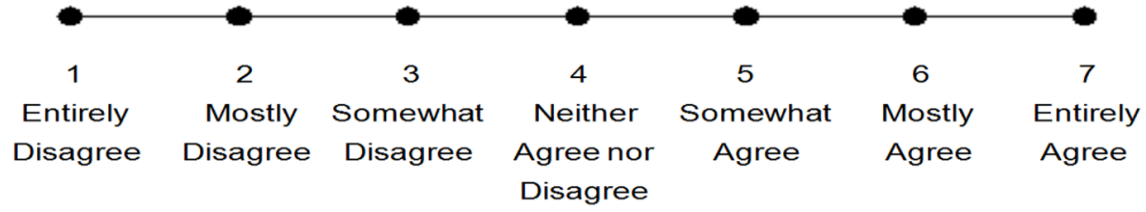
24. Those asking me to evacuate explained clearly what was happening during the evacuation.



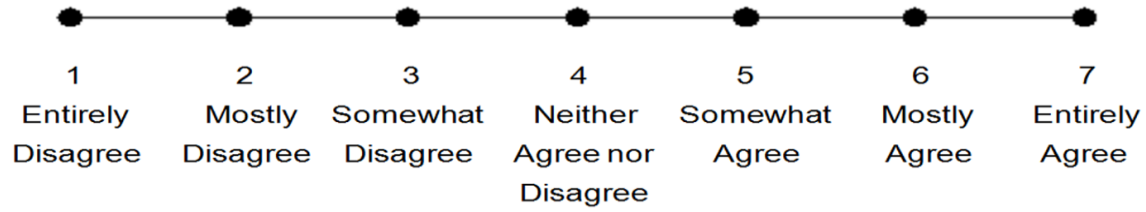
25. I felt that I was provided with sufficient information about why evacuation was necessary.



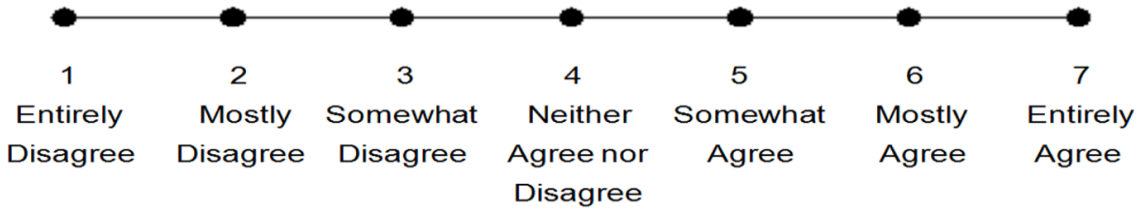
26. I understood why I was being asked to evacuate.



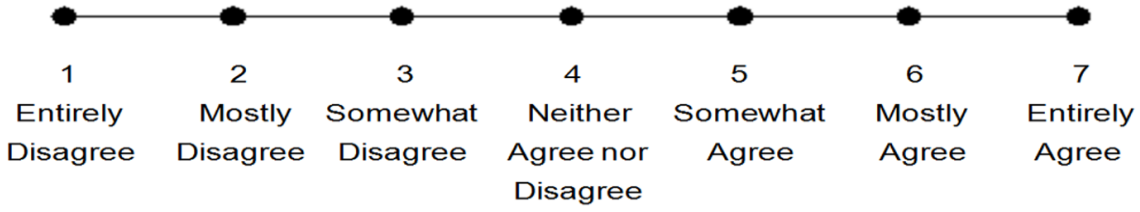
27. I felt that those evacuating me did so competently.



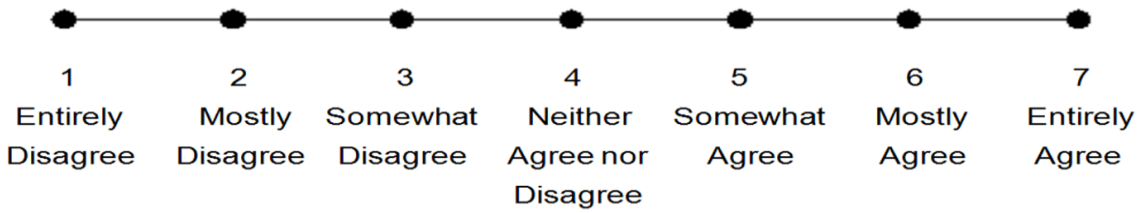
28. I felt that those evacuating me treated me fairly



29.I felt that those evacuating me treated me with respect.



30. I felt that the emergency services did their job well.



Thank you for your participation.

If you have any questions or concerns about the research you have taken part in please contact:

Francis Long

f.long16@imperial.ac.uk

francis.long@hantsfire.gov.uk

Appendix V – Casualty Behaviour During CBRN Incidents: Decontamination Stay in Place Waiting Times: Informed Consent

Participant Information Sheet'.

Title of Study

Casualty Behaviour During CBRN Incidents: Decontamination Stay in Place Waiting Times

Principle Investigator: Dr Arnab Majumdar
Coinvestigator: Dr Holly Carter
Coinvestigator: Francis Long

Invitation paragraph

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve.

Part 1 tells you the purpose of this study and what will happen to you if you take part.
Part 2 gives you more detailed information about the conduct of the study

Please take your time to read the following information carefully and discuss it with others if you wish in order to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

The study is looking to understand how long casualties are likely to remain at the scene of a Chemical, Biological, Radiological or Nuclear incident requiring mass decontamination. A number of key areas for what is likely to impact waiting times has been identified in a previous study.

These areas will now be explored to understand how these influence waiting times.

By understanding likely waiting times this study will look to inform future strategies and resourcing for mass decontamination response in the UK.

This research is part of a PhD being completed at Imperial College London.

Why have I been invited?

You have been asked to take part in this study, as you a UK resident who is over the age of 18.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What do I have to do?
If you choose to take part, you will be asked to read 3 statements asking you to visualise and emergency situation. Interspersed between these statements are four questions 3 asking you to say how long you would be willing to wait at the scene between different time points and 1 question on how willing you would be to undergo decontamination. This should take between 10-15 minutes.

What will happen to me if I take part?

No identifying details will be taken during this study meaning there will be no way for your participation to be traced and therefore everything you answer in the study will be confidential.

The study will be a one-off questionnaire after which no further engagement will be ne required. The survey will take between 10-15 minutes to complete.

What will happen to the results of the research study?
The results of the research will inform a chapter of the lead researchers PhD project. It is also expected that this chapter will be published in an academic journal.
You will not be identified in any report/publication. As we will not be collecting your data you will also not receive any further information on publications etc.

Who is organising and funding the research?

The research is being organized by Imperial College London

Who has reviewed the study?

This study has been reviewed and given a favourable opinion by Washington Ochieng, Head of Department (Civil and Environmental Engineering Civil and Environmental Engineering) and Research Governance and Integrity Team (RGIT).

Contact for Further Information
For further information please contact –
Lead Researcher Francis Long Email: f.long16@imperial.ac.uk
Address: Skempton Building, Imperial College Rd, Kensington, London SW7 2BB

Thank you for supporting this work.

Complaint

If you wish to raise a complaint on how we have handled your personal data, please contact Imperial College London's Data Protection Officer via email at dpo@imperial.ac.uk, via telephone on 020 7594 3502 and/or via post at Imperial College London, Data Protection Officer, Faculty Building Level 4, London SW7 2AZ. If you are not satisfied with our response or believe we are processing your personal data in a way that is not lawful you can complain to the Information Commissioner's Office (ICO). The ICO does recommend that you seek to resolve matters with the data controller (us) first before involving the regulator.

Transparency Notice

Summary Information sheet

In this research study we will use information from you. We will only use information that we need for the research study. We will let very few people know your name or contact details, and only if they really need it for this study.
Everyone involved in this study will keep your data safe and secure. We will also follow all privacy rules.

At the end of the study we will save some of the data in case we need to check it.

We will make sure no-one can work out who you are from the reports we write.
The information pack tells you more about this.

How will your information be used about you?

Research Study Title: Casualty Behaviour During CBRN Incidents: Decontamination Stay in Place Waiting Times

[Study number 1]

Imperial College London is the sponsor for this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. Imperial College London will keep your personal data for:
Seven years after the study has finished in relation to data subject consent forms.
Seven years after the study has completed in relation to primary research data.

We will need to use information from you for this research project.
This information will include your reference number. People will use this information to do the research or to check your records to make sure that the research is being done properly.

We will keep all information about you safe and secure.
Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study.

Legal Basis

As a university we use personal information to conduct research that will either be in the public interest, or the legitimate interests of the College.

As a publicly-funded organisation we have to ensure that when we use personally-identifiable information from people who have agreed to take part in research, it is either in the public interest, or that our legitimate purposes are both properly notified to you and are not overridden by your rights.
We will conduct scientific research in compliance with the law and the recommendations and guidance published by the UK Information Commissioners Office (ICO). This will follow similar rules to health and care research but may not meet the definition of the College's public interest task. In such cases we will be holding and using your data for what are deemed our "legitimate interests".

International Transfers
There may be a requirement to transfer information to countries outside the European Economic Area (for example, to a research partner). Where this information contains your personal data, Imperial College London will ensure that it is transferred in accordance with data protection legislation. If the data is transferred to a country which is not subject to a European Commission (**EC**) adequacy decision in respect of its data protection standards, Imperial College London will enter into a data sharing agreement with the recipient organisation that incorporates EC approved standard contractual clauses that safeguard how your personal data is processed.

Sharing your information with others
For the purposes referred to in this privacy notice and relying on the bases for processing as set out above, we will share your personal data with certain third parties. Other College employees, agents, contractors and service providers (for example, suppliers of printing and mailing services, email communication services or web services, or suppliers who help us carry out any of the activities described above). Our third party service providers are required to enter into data processing agreements with us. We only permit them to process your personal data for specified purposes and in accordance with our policies.

What are your choices about how your information is used?
You can stop being part of the study at any time, without giving a reason, and no information will be kept about you.

We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?
You can find out more about how we use your information
by asking one of the research team
by sending an email to [**f.long16@imperial.ac.uk**], or
by ringing us on [**0770930505**].

Complaint
If you wish to raise a complaint on how we have handled your personal data, please contact Imperial College London's Data Protection Officer via email at dpo@imperial.ac.uk, via telephone on 020 7594 3502 and/or via post at Imperial College London, Data Protection Officer, Faculty Building Level 4, London SW7 2AZ.

If you are not satisfied with our response or believe we are processing your personal data in a way that is not lawful you can complain to the Information Commissioner's Office (ICO). The ICO does recommend that you seek to resolve matters with the data controller (us) first before involving the regulator.

Consent Form for Participants Able to Give Consent

Full Title of Project: Casualty Behaviour During CBRN Incidents: Decontamination Stay in Place Waiting Times

Name of Principal Investigator: Dr Arnab Majumdar

Please initial box

1. I confirm that I have read and understand the participant information sheet version 1.1dated 24/04/2022 for the above study and have had the opportunity to ask questions which have been answered fully.	
2. I understand that my participation is voluntary, and I am free to withdraw at any time, without giving any reason and without my legal rights being affected.	
3. I give consent for information collected about me to be used to support other research in the future, including those outside of the European Economic Area (EEA).	
4. I consent to take part in the above study.	

_____	_____	_____
Name of person taking consent (if different from Principal Investigator)	Signature	Date

_____	_____	_____
Principal Investigator	Signature	Date

1 copy for participant; 1 copy for Principal Investigator

Appendix VI – Stay in Place Compliance Times and Decontamination Willingness – A Visualisation Approach: Demographic Data

Participants Ages for each intervention

Age	Worst Case Poor Comms	Best Case Poor Comms	Worst Case Effective Comms	Best Case Effective Comms
18-25	29	36	27	32
25-34	58	50	62	53
35-44	56	63	51	54
45-54	49	50	53	55
55 -64	69	60	71	72
65+	39	40	35	32

Participants Genders for each intervention

Gender	Worst Case Poor Comms	Best Case Poor Comms	Worst Case Effective Comms	Best Case Effective Comms
Male	145	146	140	141
Female	154	152	153	153
Non-Binary	0	1	4	4
Transgender	0	0	0	0
Other (Please Specify)	0	0	0	0
Prefer not to say	1	0	2	0

Ethnicity for each intervention

Ethnicity	Worst Case Poor Comms	Best Case Poor Comms	Worst Case Effective Comms	Best Case Effective Comms
White British	235	233	241	249
Mixed or Multiple Ethnic Groups	10	9	10	9
Asian or Asian British	18	20	20	18
Black African	3	3	4	5
Caribbean or Black British	7	7	5	4
Any Other Ethnic Group	23	24	19	13
Prefer Not to Say	4	3	0	0

Education for each intervention

Education	Worst Case Poor Comms	Best Case Poor Comms	Worst Case Effective Comms	Best Case Effective Comms
High School	120	122	112	112
Undergraduate Degree	115	125	135	137
Postgraduate Degree	65	52	52	49

Household Income for each intervention

Household Income	Worst Case Poor Comms	Best Case Poor Comms	Worst Case Effective Comms	Best Case Effective Comms
Below 10k	20	21	16	14
10-20k	51	59	41	43
20-30k	89	61	67	74
30-40k	46	60	40	48
40-50k	33	39	45	44
50-100k	52	51	79	66
+100k	9	8	11	9

Appendix VII – Stay in Place Compliance Times and Decontamination Willingness: Visualisation Survey

CBRN Mass Decontamination Scenarios

Age – 18-24, 25-34, 35-44, 45-54, 55-64, 65+

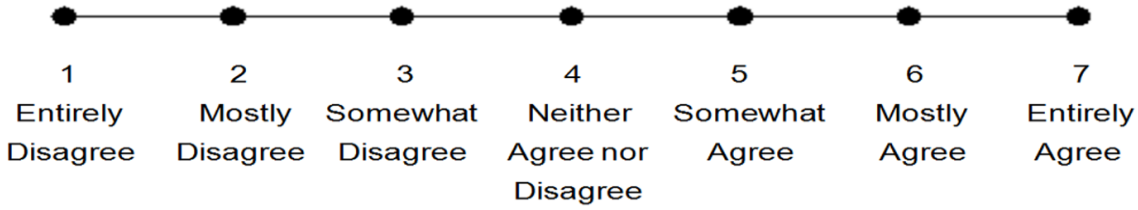
Gender – Male, Female, Non-Binary, Transgender, Other (Please Specify), Prefer not to say

Ethnicity – White British, Mixed or Multiple Ethnic Groups, Asian or Asian British, Black, African, Caribbean or Black British, Any Other Ethnic Group, Prefer Not to Say

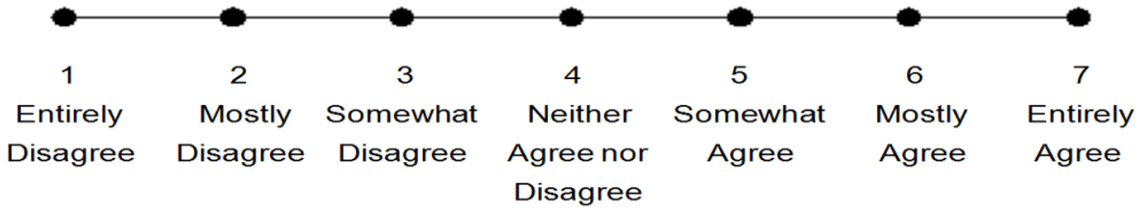
Education – High School, Undergraduate Degree, Postgraduate Degree

Household Income – Below 10k, 10-20k, 20-30k, 30-40k, 40-50k, 50-100k, +100k

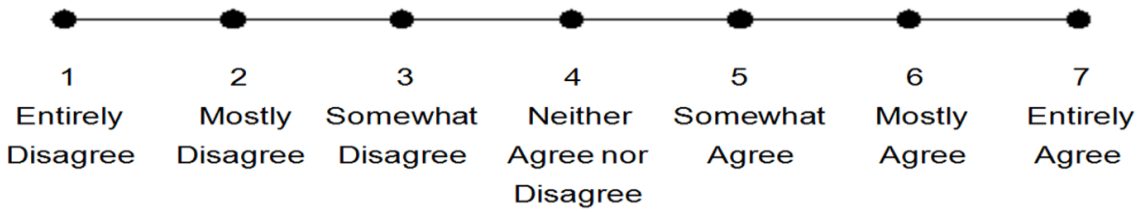
I trust the emergency services.



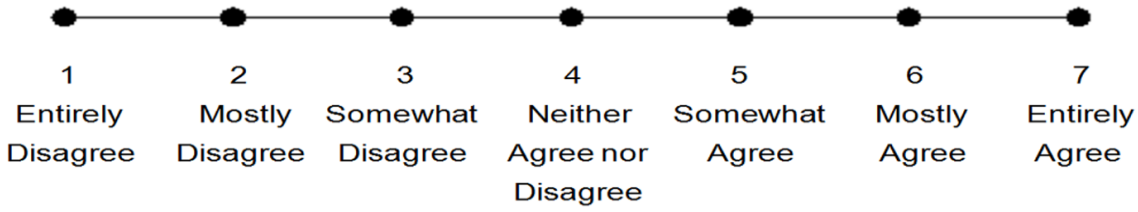
I have confidence in the emergency services.



I feel I have a good understanding of emergency incidents involving chemical, biological, radiological or nuclear materials.



I feel I have a good understanding of emergency incidents requiring mass decontamination.



Introduction

Please read the following scenario and imagine yourself in the situation. The scenarios are split into three sections with a question after each section. Please try to consider your answers carefully based upon how you think you would act.

Scenario 1: Worst case scenario, poor communication

First stage of scenario (general scenario)

On a cold, wet late evening, you are travelling with some close family members. As you are stood on the platform of an unfamiliar train station, an explosion occurs. Ears ringing, you look down to find that you and your family are covered in a fine powder. Quickly you feel your eyes start to sting and a cough rises in your throat. All around you, you can see your fellow passengers starting to suffer. Many are starting to head for the exits to leave the station. From the moment the explosion occurs how long would you be willing to wait for emergency responders to arrive before you leave the scene?

Question 1: From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Second stage of scenario (communication)

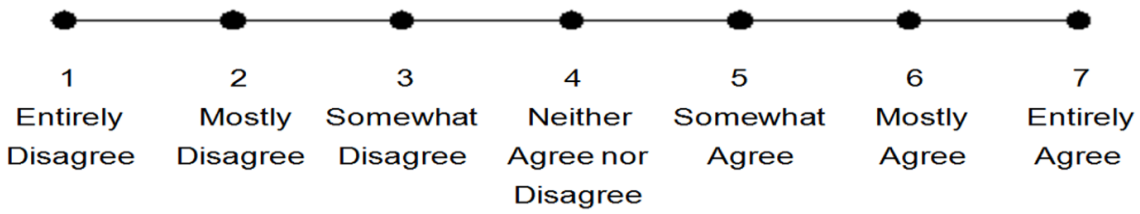
Emergency responders tell you, and others nearby, to follow them to a location outside the train station. They then tell you to remove the top layer of your clothes, down to your underwear. They give you some blue roll and tell you to use it to wipe the powder off your skin. While you are wiping the powder off your skin, emergency responders say that they are going to need to set up a large shower system, to decontaminate you. From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

Question 2: From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Emergency responders tell you and the others affected to form a queue and wait to enter the large shower system. You are all told to remove your underwear, and then enter the shower one by one.

Question 3: How would you rate the statement below? I would be willing to go through the decontamination shower.



Question 4: Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Scenario 2: Best case scenario, poor communication

First stage of scenario (general scenario)

It's 9am on a warm and dry summer day and you are wandering alone down your local high street where you often shop. You're in no hurry and are enjoying the walk. Suddenly there is a loud explosion. Looking down you see you are covered in a fine powder. The air around you smells and tastes slightly strange. But you feel fine. The people around you all seem to have stopped and are staying put. From the moment the explosion occurs how long would you be willing to wait for emergency responders to arrive before you leave the scene?

Question 1: From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Second stage of scenario (communication)

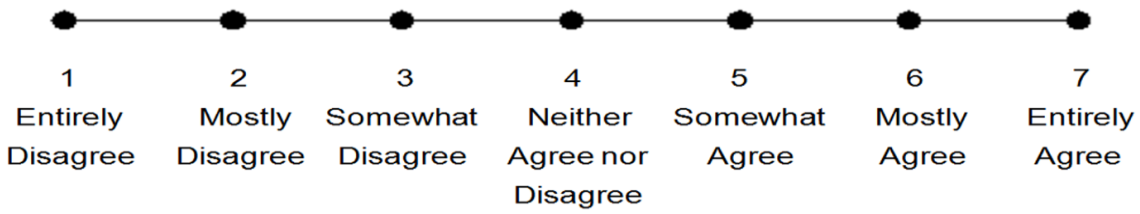
Emergency responders tell you, and others nearby, to follow them to an empty car park nearby. They then tell you to remove the top layer of your clothes, down to your underwear. They give you some blue roll and tell you to use it to wipe the powder off your skin. While you are wiping the powder off your skin, emergency responders say that they are going to need to set up a large shower system, to decontaminate you. From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

Question 2: From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Emergency responders tell you and the others affected to form a queue and wait to enter the large shower system. You are all told to remove your underwear and then enter the shower one by one. How would you rate the statement below? I would be willing to go through the decontamination shower

Question 3: How would you rate the statement below? I would be willing to go through the decontamination shower.



Question 4: Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Scenario 3: Worst case scenario, effective communication

First stage of scenario (general scenario)

On a cold, wet late evening, you are travelling with some close family members. As you are stood on the platform of an unfamiliar train station, an explosion occurs. Ears ringing, you look down to find that you and your family are covered in a fine powder. Quickly you feel your eyes start to sting and a cough rises in your throat. All around you, you can see your fellow passengers starting to suffer. Many are starting to head for the exits to leave the station. From the moment the explosion occurs how long would you be willing to wait for emergency responders to arrive before you leave the scene?

Question 1: From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Second stage of scenario (communication)

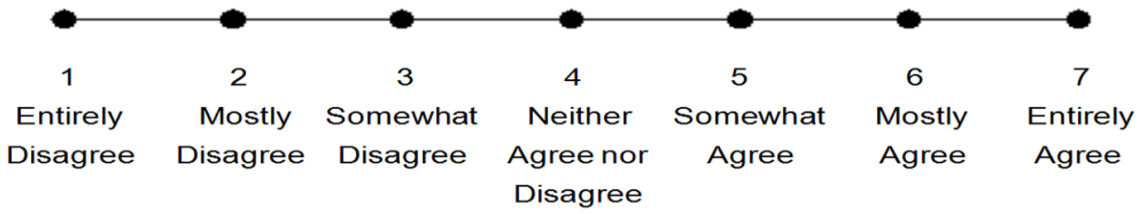
Emergency responders explain that you have potentially come into contact with a chemical, and to prevent further contamination, they ask you to follow them to a location outside the train station. They then ask you to remove the top layer of your clothes, down to your underwear. They explain that removing the top layer of your clothes will remove 80-90% of any contaminant which you may have come into contact with and will therefore help to protect you. They give you some blue roll and ask you to use it to wipe the powder off your skin. They explain that using the blue roll to wipe yourself down will remove any contaminant which may remain on your skin and will therefore help to reduce any risks from the contaminant. While you are wiping the powder off your skin, emergency responders begin to set up a large shower system, using hoses from their fire engines. Emergency responders explain that going through the shower will remove any contaminant which may remain on your skin. From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

Question 2: From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Emergency responders ask you and the others affected to form a queue and wait to enter the large shower system. You are all asked to remove your underwear, as this will help to ensure that all remaining contaminant is removed from your skin during the shower. People are asked to enter the shower one by one. How would you rate the statement below? I would be willing to go through the decontamination shower

Question 3: How would you rate the statement below? I would be willing to go through the decontamination shower.



Question 4: Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Scenario 4: Best case scenario, effective communication

First stage of scenario (general scenario)

It's 9am on a warm and dry summer day and you are wandering alone down your local high street where you often shop. You're in no hurry and are enjoying the walk. Suddenly there is a loud explosion. Looking down you see you are covered in a fine powder. The air around you smells and tastes slightly strange. But you feel fine. The people around you all seem to have stopped and are staying put. From the moment the explosion occurs how long would you be willing to wait for emergency responders to arrive before you leave the scene?

Question 1: From the moment the explosion occurs how long would you be willing to wait for emergency responders to take action before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Second stage of scenario (communication)

Emergency responders explain that you have potentially come into contact with a chemical, and to prevent further contamination, they ask you to follow them to an

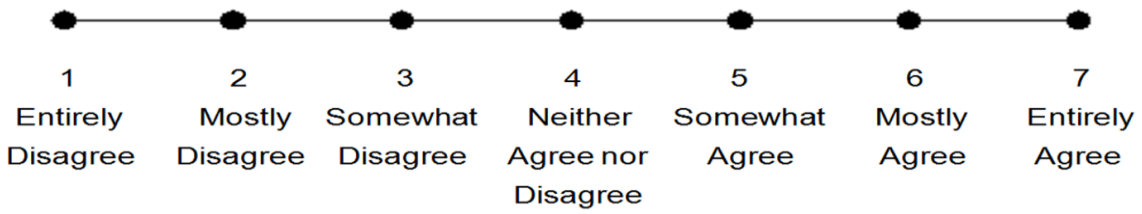
empty car park nearby.They then ask you to remove the top layer of your clothes, down to your underwear. They explain that removing the top layer of your clothes will remove 80-90% of any contaminant which you may have come into contact with, and will therefore help to protect you. They give you some blue roll and ask you to use it to wipe the powder off your skin. They explain that using the blue roll to wipe yourself down will remove any contaminant which may remain on your skin, and will therefore help to reduce any risks from the contaminant. While you are wiping the powder off your skin, emergency responders begin to set up a large shower system, using hoses from their fire engines. Emergency responders explain that going through the shower will remove any contaminant which may remain on your skin. From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

Question 2: From the time the first emergency responders arrive how long would you be willing to wait for emergency responders to begin decontaminating people before you leave the scene?

- *Scale starting from 0 in individual minute increases.*

Emergency responders ask you and the others affected to form a queue and wait to enter the large shower system. You are all asked to remove your underwear, as this will help to ensure that all remaining contaminant is removed from your skin during the shower. People are asked to enter the shower one by one. How would you rate the statement below? I would be willing to go through the decontamination shower

Question 3: How would you rate the statement below? I would be willing to go through the decontamination shower.

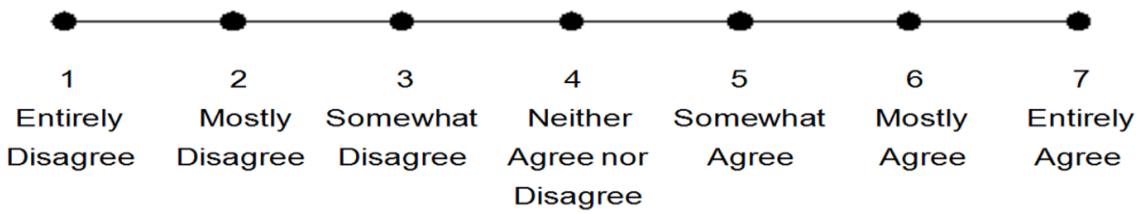


Question 4: Once decontamination has started, how long would you be willing to wait for your turn to go through the decontamination shower before you leave the scene?

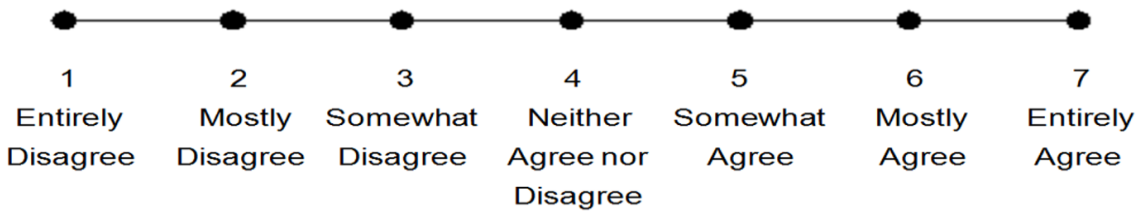
- *Scale starting from 0 in individual minute increases.*

Thank you for taking part in this visualization study. Below are further questions relating to how you found the visualization.

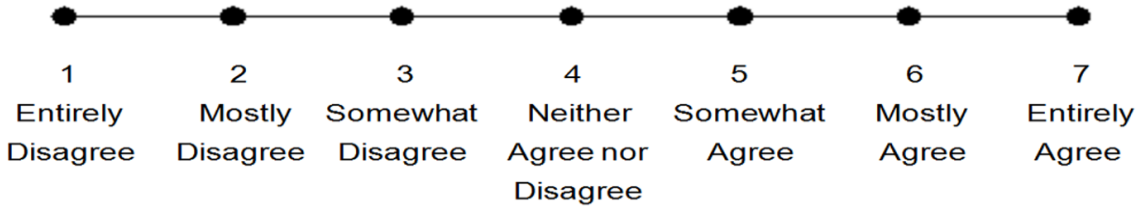
I imaged this event well.



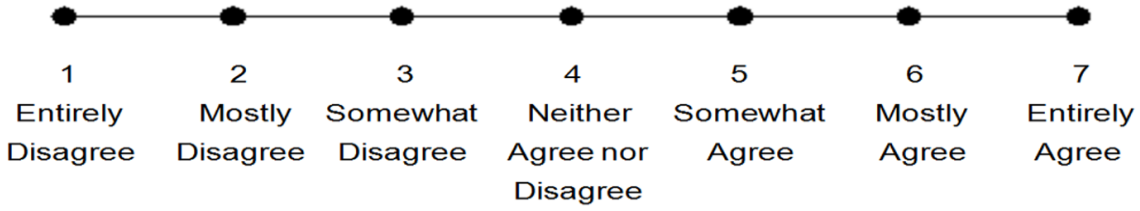
I felt emotionally engaged with the scenarios.



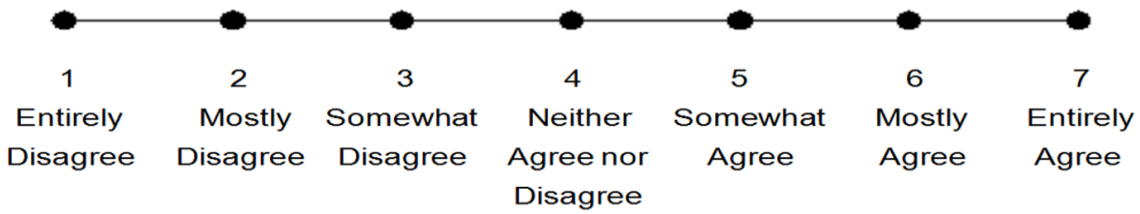
If this situation had been real, I think I would have understood what actions were expected of me during the decontamination process.



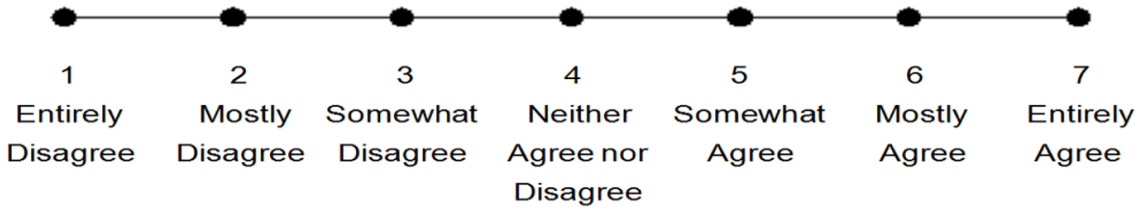
If this situation had been real, I think I would have had enough information to take appropriate actions.



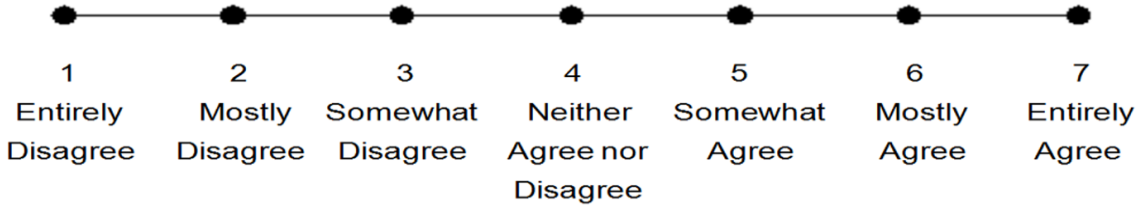
If this had been a real incident, I would have felt anxious.



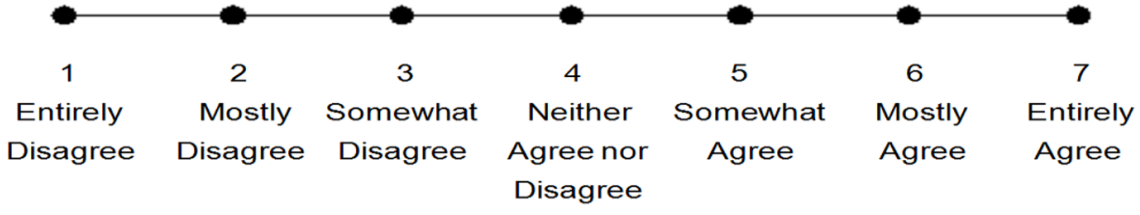
If this had been a real incident, I would have felt scared.



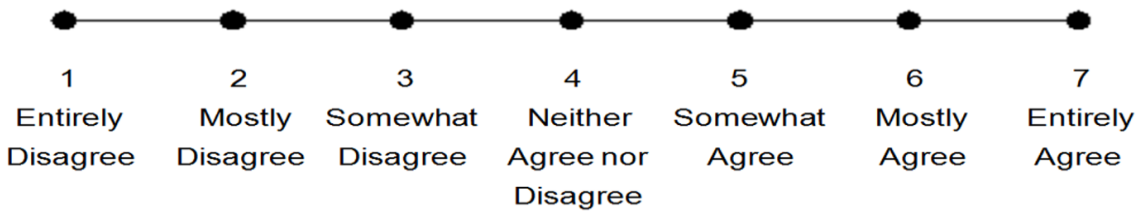
If this had been a real incident, I would have felt stressed.



I trust the emergency services.



I have confidence in the emergency services.



Appendix VIII – Demographic Differences: Stay in Place Compliance Times and Decontamination Willingness

- Age and Pre-Trust showed significant differences between 18-24 (Mean 5.68) and 45-54 (Mean 6.00) (p = .010).
- Age and Pre-Trust showed significant differences between 25-34 (Mean 5.60) and 45-54 (Mean 6.00) (p = <.001).
- Age and Pre-Trust showed significant differences between 25-34 (Mean 5.60) and 65+ (Mean 5.98) (p = .014).
- Age and Pre-Confidence showed significant differences between 25-34 (Mean 5.44) and 35-44 (Mean 5.76) (p = .028).
- Age and Pre-Confidence showed significant differences between 25-34 (Mean 5.44) and 45-54 (Mean 5.84) (p = .005).
- Age and Time Stamp 3 showed significant differences between 35-44 (Mean 91.33) and 55-64 (Mean 66.87) (p = .036).
- Age and Anxiety showed significant differences between 45-54 (Mean 6.58) and 65+ (Mean 6.29) (p = .027).
- Age and Post Trust showed significant differences between 18-24 (Mean 5.65) and 45-54 (Mean 6.02) (p = .005).

- Age and Post Trust showed significant differences between 25-34 (Mean 5.74) and 45-54 (Mean 6.02) (p = .034).
- Age and Post Confidence showed significant differences between 18-24 (Mean 5.60) and 45-54 (Mean 5.97) (p = .006).

- Age and Post Confidence showed significant differences between 25-34 (Mean 5.63) and 45-54 (Mean 5.97) (p = .009).

- Gender and Understanding CBRN Incidents showed significant differences between Male (3.65) and Female (3.11) (p = <.001).
- Gender and Understanding Mass Decontamination Incidents showed significant differences between Male (3.23) and Female (2.77) (p = <.001).
- Gender and Willingness to undergo Decontamination showed significant differences between Male (6.15) and Female (5.52) (p = <001).
- Gender and Time Stamp 3 showed significant differences between Male (87.24) and Female (73.21) (p = .049).
- Gender and Anxiety showed significant differences between Male (Mean 6.29) and Female (Mean 6.63) (p = <.001).
- Gender and Anxiety showed significant differences between Male (Mean 6.29) and Non-Binary (Mean 6.78) (p = <.022).

- Ethnicity and Pre-Trust showed significant differences between White British (5.94) and Mixed or Multiple Ethnic Groups (5.42) (p = .027).
- Ethnicity and Pre-Trust showed significant differences between White British (5.94) and Asian or Asian British (5.46) (p = .013).
- Ethnicity and Pre-Trust showed significant differences between White British (5.94) and Any Other Ethnic Group (5.30) (p = <.001).
- Ethnicity and Pre-Confidence showed significant differences between White British (5.79) and Asian or Asian British (5.37) (p = .038).

- Ethnicity and Pre-Confidence showed significant differences between White British (7.79) and Any Other Ethnic Group (5.11) (p = <.001).
- Ethnicity and Time Stamp 2 showed significant differences between White British (78.96) and Black African (40.67) (p = <.001).
- Ethnicity and Time Stamp 3 showed significant differences between White British (83.98) and Black African (30.13) (p = .010).
- Ethnicity and Time Stamp 3 showed significant differences between Black African (30.13) and Any Other Ethnic Group (73.16) (p = .017).
- Ethnicity and Communications showed significant differences between White British (Mean 5.76) and Any Other Ethnic Group (Mean 5.25) (p = .002).
- Ethnicity and Post Trust showed significant differences between White British (Mean 5.99) and Caribbean or Black British (Mean 5.00) (p = .037).
- Ethnicity and Post Trust showed significant differences between White British (Mean 5.99) and Any Other Ethnic Group (Mean 5.41) (p = <.001).
- Ethnicity and Post Confidence showed significant differences between White British (Mean 5.89) and Any Other Ethnic Group (Mean 5.39) (p = .008).

- Education and Pre-Trust showed significant differences between High School (5.94) and Undergraduate (5.76) (p = .015).

- Education and Pre-Confidence showed significant differences between High School (5.80) and Undergraduate (5.61) (p = .020) and between High School (5.80) and Postgraduate (5.58) (p = .041).
- Education and Engagement showed significant differences between High School (Mean 5.96) and Postgraduate (Mean 5.77) (p = .034).

- Education and Communications showed significant differences between High School (Mean 5.78) and Postgraduate (Mean 5.51) (p = .082).
- Education and Post-Trust showed significant differences between High School (Mean 6.02) and Undergraduate (Mean 5.82) (p = .002).
- Education and Post-Trust also showed significant differences between High School (Mean 6.02) and Postgraduate (Mean 5.76) (p = .003).
- Education and Post-Confidence showed significant differences between High School (Mean 5.95) and Undergraduate (Mean 5.72) (p = <.001).
- Education and Post-Confidence also showed significant differences between High School (Mean 5.95) and Postgraduate (Mean 5.69) (p = .007).

- Household Income and Willingness to undergo decontamination showed significant differences between Below 10k (5.10) and 20-30k (5.97) (p = .016).
- Household Income and Anxiety showed significant differences between 20-30k (Mean 6.35) and +100k (Mean 6.71) (p = .006).

Appendix IX – Mass Decontamination Recommendations

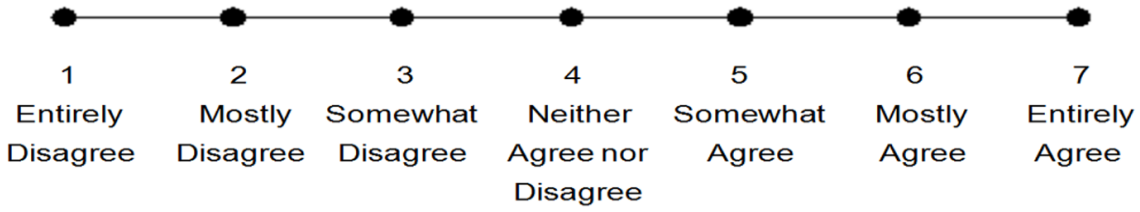
Expert Validation Survey

Recommendation 1 suggests the primary use of Interim Decontamination techniques.

How would you rate the following statements?

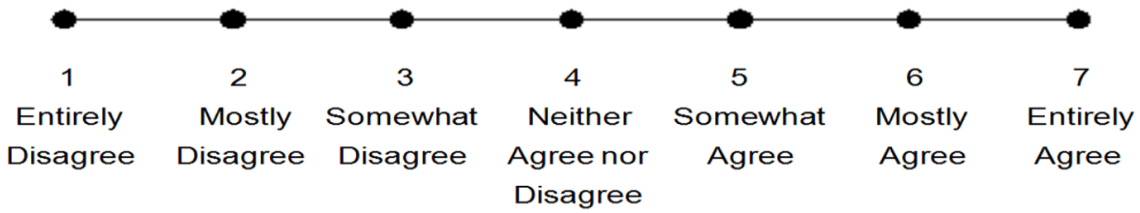
1 = Entirely Disagree
7 = Entirely Agree

1.) I feel this recommendation would be practical to implement.



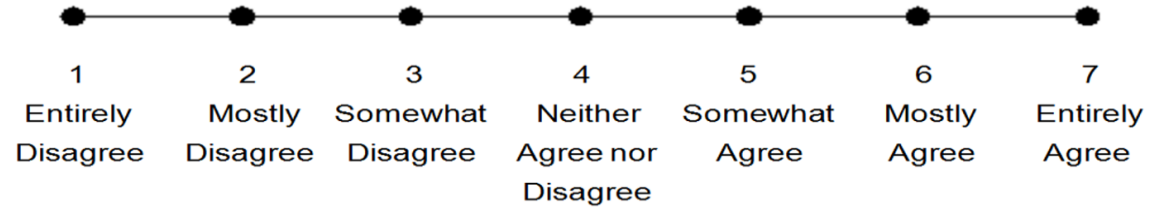
Comments:

2.) I feel this recommendation would assist effective decontamination operations.



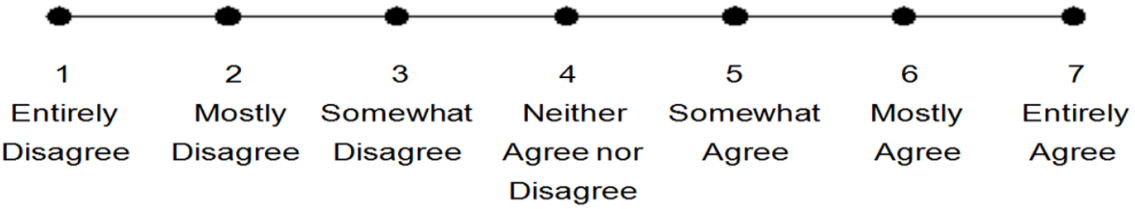
Comments:

3.) I feel this recommendation would improve the co-operation of members of the public requiring decontamination.



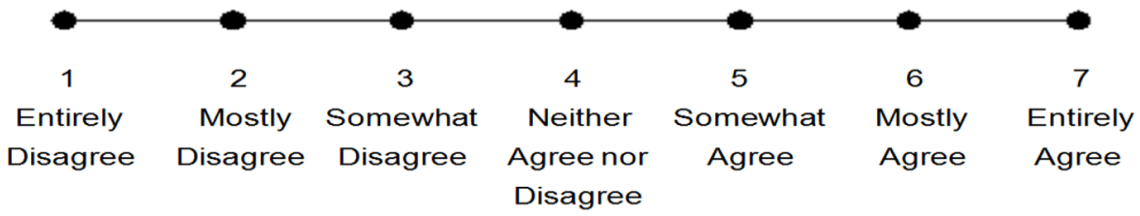
Comments:

4.) I feel this recommendation would improve the effectiveness of the overall response to a CBRN emergency.



Comments:

5.) I feel this recommendation would improve the willingness of members of the public to undergo decontamination.



Comments:

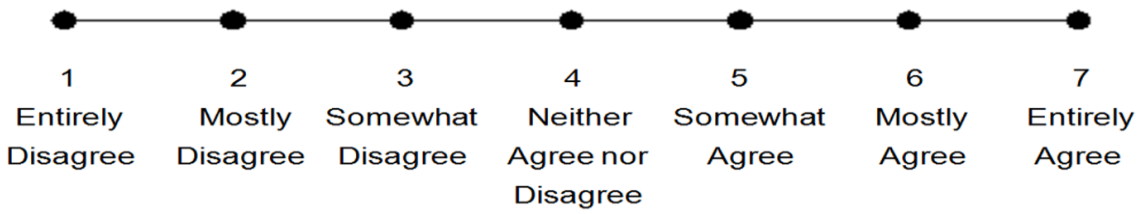
Additional Comments:

Recommendation 2 suggests the deployment of Mass Decontamination Units directly to Hospitals in the event of a Hazmat/CBRN incident.

How would you rate the following statements?

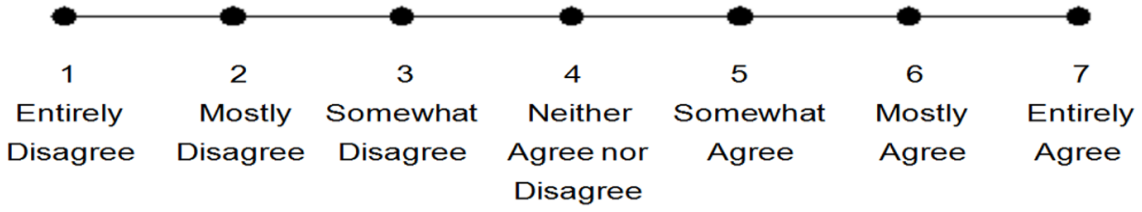
1 = Entirely Disagree
7 = Entirely Agree

1.) I feel this recommendation would be practical to implement.



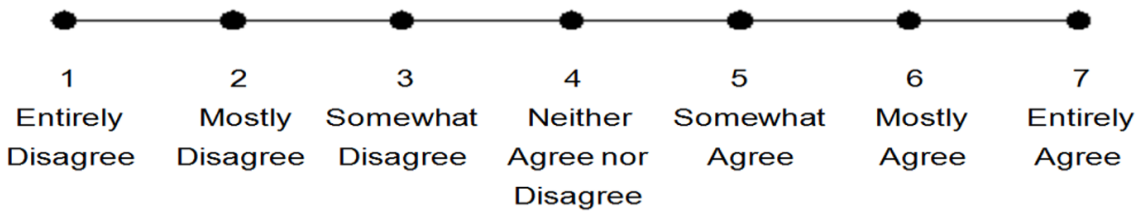
Comments:

2.) I feel this recommendation would assist effective decontamination operations.



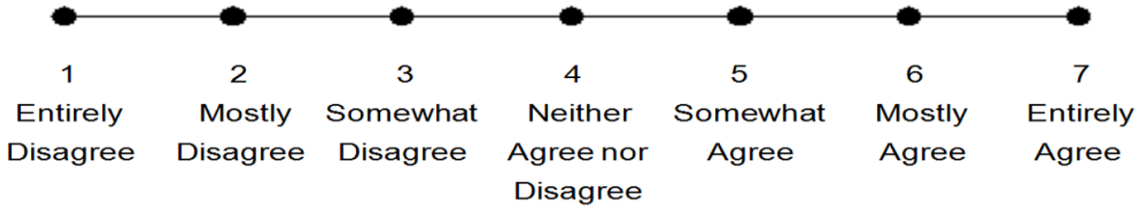
Comments:

3.) I feel this recommendation would improve the co-operation of members of the public requiring decontamination.



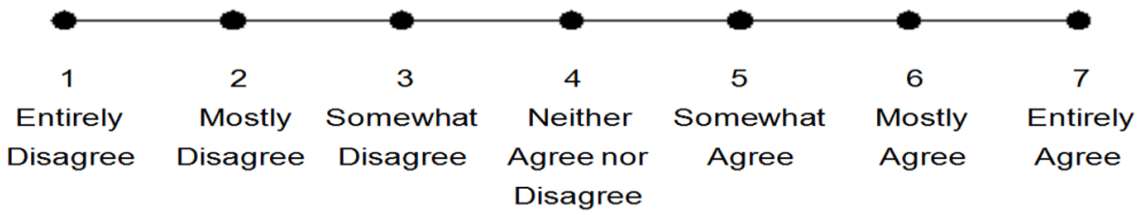
Comments:

4.) I feel this recommendation would improve the effectiveness of the overall response to a CBRN emergency.



Comments:

5.) I feel this recommendation would improve the willingness of members of the public to undergo decontamination.



Comments:

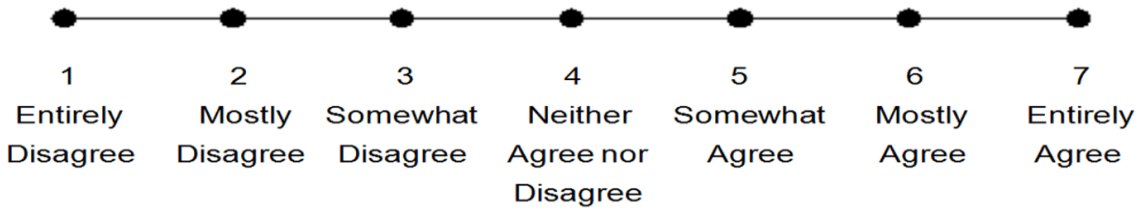
Additional Comments:

Recommendation 3 suggests the development of a mass decontamination model utilising the leaver rate identified by this Thesis.

How would you rate the following statements?

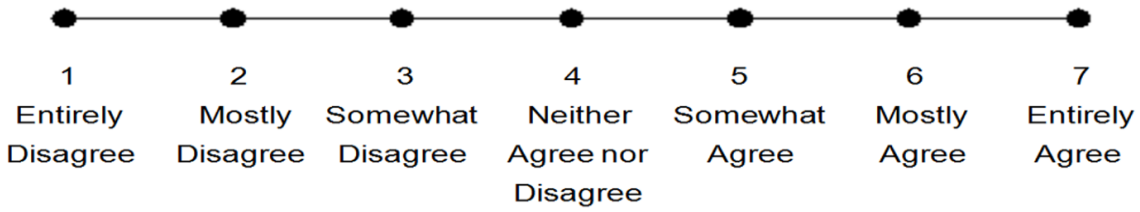
1 = Entirely Disagree
7 = Entirely Agree

1.) I feel this recommendation would be practical to implement.



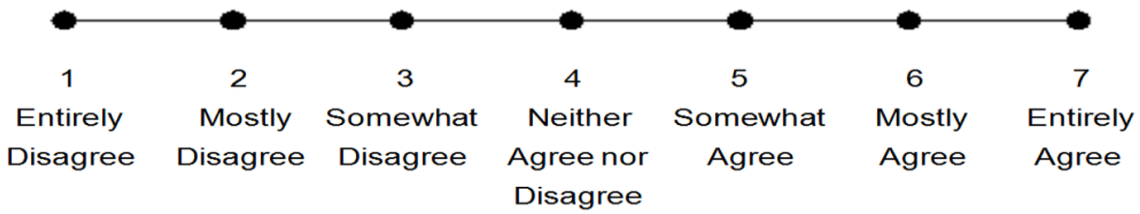
Comments:

2.) I feel this recommendation would assist effective decontamination operations.



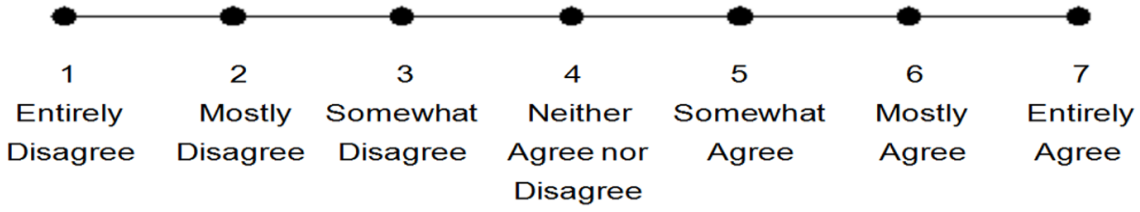
Comments:

3.) I feel this recommendation would improve the co-operation of members of the public requiring decontamination.



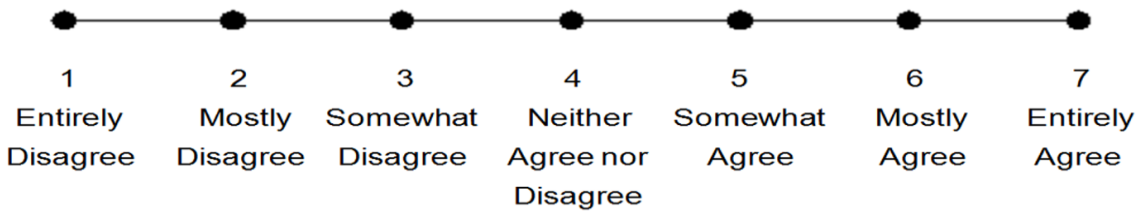
Comments:

4.) I feel this recommendation would improve the effectiveness of the overall response to a CBRN emergency.



Comments:

5.) I feel this recommendation would improve the willingness of members of the public to undergo decontamination.



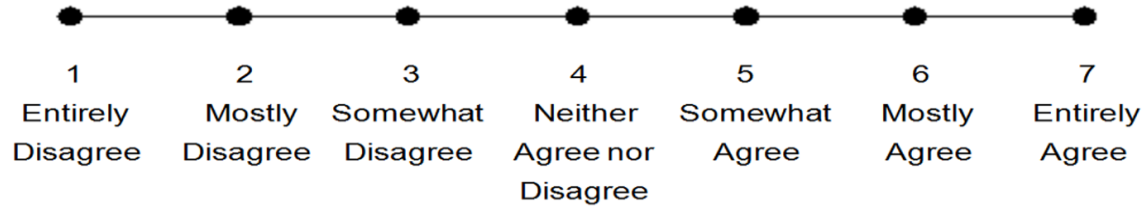
Additional Comments:

Recommendation 4 suggests development of strategies to increases the public's awareness of CBRN risk and Mass Decontamination capabilities.

How would you rate the following statements?

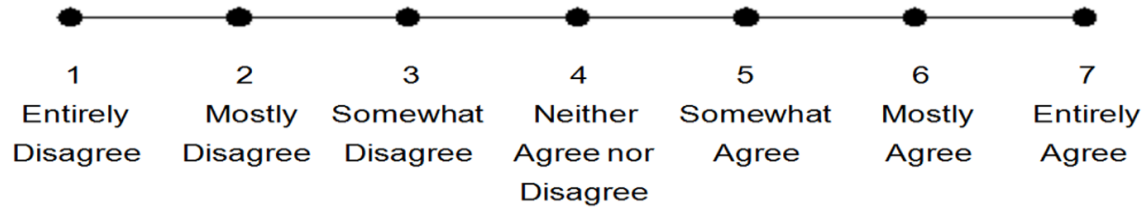
1 = Entirely Disagree
7 = Entirely Agree

1.) I feel this recommendation would be practical to implement.



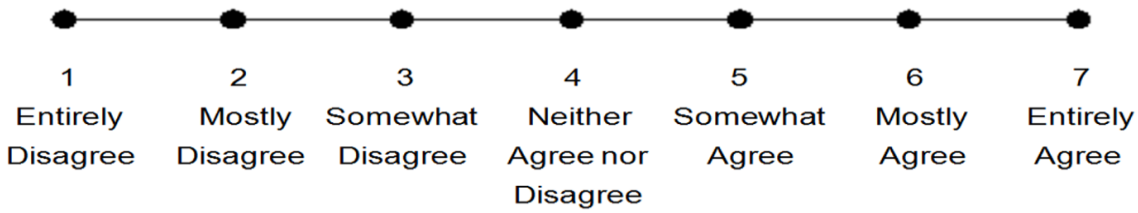
Comments:

2.) I feel this recommendation would assist effective decontamination operations.



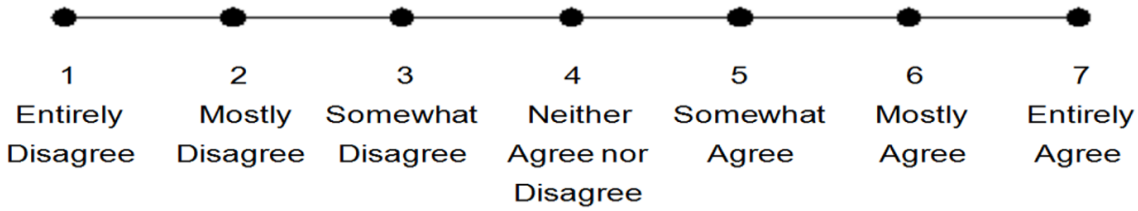
Comments:

3.) I feel this recommendation would improve the co-operation of members of the public requiring decontamination.



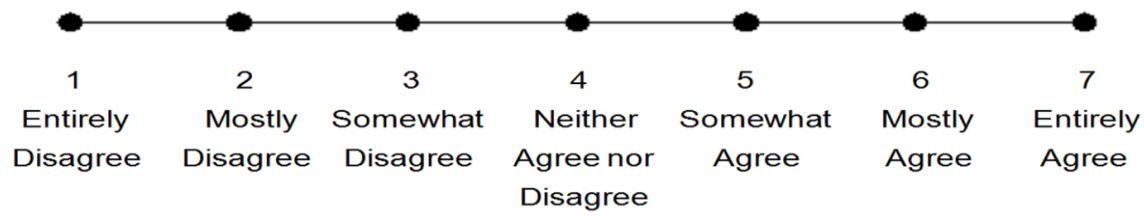
Comments:

4.) I feel this recommendation would improve the effectiveness of the overall response to a CBRN emergency.



Comments:

5.) I feel this recommendation would improve the willingness of members of the public to undergo decontamination.



Comments:

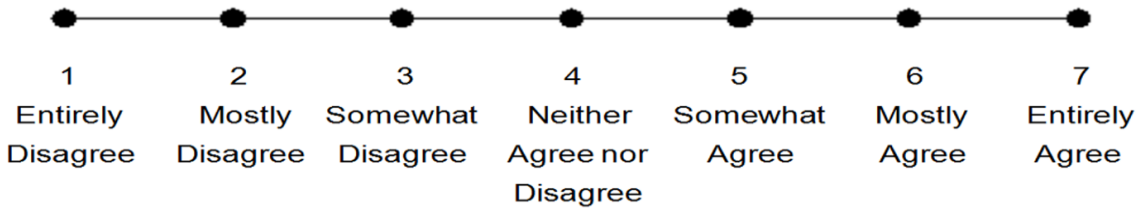
Additional Comments:

Recommendation 5 suggests developing training for all frontline responders on human behaviour and effective communications for Mass Decontamination operations.

How would you rate the following statements?

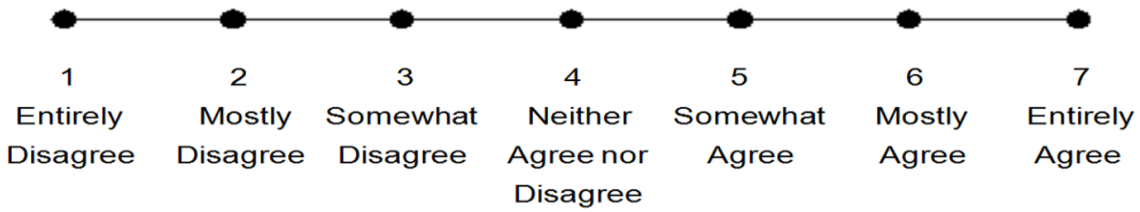
1 = Entirely Disagree
7 = Entirely Agree

1.) I feel this recommendation would be practical to implement.



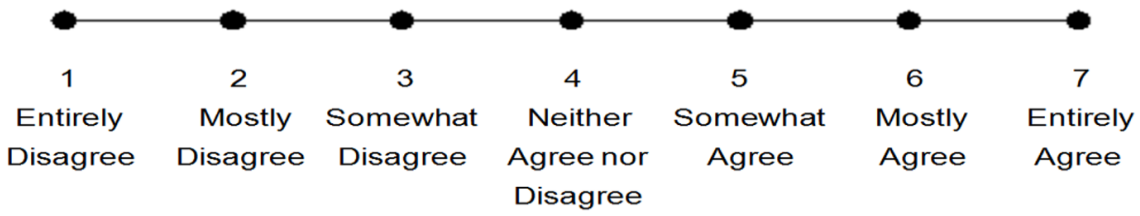
Comments:

2.) I feel this recommendation would assist effective decontamination operations.



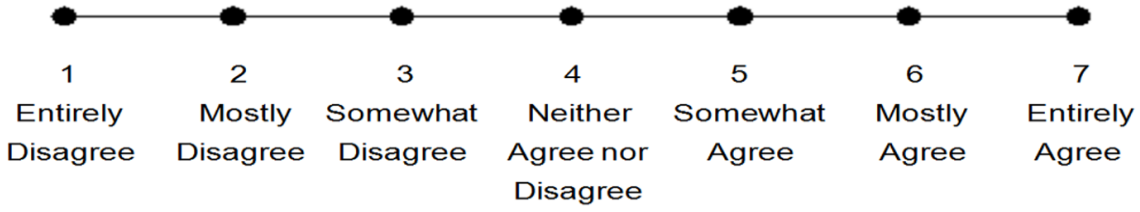
Comments:

3.) I feel this recommendation would improve the co-operation of members of the public requiring decontamination.



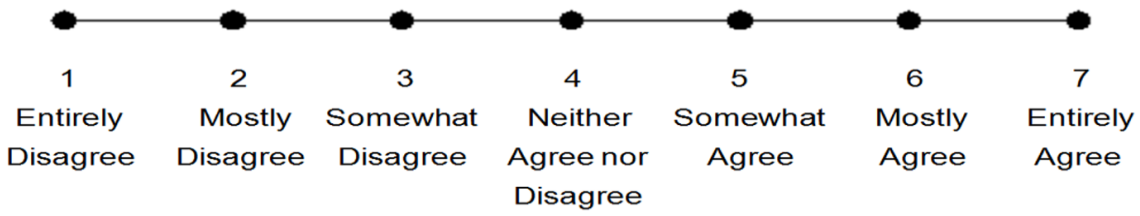
Comments:

4.) I feel this recommendation would improve the effectiveness of the overall response to a CBRN emergency.



Comments:

5.) I feel this recommendation would improving the willingness of members of the public to undergo decontamination.



Comments:

Additional Comments:

Appendix X – Mass Decontamination Recommendations Questionnaire: Informed Consent

Mass Decontamination Recommendations Questionnaire

Paricipant Information and Informed Consent

Invitation paragraph

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Take time to decide whether or not you wish to take part.

Purpose of the study

The study is looking to understand the validity of recommendations regarding mass decontamination preparedness and response put forward as part of a PhD thesis.

Why have I been chosen?

You have been asked to take part in this study due to the relationship of your role to mass decontamination in the UK.

Do I have to take part?

Taking part is entirely voluntary and you may refuse. You are also completely entitled to withdraw from the study at any time with no penalty or loss, now or in the future.

What do I have to do?

If you choose to take part, you will be asked read five recommendations relating to mass decontamination response and then to score twenty-five statements relating to your opinions on the provided recommendations on a scale of 1 – 7.

All that is expected of you is to give your opinion to the statements by selecting a number relating to that statement. The meaning of the numbers will be explained.

Will my taking part in this project be kept confidential?

No identifying details will be taken during this study meaning there will be no way for your participation to be traced and therefore everything you answer in the study will be confidential.

What will happen to the results of the research project?

The results of the research will inform a chapter of the lead researcher's PhD project.

Who is organising and funding the research?

The research is being organized by Imperial College London.

Contact for further information

For further information please contact –

Lead Researcher, Francis Long

Email: f.long16@imperial.ac.uk

Address: Skempton Building, Imperial College Rd, Kensington, London SW7 2BB

Consent Form for Participants Able to Give Consent

Full Title of Project: Mass Decontamination Recommendations Questionnaire

Name of Principal Investigator: Dr Arnab Majumdar

Please initial box

1. I confirm that I have read and understand the participant information sheet version 1.1dated 01/06/2023 for the above study and have had the opportunity to ask questions which have been answered fully.	
2. I understand that my participation is voluntary, and I am free to withdraw at any time, without giving any reason and without my legal rights being affected.	
3. I give consent for information collected about me to be used to support other research in the future, including those outside of the European Economic Area (EEA).	
4. I consent to take part in the above study.	

_____ _____ _____

Name of person taking consent (if different from Principal Investigator) Signature Date

_____ _____ _____

Principal Investigator Signature Date

Appendix XI – Mass Decontamination Recommendations

Expert Validation Survey Results

Recommendation 1 suggests the primary use of Interim Decontamination techniques.

Agency	Q.1	Q.2	Q.3	Q.4	Q.5
Fire and Rescue Service	7	7	7	7	7
Ambulance 1	7	7	7	7	7
Ambulance 2	6	6	7	7	7
Average	6.66	6.66	7	7	7

Recommendation 2 suggests the deployment of Mass Decontamination Units directly to Hospitals in the event of a Hazmat/CBRN incident.

Agency	Q.1	Q.2	Q.3	Q.4	Q.5
Fire and Rescue Service	7	7	6	7	6
Ambulance 1	6	6	6	6	6
Ambulance 2	7	7	5	7	5
Average	6.66	6.66	5.66	6.66	5.66

Recommendation 3 suggests the development of a mass decontamination model utilising the leaver rate identified by this Thesis.

Agency	Q.1	Q.2	Q.3	Q.4	Q.5
Fire and Rescue Service	6	7	7	7	6
Ambulance 1	6	6	6	6	6
Ambulance 2	5	6	6	6	4
Average	5.66	6.33	6.33	6.33	5.33

Recommendation 4 suggests development of strategies to increases the public's awareness of CBRN risk and Mass Decontamination capabilities.

Agency	Q.1	Q.2	Q.3	Q.4	Q.5
Fire and Rescue Service	7	7	7	7	7
Ambulance 1	7	7	7	7	7
Ambulance 2	6	6	6	6	6
Average	6.66	6.66	6.66	6.66	6.66

Recommendation 5 suggests developing training for all frontline responders on human behaviour and effective communications for Mass Decontamination operations.

Agency	Q.1	Q.2	Q.3	Q.4	Q.5
Fire and Rescue Service	7	7	7	7	7
Ambulance 1	7	7	7	7	7
Ambulance 2	6	7	5	6	6
Average	6.66	7	6.33	6.66	6.66