EXPOSURE WORRY: AN IN-DEPTH STUDY OF BRITISH NUCLEAR TEST VETERANS

A Thesis Submitted for the Degree of Doctor of Philosophy

By

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Abstract

There had been little research into the psychological impact of perceived ionising radiation exposure in British nuclear test veterans. The aim of this thesis was to examine the extent of exposure worry in British nuclear test veterans and the factors associated with exposure worry, and to explore the broader psychological impact of the British nuclear testing programme. Following scale piloting, the thesis comprised a multiple-methods design: a quantitative analysis of self-report and cognitive test data (n = 91) and a thematic analysis of interview data (n = 20). The quantitative findings indicated that, generally, British nuclear test veterans are more worried about possible health effects in their descendants compared to their own health: an observation which corroborated with the qualitative findings. While the quantitative findings showed that roughly half of the sample reported feeling stressed due to exposure worry, the qualitative findings suggested that worry was only relevant to a few participants and generally focused on their grandchildren's health. Furthermore, more pertinent psychological issues were present relating to a sense of guilt regarding genetic responsibility and anger towards authorities. The presence of clinically relevant anxiety (the prevalence appeared excessively high in the sample) and the extent one attributes their health condition(s) to ionising radiation exposure were significantly associated with exposure worry. The role of clinically relevant anxiety occurs in the absence of any mediating role of attributing a condition to ionising radiation (n = 55). Interestingly, factors such as the veterans' location, role, and national service status during the testing programme, socioeconomic factors, and cognitive functioning, were not associated with levels of exposure worry. The findings generated a comprehensive conceptual model illustrating the potential psychological impact of the British nuclear weapons testing programme. The thesis concludes with recommendations for transparency, narrative-based medicine, and a future line of inquiry exploring possible psychological issues in their descendants.

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List of Abbreviations

AGM	Annual General Meeting
AWRE	Atomic Weapons Research Establishment
BNTVA	British Nuclear Test Veterans Association
CHRC	Centre for Health Effects of Radiological and Chemical Agents
CI	Confidence Interval
DDT	Dichlorodiphenyltrichloroethane
GAI-SF	Geriatric Anxiety Inventory-Short Form
GHQ	General Health Questionnaire
IMD	Index of Multiple Deprivation
kt	Kiloton
LET	Linear energy transfer
MoCA	Montreal Cognitive Assessment
MoD	Ministry of Defence
MP	Member of Parliament
mSv	Millisievert
NCCF	Nuclear Community Charity Fund
PCA	Principal Components Analysis
PTSD	Post-Traumatic Stress Disorder
RAF	Royal Air Force
RCAS	Radiotherapy Categorical Anxiety Scale
RES	Reticuloendothelial system
RNZN	Royal New Zealand Navy
TMI	Three Mile Island
UK	United Kingdom
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
US	United States
WHO	World Health Organisation

Preface

"*CURSE OF THE A-BOMB: THE DAMNING DOSSIER: A GENETIC TIMEBOMB; VETERANS' GRANDCHILDREN SUFFER: CANCER, LEUKAEMIA, DEFORMITIES, MENTAL ILLNESS, DOWN'S SYNDROME, SKIN DISEASES*" (Rimmer, 2002).

Some 22,000 British veterans took part in the British nuclear testing programme during the 1950s and 1960s in Australia, Malden Island, Montebello Islands, and Christmas Island (Kiritimati) (G. M. Kendall et al., 2004). Some veterans witnessed nuclear weapons testing while others did not witness any tests, but nevertheless maintain that their health and the health of their family members had been adversely affected by ionising radiation exposure caused by the tests. The United Kingdom (UK) was not the only country involved in nuclear weapons tests: France and the United States (US) had their own testing programmes which spawned respective nuclear test veteran associations. Each nation's respective nuclear veterans association (e.g. British Nuclear Test Veterans Association; BNTVA) has the common campaign for recognition for the veterans' service and restitution for adverse physical and mental health consequences of participating in the nuclear testing programme.

It is thought that most veterans participating in the British nuclear testing programme were exposed to low doses[1](G. M. Kendall et al., 2004). Specifically, out of the available dose records, only 8% of the total cohort had a non-zero dose (G. M. Kendall et al., 2004). Of these non-zero recorded doses, only 828 individuals received a total dose of 1 millisievert (mSv) during the testing programme (G. M. Kendall et al., 2004). Moreover, only 81 individuals had a recorded dose of more than 50 mSv and a small number of these (37 individuals who were predominantly RAF personnel) were exposed to doses higher than 100 mSv[2] (G. M. Kendall et al., 2004), though accurate dose records cannot be verified. Nonetheless, even in low and moderate dose exposure contexts outside of nuclear weapons testing (Collins & de Carvalho, 1993; Danzer & Danzer, 2016; Kim et al., 2011; UNSCEAR, 2020), the psychological impact of perceived exposure to ionising radiation remains a pertinent issue regardless of any potential for actual adverse physical health effect.

[1] Description of dose ranges and basic information about ionising radiation and health effects are provided on page 30.

[2] Maximum dose recorded was 300 mSv (G. M. Kendall et al., 2004).

The emotionally laden headline above about a news article on British nuclear veterans from the Sunday Mirror (the Sunday sister paper of the Daily Mirror) captures the general understanding of ionising radiation exposure in the lay reader, where the predominant perception is its relation to genetic diseases and cancers. It is interesting to note the newspaper's inclusion of mental illness as a consequence of the British nuclear weapons testing programme. As described in more detail shortly, the claims of health effects from the nuclear test veteran community and from media outlets did not emerge immediately following the testing programme. Rather, the claims regarding health effects in themselves and in family members, along with epidemiological studies investigating the empirical evidence for such claims (specifically cancers), emerged during the 1980s.

While the potential physical health effect on nuclear test veterans has gained considerable interest, the psychological impact of perceived ionising radiation exposure, which generally relates to worry about potential adverse health effects in oneself and in one's family members, is relatively unexplored despite the overwhelming evidence for psychological effects in other radiological contexts (the evidence for this will be presented later). Not only this, but the psychological effects of perceived ionising radiation exposure is relatively unexamined in older adults (with the exception of Japanese atomic bomb survivor studies) and, more broadly, psychological issues relating to anxiety and worry are relatively less well understood in older men (Kiely et al., 2019; Schuurmans & Van Balkom, 2011). Therefore, this doctoral thesis makes a novel contribution by expanding our understanding of the psychological impact of ionising radiation in a unique and relatively unexamined population.

Despite this population being relatively unexplored with regards to mental health, there has been some indication from previous work (and the newspaper headline above) to suggest that the psychological effects of the nuclear testing programme are a pressing issue. Previous work with British nuclear test veterans such as the Miles and Green health needs audit which reported the prevalence of depression *and* anxiety (under the same measure) (Miles et al., 2011), and Alexis-Martin et al.'s (2019) ethnographic study which includes self-report data of anxiety (it is unclear whether this is an anxious state or clinically diagnosed anxiety) suggest that psychological issues such as anxiety (and worry) are a significant health concern in this population. Nonetheless, the limitations associated with these studies specifically regarding the psychological impact of perceived ionising radiation exposure warrant further in-depth psychological investigation. Thus, this doctoral thesis aims to investigate the psychological

impact of perceived ionising radiation exposure in British nuclear test veterans, with a particular focus on exposure worry, and to explore the broader psychological impact of the British nuclear testing programme.

To achieve this aim, this doctoral thesis comprises a multiple-methods research project: combining scale development work, qualitative semi-structured interviews, and quantitative analysis of survey and scale data. This research draws on the extant literature specific to the psychological impact of exposure in contexts such as atomic bomb survivor studies (Kamite et al., 2017; Lifton, 1963; Ohta et al., 2000), nuclear power plant accidents (Abbott et al., 2006; Bromet, 2014; Ginzburg, 1993), and more miscellaneous exposure scenarios of relatively small magnitude (Collins & de Carvalho, 1993; Semenova et al., 2019). Aside from radiation-related research, this thesis also draws on research and theory pertaining to emotions and psychological stress, ageing, and masculinities, to provide a comprehensive analysis of the data. The key output of this thesis is a conceptual model illustrating the potential psychological impact of perceived ionising radiation exposure (extending beyond exposure worry) relevant to the context of the British nuclear weapons testing programme.

This thesis comprises eight chapters:

Chapter 1 gives a detailed description of the history of British nuclear weapons testing in terms of when the tests were conducted, the later related epidemiological studies, and relevant legal cases, which all provide context to the present thesis.

Chapter 2, the literature review, briefly introduces the reader to a basic understanding of ionising radiation and a short overview of how radiation damage occurs, and the known deterministic and stochastic health effects associated with ionising radiation. The psychological impact of perceived ionising radiation exposure ('exposure worry'), which can occur at negligible doses (i.e. believing one has been exposed to ionising radiation), is then highlighted with reference to research conducted with populations exposed to various radiological events. In addition to highlighting the psychological impact of perceived ionising radiation exposure, the chapter describes relevant theory in the context of psychological stress and emotions such as anxiety.

Chapter 3 presents the key research questions to be addressed and a justification for the value of the project to the wider society. This chapter also briefly explains the structure and narrative of the subsequent chapters and highlights the paradigmatic position underpinning the research.

Chapter 4 describes the process of developing a quantitative scale aimed to measure exposure worry. Here, the scale development process consists of a single focus group study, a set of informal telephone discussions, and examining data obtained from piloting the proposed scale on a sample of 124 British nuclear test veterans.

Chapter 5 then uses this developed scale to measure exposure worry amongst a sample of 91 British nuclear test veteran and examines differences in responses between veterans categorized in terms of national service status, their role in the nuclear testing programme, and the location they were stationed. This chapter also discusses differences in worry responses regarding specific items on the scale and reflects on validity of scale items.

Chapter 6 presents a qualitative study concerned with in-depth exploration of the nature and dynamic of exposure worry over the life course in British nuclear test veterans. This qualitative interview study of 20 British nuclear test veterans was, naturally, a response to Chapter 5 and provides detailed insight into the phenomena of exposure worry. This exploratory study goes further and examines the veterans' beliefs regarding health risk and health conditions in themselves and family members. The study also explores the broader psychological impact of participating in the test programme. The findings of the study are illustrated in a conceptual model developed from the qualitative data and a sub-section of the chapter presents exemplars to demonstrate the model's workings.

Chapter 7 revisits the quantitative data collected in Chapter 5 and examines the relationships between exposure worry and variables such as clinically relevant anxiety, several proxy measures of socioeconomic status, and cognitive function. The analysis goes further and examines the role of believing one's physical health condition is caused by ionising radiation on exposure worry. Using bivariate correlation analyses and a path analysis, this analysis extends the conceptual model and provides further insight into the variables associated with exposure worry.

Chapter 8 presents an overall discussion uniting the insights obtained through the qualitative and quantitative analyses, and an evaluation and reflection of the methods used in their

respective chapters. Chapter 8 also reflects on the usefulness of the original cognitive functioning hypothesis considering the findings of this thesis. This chapter provides recommendations for how future work can follow-up on this thesis, before presenting a conclusion to the project.

The Inception of this Project

Before I continue, the reader needs to understand that not only is this thesis primarily concerned with the psychological impact of perceived exposure, namely 'exposure worry', but this thesis was a funded project - a Centre for Health Effects of Radiological and Chemical Agents studentship funded by the Nuclear Community Charity Fund (NCCF) and Brunel University London - originally intended to investigate the impact of exposure worry on cognitive functioning. Cognitive functioning refers to mental abilities such as learning, reasoning, problem solving, decision making, and attention (Fisher et al., 2019) which is vital for maintaining independent living (Jekel et al., 2015; Willis et al., 2006) and positive well-being in older adults (Llewellyn et al., 2008). Indeed, the effects on cognitive functioning in relation to low- and moderate-dose ionising radiation exposure have gained considerable interest (Pasqual et al., 2021), but little research accounts for any impact of the psychological stress of ionising radiation exposure on cognitive functioning (Collett et al., 2020)[3].

As outlined in a detailed review by Collett et al. (2020), the hypothesis that the psychological impact of perceived ionising radiation exposure affects cognitive functioning is grounded in the view that chronic psychological stress over time is a risk factor for impaired cognitive functioning and cognitive decline. Although findings have not always been consistent (de Bruijn et al., 2014), it is generally accepted that poorer cognitive functioning and accelerated cognitive decline in older adults is associated with greater levels of anxiety or stress (Aggarwal et al., 2014; Gulpers et al., 2019; Munoz et al., 2015; Sinoff & Werner, 2003), and self-reported worry symptoms (de Vito et al., 2019; Pietrzak et al., 2012). Anxiety may also be a risk factor for dementia incidence (Petkus et al., 2016) and progression in those with mild cognitive impairment (Li & Li, 2018). Curiously, recent neurobiological work utilising machine learning has observed that worry is associated with greater 'brain age' in later life (Karim et al., 2021).

[3] For a review on this hypothesis, see:
Collett, G., Craenen, K., Young, W., Gilhooly, M., & Anderson, R. M. (2020). The psychological consequences of (perceived) ionizing radiation exposure: a review on its role in radiation-induced cognitive dysfunction. *International Journal of Radiation Biology*, *96*(9), 1104-1118.

Given that cognitive functioning is an important aspect of healthy ageing (Fuchs et al., 2013) and has gained considerable attention in the context of low- and moderate-dose ionising radiation exposure scenarios (Pasqual et al., 2020, 2021), it is highly relevant to the British nuclear test veteran population. Thus, whilst this hypothesis was the primary instigator for this PhD thesis, how the focus evolved and changed is addressed in subsequent chapters.

Addressing this hypothesis was ambitious. Most studies examining the impact of psychological stress on cognitive functioning have large sample sizes and are longitudinal (see Aggarwal et al., 2014; Chen et al., 2019; Gulpers et al., 2019; Scott et al., 2015, as examples). Due to the time restraints of a PhD project and the declining numbers of this population due to their age, a robust research design was not possible, although this was not determined prior to the PhD project being initiated.

In addition to the soon-to-be-realised methodological constraints, there were conceptual realisations pertaining to the British nuclear test veteran population. In short, the presumption that British nuclear test veterans were worried (and thus psychologically stressed) to the extent that it may impact on cognitive functioning was misled by the research of populations in other radiological contexts. Therefore, the pursuit of unpicking the role of exposure worry in older adults' cognitive functioning took a different path, whereby an in-depth understanding of the psychological impact of perceived exposure and the broader psychological impact of the British nuclear testing programme became the focus.

This doctoral project was one of several projects carried out by the CHRC, directed by Dr Rhona Anderson at Brunel University London. The CHRC's general aim is to generate and integrate multidisciplinary research that is particular to the British nuclear test veteran community. Along with the genetic and cytogenetic research carried out by the CHRC (which will inform our understanding on the biological impact of the nuclear testing programme), there is a strand of social-scientific research examining and aiming to promote well-being within the nuclear veteran community. Taking a psychological approach to examine the psychological impact (with a focus on worry) of perceived ionising radiation exposure in British nuclear test veterans, this project falls under the social-scientific strand of the CHRC.

Chapter 1 – History of the British Nuclear Testing Programme and Background to the Thesis

Before presenting the extant literature regarding worry (and anxiety) in the context of (perceived) ionising radiation exposure, it is important to understand the context and the historical events leading up to and following the British nuclear testing programme. The project and its findings do not exist in isolation, but they are anchored by a long history of events and a unique context. That is, it is important to understand *who* was involved (inside and outside the nuclear testing programme), and *where* and *when* the events took place. These details help the reader understand why the research is conducted, how the cohort is unique, and how this context is distinct from (or similar to) other radiological contexts.

I begin by presenting a brief history of the British nuclear testing programme and demonstrate the societal significance of the testing programme by highlighting the subsequent published epidemiological research articles, media reports, and legal cases relevant to the testing programme.

Historical context of the nuclear tests

Following the atomic bombs dropped in Hiroshima and Nagasaki effectively ending the Second World War, many countries subsequently felt the need to develop and possess atomic weapons. A project to develop Britain's own nuclear programme was initiated in 1945 by an ad hoc committee of Cabinet ministers, called the GEN.75. The GEN.75 was set up by Prime Minister Clement Attlee to act as a forum for decision-making on nuclear energy policy. The GEN.75 then evolved into the GEN.163 committee in January 1947 which then decided to proceed with the development of nuclear weapons. The GEN.163 only met once with a sole purpose to decide to produce an atomic bomb and, following this decision, the GEN.163 disbanded (Baylis & Stoddart, 2012).

The programme began with *Operation Hurricane* in October 1952, conducting a 25 kiloton (kt) atomic test in the lagoon at the Montebello Islands, Western Australia. This involved detonating a plutonium implosion device aboard the HMS *Plym* to simulate the effects of an atomic bomb in a harbour (G. M. Kendall et al., 2004). This was followed by *Operation Totem* which took place in October 1953 at Emu Field. This consisted of two tower-mounted atmospheric atomic tests of 10 kt and 8 kt yields. The programme was then halted until

returning to the Montebello Islands to conduct *Operation Mosaic* in May and June 1956, which were two tower-mounted tests of 15 kt and 60 kt yields. Two major tests series, *Operation Buffalo* and *Operation Antler*, were also carried out at the Maralinga site in South Australia and consisted of a total of seven nuclear tests. The first test of these two series began in September 1956 and the last took place October 1957.

The nuclear testing programme also extended to tests conducted outside of Australia, with *Operation Grapple* consisting of four series of hydrogen bomb and atomic bomb tests taking place off Malden Island and Christmas Island in the Pacific Ocean. A total of nine shots occurred, six of which were hydrogen bomb tests. All were high altitude airbursts, except two which were balloon suspended detonations. The *Grapple* test series began in May 1957 and ended in September 1958. In addition to this, four series of minor trials involving over 600 tests experimenting with different bomb components were conducted in Maralinga and Emu Field between September 1953 and May 1963.

During the closure of Maralinga site, a clean-up operation (*Operation Brumby*) was conducted in 1967 to dilute and bury contamination and was overseen by the UK Ministry of Defence. Following campaigns in Australia by indigenous groups, investigative journalists, and the Australian Nuclear Veterans Association, the Australian Labour government (led by Bob Hawke) initiated an inquiry into the British testing chaired by Jim McClelland. This was known as the Royal Commission into British Nuclear Tests in Australia, which was established in 1984 and delivered in 1985, which gave considerable attention to the contamination status of Maralinga and Emu Field. The report concluded that significant radiation hazards remained at Maralinga and that a further clean-up funded by the British government must be conducted. It also concluded that the safety precautions at the test-sites were inadequate and negligent (Maclellan, 2017).

Thus, the programme spanned almost two decades (including decontamination operations in Maralinga) and many veterans were late teenagers or in early adulthood at the time of the programme. It is reported that some 22,000 men participated in the British nuclear testing programme and clean-up operations (Darby et al., 1988; G. M. Kendall et al., 2004), but it is estimated that ~7000 were alive as of 2021 (R. M. Anderson, personal communication, June, 2021). Many of the veterans witnessed a profound event which, for some, was a significant event in their lives. But it was not the event itself (i.e. witnessing detonation) which was central to the veterans' health concerns. Rather, the perceived exposure to ionising radiation emitted

from nuclear weapon detonations was central to their concerns and this led to media reports, academic research, and legal cases concerned with the potential physical health impact on the veterans.

Subsequent academic research

Since the testing programme, there have been suggestions from research studies (Busby & de Messieres, 2014; Knox et al., 1983a, 1983b; Roff, 1999) and the British nuclear test veterans themselves that their health and quality of life have suffered because of the tests. Attention to the potential physical health impact of the tests did not emerge until the 1980s, when in December 1982, a BBC television programme (*Nationwide)* broadcasted a story on the servicemen who participated in the test programme in the South Pacific. This gained considerable interest and led to the formation of the BNTVA in 1983 to campaign for the recognition and restitution of servicemen who participated in the nuclear testing programme.

On the 9th April 1983, a letter to *The Lancet* (Knox et al., 1983a) described evidence to suggest an abnormally high rate of mortality due to reticuloendothelial system (RES) tumours (e.g. leukaemia) compared to what is normally expected. A letter on the same page (Boag et al., 1983) also noted the unusually high occurrence of cataract reported by Knox et al. (1983a) which would otherwise be unheard of occurring spontaneously in young men, suggesting this was caused by exposure to doses of ionising radiation exceeding levels considered safe. This letter also urged that an independent academic body be set up to conduct a study examining the mortality and cancer incidence in the test veterans. The letter sent by Knox et al. (1983a) has been criticised in that it was heavily dependent on estimates by the Ministry of Defence (MoD) on how many test veterans participated at Christmas Island (G. M. Kendall et al., 2004). Knox and colleagues made estimates on the incidence of cancers based on the accounts that veterans' sent to *Nationwide* (G. M. Kendall et al., 2004). Later that year, a second letter to *The Lancet* by Knox and colleagues (Knox et al., 1983b) was published reporting that there was no longer an excess of reported RES tumours compared to what is normally expected, subsequent to the MoD revising their estimations of the number of Christmas Island test veterans (G. M. Kendall et al., 2004). It was maintained, however, that there was a significantly higher incidence of RES tumours in those younger than 30 at the time of the tests compared to what would be normally expected.

Later that year, the UK government responded to the veterans' call for justice by commissioning the National Radiological Protection Board to undertake an epidemiological study which was published in 1988 (Darby et al., 1988). Darby and colleagues (1988) examined the mortality and cancer incidence of leukaemia, multiple myeloma (cancer of plasma cells) and cancers affecting different areas of the body in 22,347 nuclear test veterans identified from the MoD archives, and compared the results with 22,326 servicemen who served in tropical areas during the testing programme but did not participate in the tests. The controls were matched on age, rank, type of service, and date of entry to the study. Darby et al. (1988) concluded that participation in the nuclear testing programme had no significant increase in mortality rate or total risk of developing cancer, but there appeared to be a slightly elevated risk of mortality from leukaemia and multiple myeloma in nuclear veterans compared to what is normally expected based on national mortality rates.

Studies of nuclear test veterans have also been conducted in other countries. Shortly after the study by Darby et al. (1988), the New Zealand MoD commissioned a smaller-scale study examining the mortality and morbidity of New Zealand veterans who participated in the British programme (Pearce et al., 1990), in response to a growing public concern that the health of the Royal New Zealand Navy (RNZN) personnel had been adversely affected by ionising radiation exposure. Pearce et al. (1990) compared the mortality and cancer incidence in 528 RNZN personnel who were involved in *Operation Grapple*, with a control group of 1,504 RNZN personnel serving in the same period but not involved in *Operation Grapple* or the nuclear programme, generally. Similar to the findings of Darby et al. (1988), the New Zealand study did not report a significant increase in overall mortality from cancer or mortality from other causes in test participants, nor did it report a significant increase in overall cancer incidence in test participants compared to controls. However, there was indeed a significantly higher leukaemia mortality rate in test participants compared to controls. The findings of Darby et al. (1988) were extended to a 7-year follow-up with a second analysis, published in 1993 (Darby et al., 1993). Like the first analysis, the second analysis did not reveal significantly different mortality rates (from broad causes and all cancers) in test veterans compared to controls. It was also observed that, during the 7-year follow-up period, leukaemia and myeloma mortality was slightly (non-significantly) lower in test veterans compared to controls (Darby et al., 1993). The findings of Pearce et al. (1990) were also extended in a follow-up to 1992 which indicated that the increased risk of leukaemia had receded, despite one extra hematologic cancer death (no extra cases in controls) and one extra incidence of hematologic cancer in the test

participants (two extra cases in controls), resulting in no change in relative risk for incidence (Pearce et al., 1997).

The findings of the UK epidemiological studies were not positively received by the British test veteran population, who subsequently raised funds for a study to be conducted in the late 1990s, commissioned by Susan Roff (Roff, 1999, 2002). In 1999, Roff published a paper exploring the morbidity and mortality of the test veterans based solely on self-reported questionnaire data from 1041 British test veterans, as well as capturing the conditions of the test veteran children and grandchildren. The findings of Roff's (1999) self-report data reported 40 cases of cancer and 5 cases of cataracts in 2,261 children, which appears exceedingly high. Despite this, the lack of a control population diminishes the utility of the data, and issues of selection bias arise given that the data is gained solely from BNTVA members which may not represent the whole test veteran population.

The self-report data of Roff (1999) also appeared to show a large incidence of myeloma cases in the test veterans, which prompted the MoD to reopen the epidemiological study, thus Muirhead et al. (2003) extended the follow-up to a further eight years, with the cohort being almost identical to the second analysis. It was reported that the overall levels of mortality and cancer incidence were not statistically significant between the test veteran group and the control group. There appeared to be an increased risk of leukaemia in test veterans compared to controls, but this difference appeared to become smaller with increasing follow-up. Muirhead and colleagues (2003) acknowledged that this finding was difficult to interpret giving that leukaemia risk in controls was lower than that of the general population. The overall rates of mortality were significantly lower in both groups compared with national rates, and the cancer risk after grouping for all cancers was significantly lower for both groups compared to national rates up until 1990, before becoming similar until 1998. These findings are likely to represent the 'healthy worker'[4] effect given that the control group were other servicemen stationed elsewhere at the time of the tests. Overall, the UK epidemiological studies did not provide compelling evidence to suggest that test participation resulted in an increased risk of cancer incidence, but the potential for a small increase in leukaemia incidence cannot be excluded (Muirhead et al., 2004).

[4] A bias marked by a deficit in mortality and morbidity in certain populations of occupations such as the military.

These epidemiological findings have prompted biological assay studies. In New Zealand, Rowland et al. (2007; Wahab et al., 2008) conducted a controlled genetic study, involving three assays on 50 New Zealand naval nuclear test veterans and 50 male age-matched controls who had undergone military or police training in the past. The purpose of this was to examine if the test veterans had incurred long-term genetic damage resulting from participating in *Operation Grapple*. Regarding the first two assays, Rowland et al. (2007) reported that there was no significant difference between test veterans and controls in terms of radiosensitivity, indicating that DNA repair mechanisms are no more deficient in either cohort. The third assay, however, using the multiplex fluorescence in situ hybridization technique (mFISH), showed that test veterans displayed significantly more chromosomal translocations compared to the control group, suggesting that test veterans incurred chromosomal breakage due to ionising radiation exposure received during *Operation Grapple*.

Subsequently, the findings of Rowland et al. (2007) sparked renewed debate in the UK, and following pressure from the BNTVA and MP John Baron, the MoD commissioned a health needs audit to be carried out by an independent research group (Miles et al., 2011) aiming to identify the health experiences and needs of the test veterans (Maclellan, 2017). The audit gathered data based on postal-questionnaires from 633 BNTVA members and eight discussion groups involving 84 BNTVA members. The questionnaire data asked questions relating to the veterans' health, based on International Classification of Diseases (ICD-10) categories. Only 9% of respondents reported having no diagnosed serious or long-term illness since the nuclear tests, and 91% of respondents reported, between them, a total of 2801 separate conditions since the nuclear tests. The questionnaire included the EuroQol Five Dimensions of Health measure to assess quality of life. Among 585 respondents, 57% reported some problems on at least one of the five dimensions, and 19% reported some problems or severe problems on all five dimensions. In terms of future generations, 29% of the 633 respondents believed that there was a link between participating in the nuclear tests and their descendants' ill health, while 42% said 'maybe' or said they didn't know (Miles et al., 2011).

While not all veterans were in ill health, and although not all who were in ill health or who had descendants in ill health believed that the nuclear testing was responsible for their ill health, the health needs audit suggests that the test veteran community has concerns that they have been adversely affected by participating in the testing programme (Miles et al., 2011). The participants, however, are all BNTVA members suggesting that the audit may not be

representative of the whole British nuclear test veteran population. Moreover, while the audit is a useful descriptor of the BNTVA community's current health concerns, it is difficult to establish whether or not the test veteran cohort have a higher incidence of disease/lower quality of life compared to the general population because there is no comparable data available. Finally, the self-reporting of diagnosed conditions may not accurately capture the health of the test veterans because no verification of health records was conducted in the audit.

There is also more recent self-report research conducted to examine health effects in British nuclear test veterans. Busby and de Messieres (2014), part-funded by the BNTVA, conducted a postal questionnaire case-control study examining miscarriage in wives and congenital conditions in the offspring of BNTVA test veterans. Based on 605 veteran children and 749 grandchildren compared with 311 control children and 408 control grandchildren (controls selected by veterans), the findings report a significantly greater number of miscarriages in veterans' wives compared to controls, and a significantly greater number of congenital defects in veteran children compared to control children. The findings suggest that participation in the British nuclear testing programme increased the risk of genetic illness in the children and grandchildren. Selection bias may be an issue with Busby and de Messieres (2014) study, but the authors reject this on the grounds that veterans would have been unlikely to select themselves into the study based on the number of miscarriages that their wives experienced. Furthermore, there may be a potential conflict of interest because the research was part-funded by the BNTVA. To validate the reported findings of Busby and de Messieres (2014), biological studies are required which aim to examine whether veterans and their children display significantly more chromosomal aberrations than controls. A number of projects are currently being carried out to examine this by the CHRC at Brunel University London.

Overall, the epidemiological research attention (and the later self-report social research studies) spawned by campaigns by nuclear veteran groups demonstrates that a substantial number of nuclear veterans were convinced that their physical health had been adversely affected. However, the epidemiological and biological evidence provides no conclusions suggesting that their physical health had been affected or that they have been exposed to potentially dangerous doses of ionising radiation, respectively. Nevertheless, alongside these studies are the numerous legal cases beginning in the 1990s demonstrating the nuclear community's conviction that certain nuclear veterans had been adversely affected by ionising radiation exposure.

Subsequent legal cases

To demonstrate the significance of the testing programme to this population, I briefly present the numerous legal cases from this context. The importance of this is that it highlights the nuclear veteran communities' general conviction that some individual's physical and mental health has been adversely affected by participating in the programme, despite the availability of epidemiological evidence relevant to their circumstance (though this generally relates specifically to cancer incidence and mortality).

One of the first claims against the British government, launched by Ken McGinley and Ken Egan in 1997, was lodged before the European Court of Human Rights but was unsuccessful (Maclelland, 2017). Elsewhere, the self-governing British crown dependency, the Isle of Man, approved the motion to compensate eight veterans who had participated in the British testing programme an *ex-gratia* payment of £8,000 each (Isle of Man Government, 2008).This payment was approved in view of the physical health effects in British nuclear test veterans remaining disputed, but notably the mental health impact of the testing programme was considered. The report from the Director of Public Health, found in the aforementioned legal report appendices, concluded that while there is no concrete evidence for physical illnesses common in nuclear test veterans, the mental distress could not be ignored and should be addressed urgently.

Elsewhere, due to several unsuccessful cases from individual groups, a collective High Court case involving 1011 veterans and civilians from British military services, Fiji, and New Zealand began on the 21st January 2009 and was heard over three weeks (Maclelland, 2017). The case considered the Ministry of Defence's contention that the claimants were unable to pursue their claims because they are deemed invalid, based on the Limitation Act 1980 (i.e. such claims were made more than three years after the alleged radiation-injuries were received). The case cited evidence of Rowland et al. (2008) and invited a number of academics from the field of radiobiology to give their views. The MoD accepted that a small number of cases, particularly those working as pilots during the programme, had been exposed to acute high dose radiation because of their proximity to the mushroom cloud (Maclelland, 2017). In June 2009, Judge Foskett decided to exercise his discretion and 'disapply' the time limit barring the case. The claimants had to choose 10 cases out of the 1011, which were subsequently ruled to proceed to full trial and regarded as a victory for the claimant group. The MoD appealed against the ruling and on 19th November 2010 the Court of Appeal overruled Judge Foskett's

decision. The Court of Appeal judged that nine out of the 10 cases were too difficult to prove causative because they were presented more than 50 years after the testing programme. The following year, on 28th July 2011 the UK Supreme Court agreed to consider an appeal against the Court of Appeal's decision from the nine unsuccessful claimants, which subsequently overturned the Court of Appeals ruling. On 14th March 2012 in the Supreme Court, the MoD legal team won the verdict by a 4:3 majority, overturning the initial 2009 Foskett ruling. This subsequently led to the government stating that the MoD had no plans to give compensation in response to common law claims (Maclelland, 2017).

On the whole, the epidemiological evidence and court case rulings conclude that there is no definitive evidence the physical health of British nuclear test veterans being adversely affected by ionising radiation exposure. In spite of that, the self-report data demonstrates that a substantial number of the nuclear veteran community perceive their physical health and quality of life to have been adversely affected (Busby & de Messieres, 2014; Miles et al., 2011; Roff, 1999). Therefore, whether or not physical health is directly affected by ionising radiation exposure, what appears more striking is the perceived impact and the ongoing struggle against the MoD to demonstrate that their physical health has been adversely affected. Importantly, this inevitably leads one to consider the psychological impact of perceived exposure in this veteran group, particularly given the wealth of psychological literature exploring this in other contexts (presented in the following chapter). Indeed, this consideration for the psychological impact is supported by the Manx court ruling for the broad impact on the veterans, *including* the mental health effects (Isle of Man Government, 2008).

Chapter 2 – A Review of the Extant Literature Regarding the Psychological Impact of Ionising Radiation Exposure

Now that the history and context of the British nuclear testing programme has been covered, as well as the subsequent academic and legal inquiries which followed, it is important for the reader to understand the existing research demonstrating the psychological impact of perceived ionising radiation exposure in populations elsewhere. Following a basic introduction of ionising radiation, this chapter presents an argument for why *worry*, specifically, is particularly relevant to the context of perceived ionising radiation exposure, a review of extant literature demonstrating the psychological impact of ionising radiation exposure, and an overview of key relevant psychological theories of emotion and psychological stress (not limited to the radiation context).

In this thesis, the term psychological impact refers to any emotional state or thought process (i.e. a cognition[5]) which is considered unpleasant to experience in response to perceived ionising radiation exposure. Negative emotional states (e.g. anger, fear) or thought processes (e.g. worry, rumination) may lead to the experience of emotional and/or psychological strain if they exceed one's ability to cope, otherwise known as 'psychological stress' (Lazarus, 1993). A central feature of the psychological impact of perceived exposure appears to be the worry about potential future adverse health effects in the exposed or in their descendants (Bromet, 2011; Fukasawa et al., 2017; Lifton, 1963). This is primarily due to the inherent uncertainty relating to perceived ionising radiation exposure (Danzer & Danzer, 2016; Vyner, 1988).

In the radiation literature, a variety of terms (similar to 'worry' in the lay-person) to describe the psychological impact have been used, such as 'radiophobia' (Pastel, 2002; Ropeik, 2016), 'radiation-anxiety' (Fukasawa et al., 2017), and 'radiation-PTSD' (Loganovsky & Zdanevich, 2013). This latter term, radiation-PTSD, is most relevant to emergency clean-up workers finding themselves in highly traumatic circumstances (Loganovsky & Zdanevich, 2013). Regarding the 'fear' (radiophobia) and 'anxiety' (radiation-anxiety[6]) terms, this thesis regards

[5] To avoid confusion, it is important to note the distinction between 'cognition' and 'cognitive functioning'. The former refers to thought processes or mental processes such as 'worry', while the latter refers to our mental abilities required for knowledge, manipulation of information, and reasoning (e.g. memory, processing speed, executive function).

[6] Fukasawa et al. (2017) define radiation-anxiety as a negative cognition regarding the potential adverse health effects of radiation exposure, as well as the related psychosocial problems such as perceived stigma relating to

'worry' as the correct term because 'fear' is generally not temporally-correct[7] in the radiation-related context (LeDoux & Pine, 2016), and 'anxiety' is a multifaceted emotional term including somatic and behavioural symptoms in addition to the central cognitive component that is 'worry' (Mathews, 1990).

Drawing on the inherent uncertainty of radiological exposure scenarios, this chapter briefly describes the theory and function of worry and highlights why it is an appropriate response to perceived ionising radiation exposure. I then review the extant literature exploring the psychological impact of ionising radiation in contexts such as atomic bomb survivor studies, US nuclear test veteran studies, nuclear power plant accidents, and more miscellaneous radiation exposure scenarios. Indeed, the review[8] is not limited to worry because various terms have been used ('fear' vs. 'worry'), and different outcome variables are often used in quantitative work (for example, measuring anxiety symptoms, degree of psychological stress, or biomarkers of psychological stress). Following the review of the literature, I then present key theories relevant to psychological stress and emotional responses in the context of risk and adversity which help us understand the psychological (and emotional) outcomes following perceived ionising radiation exposure.

Before proceeding with this review, I first provide a basic introduction to ionising radiation and a brief overview of the possible physical health impact of ionising radiation exposure. This will provide the reader with an objective indicator of the health risk of ionising radiation exposure in this context and begin to show how the psychological reactions to perceived ionising radiation exposure is not necessarily in accordance with the dose received.

Ionising radiation

Ionising radiation refers to photons (X-ray and gamma) and particles (alpha, beta, electrons, protons, and neutrons) with sufficient energy to remove bound electrons from an atom's orbit, resulting in the atom becoming ionized (Hallenbeck, 1994). Ionising radiation can cause

radiation exposure. While this term is labelled as an 'anxiety', the fact that it is defined as a cognition (or thought process) means that it is indeed a 'worry'.

[7] Fear is temporally imminent while anxiety (and worry) is temporally distance, in comparison (Ledoux and Pine, 2016).

[8] This review chapter resulted in published article:
Collett, G., Craenen, K., Young, W., Gilhooly, M., & Anderson, R. M. (2020). The psychological consequences of (perceived) ionizing radiation exposure: a review on its role in radiation-induced cognitive dysfunction. *International Journal of Radiation Biology*, *96*(9), 1104-1118.

cellular damage both directly and indirectly. Direct damage refers to when the ionising radiation track directly interacts with a DNA molecule and causes structural change, resulting in cell damage or cell death. Indirect damage refers to radiation hitting water molecules in the cell, producing free radicals (unpaired electrons) which can react with a DNA molecule resulting in structural damage (Desouky et al., 2015). About 30% of DNA damage is directly induced following low-linear energy transfer (LET) radiation (e.g. gamma, X-ray), while about 70% of DNA damage is directly induced following high-LET radiation (e.g. alpha particles; (Nikjoo et al., 1999).

Generally, there are several main factors which need to be considered when determining the potential damage of ionising radiation to human tissue. The type or quality of radiation and the amount (dose) of energy of radiation absorbed usually expressed in Gray (Gy) needs to be acknowledged, as well as the activity (rate of decay measured in becquerels; Bq), the dose-rate, and the mode of exposure (internal or external). Internal exposure is regarded as the most dangerous and occurs when the radiation source is inside an organism, usually through inhalation (e.g. inhalation of naturally occurring radon gas: an alpha particle emitter) or ingestion of contaminated foodstuffs. External exposure occurs when the source is located outside the organism and usually refers to gamma or X-ray radiation passing through the body (Delacroix et al., 2002). It should be noted that radiation can be natural and be produced through technological means. All living organisms are continually exposed to ionising radiation, both terrestrial (Earth and the atmosphere) and cosmic radiation, which amounts to an average exposure from natural sources of 2.4mSv per year, according to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000).

The damage that ionising radiation can cause to human tissue can be divided into two categories: deterministic and stochastic effects (UNSCEAR, 2020). Deterministic effects describe damage caused only when a threshold of radiation dose has been reached, and the severity of the damage increases as the dose increases, thus deterministic effects are primarily associated with high-dose ionising radiation exposure (> 1000 mSv) normally delivered over a short period of time. Deterministic health effects are caused by significant cell death thereby impacting on the function of tissue or organ. Cataracts, erythema, and acute radiation syndrome are all examples of deterministic effects. Stochastic effects include cancer and heredity effects whereby increasing dose increases the risk but not severity of the effect (UNSCEAR, 2020). Generally, doses lower than 100 mSv are regarded as low-dose exposure (Pradhan, 2013). It is

generally considered that stochastic effects have no threshold but that the effects are linear, meaning the risk of an effect increases as dose increases (Little et al., 2009), but where it is not possible to distinguish by observation or testing whether the disease of a specific patient has been caused by the radiation exposure (UNSCEAR, 2020). In other words, such stochastic effects generally appear in large epidemiological studies. The main stochastic effect of low-dose ionising radiation exposure is cancer.

While the levels of risk for health effects vary with dose and radiation-type, most people tend to overestimate the risks of ionising radiation, especially outside of the medical context (Slovic, 2012). This difference in risk is particularly notable when comparing perceptions of naturally occurring ionising radiation to perceptions of technological ionising radiation (Slovic, 2012). It is worth highlighting the presumed perceptions of risk in the veterans at the time of the weapons tests. It has been argued that, at the time, there was extensive knowledge regarding health risks obtained from Japanese atomic bomb studies and the work of British physicists and biologists which was transmitted to British politicians and officials (Maclellan, 2017). While only a minority (8%) of veterans during the tests received a non-zero dose, of which only 828 individuals received a total dose of 1 mSv (G. M. Kendall et al., 2004) (occupational dose limits in 1956 were 3 mSv per week vs. 20 mSv per year today; Maclellan, 2017), Maclellan (2017) argues that the politicians made efforts to keep potential health risks secret from the public. Indeed UK prime minister at the time, Harold Macmillan, told the House of Commons that any present and foreseeable hazards are considered negligible (Maclellan, 2017). Therefore, regardless of whether there were health risks, the British nuclear test veterans were told (and as indicated through anecdotal discussions with the veterans) very limited details regarding the potential health risks in themselves or family members. The potential for lack of trust in authorities, lack of transparency, and perceived injustice is posited to amplify perceived risk (Kasperson, 2012; Kasperson et al., 1988). As such, aside from the possible biological or physical health effects of ionising radiation, the psychological impact (relating to unjust risks) of believing one has been exposed to ionising radiation could be a critical issue in the British nuclear test veteran population (the moral aspects of risk will be discussed later in this thesis). The relevant literature and theory regarding the psychological impact (with a focus on worry) will now be examined.

Psychological effects of perceived ionising radiation exposure

Without dosimetry, ionising radiation is inherently invisible in the sense that an individual cannot touch, see, or smell it. Therefore, it can be considered an invisible contaminant (Vyner, 1988). The Plague or Black Death (*Plaguerella pestis*) during the 14th century is perhaps one of the earliest examples of invisible contaminants (Vyner, 1988). It was both environmentally invisible in that humans could not detect it and, at the time, it was medicinally invisible in that medieval scientists did not know that the bacterium causing it existed. Other pandemics such as the Spanish Flu of 1918 also occurred before the advent of psychological science, thus there is a lack of literature on the anxieties surrounding invisible contamination in this regard (Nelson et al., 2020; Taylor, 2019), while more recent pandemics (e.g. Covid-19) have been marked by widespread psychological impact consisting of anxieties of catching the contaminant itself (McElroy et al., 2020) and the impact of protective lockdown measures (Fancourt et al., 2021).

With all invisible contaminants, it is the uncertainty which appears to be a key component in the aetiology of radiation-related psychological stress, usually in the form of worry or anxiety (Abbott et al., 2006; Danzer & Danzer, 2016; Vyner, 1988). Danzer and Danzer (2016) posit two sources of uncertainty which may put an individual in distress regarding possible radiation exposure. Firstly, and as mentioned previously, the radiation dose received is difficult for the individual to understand because radiation is invisible, tasteless, and odourless. Due to dose levels being unascertainable to the general public without dosimetry, those exposed to subclinical doses could interpret government counter-protective measures (e.g. evacuation) as a signal for serious harm from ionising radiation exposure. A notable example is the increased screening which led to the detection of thyroid cancer in children following Fukushima being erroneously attributed to radiation exposure, despite effective thyroid doses in children being well below 100 mSv (Tokonami et al., 2012; Yamashita et al., 2018). Secondly, Danzer and Danzer (2016) suggest that the invisible nature of radiation and limited information regarding the health consequences can make it difficult to ascertain whether and when the health consequences will be realised. I can go further and argue that, to some extent, there is scientific uncertainty regarding the health effects of ionising radiation exposure, particularly at low doses or if chronic over time. For example, radiation-biologist Dr. Ian Fairlie (Fairlie, 2021) quickly asserted his criticisms regarding the latest UNSCEAR (2020) report which concluded that the increased detection of thyroid cancers in children was not due to inhalation of radioisotopes. I

argue that the ongoing scientific debates contribute to the uncertain nature of perceived ionising radiation exposure.

Uncertainties may also extend beyond those mentioned by Danzer and Danzer (2016). In his book *Invisible Trauma,* Vyner (1988, p. 31) lists 13 types of uncertainty associated with radiation and other toxic exposures, pertaining mainly to nuclear accidents but which can be applied to other exposure contexts (see Table 1).

Thus, there are multiple levels of uncertainty which may be more relevant to one exposure context than another (e.g. evacuation uncertainty and financial uncertainty are especially relevant to nuclear power plant accidents, but perhaps not relevant in medical exposure contexts). Radiation exposure scenarios are, therefore, inherently uncertain. To understand why these scenarios lend themselves to eliciting worry in individuals, it is important to examine how worry is conceptualised and the relevance to uncertainty.

Table 1.

Vyner's (1988) list of uncertainties relevant to ionising radiation exposure

Type of uncertainty	Description
Previous exposure	Uncertainty as to whether one has been exposed to an invisible contaminant in the past.
Present exposure	Uncertainty as to whether one is currently absorbing an invisible contaminant.
Evacuation	Uncertainty as to whether one should leave the geographical area in which an invisible contaminant is occurring.
Boundary	Uncertainty relating to the geographical limits of a dangerous invisible exposure.
Dose	Uncertainty about the level of radiation one has been exposed to.
Significance-of-dose	Uncertainty as to whether such a known dose eventually results in a disease.
Latency	Uncertainty as to when a resultant disease becomes realised.
Etiological	Uncertainty as to whether a current illness has been caused by previous exposure.
Diagnostic	Uncertainty about diagnosis of somatic symptoms following exposure.

Prognostic	Uncertainty about one's future health after they realise they have been affected by previous exposure.
Treatment	Uncertainty about how the somatic symptoms can be treated medically.
Coping	Uncertainty about how to adapt to exposure.
Financial	Uncertainty regarding who is responsible for financial losses resulting from exposure.

Worry

The term *worry* refers to a chain of negatively-valenced thoughts regarding events that might happen in the future (Borkovec et al., 1998). It is distinct from 'anxiety' which encompasses both somatic (e.g. palpitations, shortness of breath), behavioural (e.g. avoidance) and cognitive (e.g. worry; Mathews, 1990; Zebb & Beck, 1998). Experientially, worry can be best described as verbo-linguistic thought, but it also includes imagery (Sibrava & Borkovec, 2008). The function of worry is, broadly speaking, to anticipate possible threat.

Descriptions of worry tend to include a future orientation in their definitions, in contrast to rumination which tends to focus on past events[9] (Papageorgiou, 2006; Watkins et al., 2005). Lay-persons may describe being worried about an event which happened in the past, but the worry is pertaining to possible future consequences of that past event. While worry can be pathological in the sense that it is a cardinal feature of generalized anxiety disorder (American Psychiatric Association, 2013), it must be stressed that it is a normal cognitive/thought process (Papageorgiou, 2006).

By examining the way worry is conceptualised, we can speculate why worry in the context of ionising radiation exposure may be persistent. Tallis and Eysenck (1994) posit that worry is a mental problem-solving mechanism that, similar to other definitions, enables the individual to prepare for an uncertain future outcome that contains one or more possible negative consequences. In the context of perceived ionising radiation exposure, the uncertain outcomes can extend beyond their own health. For example, if an individual, who perceives themselves to have been exposed to ionising radiation, is towards the end of life then the future is not regarded as uncertain and worry about their own health might be reduced. On the other hand,

[9] Worry and rumination are closely related and fall under the broad term 'repetitive thought' (Watkins, 2008).

their descendant's future remains uncertain, and this worry may then be focused on the descendant.

This position is generally supported by quantitative data in both unexposed and (potentially) exposed cohorts. For example, older adults (65 to 85 years) report significantly higher likelihood of worrying about the health and welfare of loved ones, despite a lower likelihood of worrying about interpersonal relations, health, and work, compared with younger adults (18 to 29 years; Gonçalves & Byrne, 2013). Regarding worry content in the context of ionising radiation exposure, Suzuki et al. (2015) report that adults aged at least 50-years old were more concerned about the effects of radiation exposure on their future generations, while those of reproductive age (15 - 49) were more concerned about the delayed effects on themselves. This is consistent with the presumed trend that parents and grandparents (who are generally older) are more concerned about adverse effects on their progeny, compared to young adults.

To summarise, uncertainty plays a central role in the psychological impact (worry) of ionising radiation exposure, and while there are age-related declines in worry about one's own health[10], radiation-related worry may persist due to its relevance to family members' health.

Literature demonstrating the psychological impact of perceived exposure

To demonstrate the significance of the psychological impact of perceived ionising radiation exposure, it is important to examine the available literature from various nuclear incidents. As suggested by Barnett (2007), the mental health consequences of ionising radiation exposure observed in one individual can be difficult to generalise because different people react to stress in different ways. Indeed, some individuals tend to embrace uncertainty, while others exhibit an intolerance of uncertainty which would elicit greater levels of worry (Koerner & Dugas, 2006). Not only this, but there are varying levels of risk involved between individuals which must be considered when examining such psychological effects. While it is generally regarded that clean-up workers (or 'liquidators') and mothers of young children are particularly vulnerable to the psychological consequences of IR exposure in the context of nuclear power plant accidents (Bromet, 2014), it is evident that many other individuals can be affected psychologically and in different radiation contexts.

[10] This is important to consider in the context of the British nuclear test veteran population because they are all older adults.

I begin by presenting literature in chronological order, firstly regarding individuals who survived the nuclear bombs dropped on Japanese cities of Hiroshima and Nagasaki. I then briefly present literature on armed forces personnel who participated in the British and American nuclear testing programme, before presenting research conducted in the context of nuclear power plant accidents and other radiation exposures.

Japanese atomic bomb survivors.

The atomic bombings of Hiroshima and Nagasaki in Japan, which effectively ended the Second World War, have gained considerable research attention in the light of both cancer and non-cancer effects across the lifespan of the survivors (Little, 2009). Such events were also the first time in history that populations have been adversely affected by ionising radiation produced by technology. The psychological impact of experiencing the atomic bomb events is significant and has been documented for decades (for a historical in-depth overview of Japanese atomic bomb studies, see Kamite et al., 2017). Prominent early work in this field is that of Lifton (1963) who interviewed Hiroshima survivors and illustrated the 'fear' of acute radiation effects in themselves and, perhaps more relevant to test veteran population, the fear of transmitting adverse health effects to subsequent generations. Thus, despite using the term 'fear' (Lifton, 1963) possibly due to earlier understandings of how 'worry' and 'fear' are conceptualised, this focus on the adverse health effect in themselves and in family members appears central to the psychological impact.

More recent qualitative work has been conducted with Hiroshima and Nagasaki survivors. For example, Sawada et al. (2004) interviewed eight survivors and observed several themes which focused on the experience itself and life thereafter. Importantly, one theme emphasised the worry about health effects particularly in their children and other family members, and the uncertainty as to whether a particular condition in a descendant was caused by ionising radiation exposure. Similar ethnographic observations have been found in survivors who emigrated to the US, especially in those who may not be psychologically resilient to the event (Knowles, 2011).

Quantitative work has also examined the psychological effects in atomic bomb survivors. For example, in a total sample of 9,421, an elevated prevalence of anxiety symptoms in individuals residing within either Hiroshima or Nagasaki at the time of detonation compared to those living outside of the cities has been observed (Yamada & Izumi, 2002). Furthermore, Ohta et al.

(2000) observed that overall psychological stress (measured by the General Health Questionnaire; GHQ-30) was greater in Nagasaki atomic bomb survivors compared to controls who did not experience the atomic bomb event. Interestingly, the anxiety factor score of the GHQ-30 was greater in controls compared to atomic bomb survivors suggesting that the psychological distress in the survivors appeared to be rather related to disrupted social ties and daily living. Despite this unexpected difference in anxiety scores, the 'suspected link between atomic bomb exposure and health problems' variable significantly predicted GHQ-30 score, further highlighting the central role of perceived health effects in the psychological impact. Moreover, in an aged cohort that had lived in the vicinity of the atomic bomb explosion in uncontaminated suburbs in Nagasaki, poorer mental health correlated with anxiety about the radiological hazard was observed (Kim et al., 2011), indicating that the psychological effects can persist over a lifetime even in relatively unaffected areas, radiologically-speaking.

Due to the general public's worry about being contaminated by ionising radiation or other chemical agents, residents of affected areas might be subject to stigma and discrimination (S. M. Becker, 1997; Sawada et al., 2004). This may also contribute to psychological stress (Ben-Ezra et al., 2015) but may not be relevant to the nuclear test veteran context. Overall, it is evident that the psychological impact of witnessing the atomic bombs in Hiroshima and Nagasaki was considerable, primarily characterized by health anxieties in themselves and descendants.

Military veterans and nuclear weapons testing.

There were two further instances of technological ionising radiation exposure shortly following the atomic bomb events in Japan, occurring in the Chelyabinsk regions of Russia. The first occurring as early as 1949 (actively dumping radioactive waste into the Techa river), and the second in 1957 was an explosion which added to the contamination in the Techa river (Collins, 1992). Despite some research examining the potential biological effects, there is very little research regarding the psychological impact of these events (Collins, 1992).

Occurring at a similar time point to these incidents, but starkly contrasted in terms of context, is that of the nuclear testing programmes. As described in the preceding chapters, following the atomic bomb events in the Second World War, the Cold War soon followed characterised partly by the nuclear arms race which involved nuclear weapons testing by the major powers, including the US, Russia (then Soviet Union), the UK, and France (Maclellan, 2017). This

weapons testing occurred in various locations and proliferated from the early 1950s. The participants of the nuclear weapons testing were potentially exposed to 'above-background' levels of ionising radiation and are called nuclear test veterans (or atomic veterans in the US) which are the focus of this research project.

One of the earliest studies documenting the psychological effects of radiation exposure is a case study of 11 US test veterans (Vyner, 1983). According to Vyner (1983), the ultimate psychological effects of radiation exposure were a change in identity, worldview, and lifestyle reportedly resulting in a lack of employment and loss of social relationships. These identity conflicts may be a unique contributor to a veteran's stress throughout life (Vyner, 1983). For example, Vyner noted one test veteran who describes the contradiction between being patriotic and being deceived by the US government, which may also apply to British nuclear test veterans. In addition to feeling that the government is concealing information, further distress may arise from this contradiction.

Another qualitative study (Murphy et al., 1990) reported several themes addressing the concerns raised by seven US test veterans. Two themes, in particular, describe the anxieties relating to the health effects of radiation exposure on themselves, and on their descendants. More recently, an online survey study examining self-reported health outcomes in New Zealand nuclear test veterans found that, out of the 83 veteran respondents, the mean self-reported prevalence of depression and anxiety (assessed by the GHQ-12) was greater than the mean of the Australian and New Zealand general population (Dockerty et al., 2020). The authors suggest that this may partly be due to worry about ionising radiation exposure, although higher rates of psychological distress tend to be found in veteran populations (Dockerty et al., 2020).

Apart from these studies in US and New Zealand nuclear veterans (Dockerty et al., 2020; Murphy et al., 1990; Vyner, 1983), and although there is some literature examining the sociological context in Britain (Trundle, 2011), there is little peer-reviewed published research examining the psychological impact of radiation exposure in British nuclear test veterans.

Three Mile Island (TMI).

The next event relating to technological ionising radiation exposure, and documented in the context of psychological effects, is that of the TMI nuclear power plant accident. The TMI

nuclear power plant in Pennsylvania had a partial meltdown of the core in 1979 releasing small amounts of radioiodine in the reactor itself (Bromet, 2014), but the average dose emitted was low (Hatch et al., 1990). No conclusive evidence for solid cancer incidence risk was observed in residents near the plant (albeit some indication of increased leukaemia risk in men; Han et al., 2011), and no evidence for increased cancer mortality risk was observed (Talbott et al., 2003). Nevertheless, the psychological impact of the accident received considerable research attention (see below).

As it will become apparent in studies from later nuclear incidents, mothers of young children appeared to be particularly susceptible to persistent psychological effects of perceived radiation exposure (Bromet et al., 1990). In addition to the mothers of young children, the nuclear workers who were present at TMI also gained some research interest. Kasl et al., (1981) observed an increased reporting of 'extreme worry' in TMI workers compared with another nuclear power plant six months after the accident, but another study observed that they had been relatively unaffected in terms of long-term (2.5 years) mental health symptoms (Parkinson & Bromet, 1983). As such, these studies indicate limited psychological impact in TMI workers following the accident.

Despite this, further work was conducted to examine the psychological effects in residents around the plant and was combined with biomarkers of psychological stress. For example, Schaeffer and Baum (1984) observed persistently elevated levels (albeit subclinical) of psychological stress biomarkers, namely urinary catecholamines and cortisol, in residents living near the plant compared to controls. Furthermore, Gatchel et al. (1985) observed elevated levels of urinary catecholamines, reduced behavioural performance and higher self-reported psychological distress symptoms in TMI residents compared to controls. Despite this, all levels appeared subclinical and below that of individuals diagnosed with a mental disorder. Davison et al. (1991) also observed higher levels of urinary catecholamines and lower behavioural performance but also increased blood pressure in TMI residents compared to controls. As with many TMI studies, the sample sizes are relatively small suggesting caution when interpreting the findings, but none the less they remain a useful set of studies demonstrating biological support for radiation-related psychological stress.

Chernobyl power plant accident.

Another incident which has been examined extensively in relation to its psychological effects is the 1986 Chernobyl nuclear power plant accident. According to the World Health Organisation, the mental health impact was the largest public health consequence following the Chernobyl accident (Bennett et al., 2006), expressed by widespread anxiety and depression in both contaminated and decontaminated regions (Ginzburg, 1993; Pastel, 2002). Even in those who were exposed to low, sub-clinical doses of ionising radiation, the psychological effects also appeared to be large and persistent (Danzer & Danzer, 2016).

Quantitative work has examined the psychological impact in residents who had been living near the Chernobyl power plant. For example, in a sample of 261 Russian immigrants from Chernobyl to the US, Foster (2002) found that those who lived close to the disaster experienced significantly greater levels of anxiety 15 years following the disaster, than those who lived further away. Additionally, in a sample of those who emigrated to Israel, residents who lived in areas of higher exposure displayed greater worry than those of lower exposure and non-contaminated regions, but such psychological effects appeared to decrease over time (Cwikel et al., 1997). Havenaar et al. (1997) observed a higher prevalence of anxiety disorders and more generally, psychological distress, among people who have been evacuated and in mothers with children under 18 years of age. There was no link between psychopathology and areas of contamination but, as the authors acknowledge, this finding is limited since many residents left the contaminated areas before the study had been established. Recently, analysing secondary data from a large sample of 4,725 survey respondents obtained by the WHO, Bolt et al. (2018) observed a significantly greater prevalence of alcohol-use disorders, a greater prevalence of affective disorders in men (albeit non-significant after adjusting for demographic variables), and poorer self-reported perceptions of health in those who had lived in the Chernobyl-affected area. Interestingly no differences in anxiety disorders (excluding PTSD) were observed between those self-reporting as affected by the Chernobyl accident and those who were not. Furthermore, qualitative case study work has also helped explain the uniqueness of the Chernobyl scenario regarding psychological stress. Abbott et al. (2006) illustrated anxieties relating to radiation effects but also compounded by distrust in authorities, lifestyle changes, and economic problems associated with evacuation and the dissolution of the Soviet Union. This highlights that the psychological stress of the Chernobyl accident may not pertain specifically to the radiation itself but also the radical societal change following the event.

Other cohorts aside from residents have been examined in relation to the Chernobyl accident, particularly the clean-up workers (termed 'liquidators' in former Soviet Union) involved in handling the contamination. For example, working with a sample of 614 Estonian Chernobyl clean-up workers and 706 age-matched controls, Laidra et al. (2015) found an increased prevalence of high scores on various mental health domains such as anxiety and depression, and also insomnia which may be a result of such mental health effects. Furthermore, Rahu et al. (2014) compared 3,680 male Estonian Chernobyl clean-up workers with 7,631 male controls and found, aside from elevated morbidity in various non-cancer diseases (particularly benign thyroid disease), there was an elevated morbidity of alcohol-related mental disorders but no excess risk in depressive or anxiety disorders which the authors postulate are likely under-reported in the exposed cohort. Similar findings have been observed in Ukrainian clean-up workers in relation to depression, anxiety, and PTSD symptoms, but no difference in alcohol-use disorders observed between clean-up workers and controls (Loganovsky et al., 2008). Such effects on mental health were observed at least 14 years after the Chernobyl accident which demonstrate the persistence of the psychological impact. Like the TMI biomarker studies, biological indicators of psychological stress have also been examined in Chernobyl clean-up workers (Goncharov et al., 1998; Souchkevitch & Lyasko, 1997). Elevated cortisol levels were reported in some (Souchkevitch & Lyasko, 1997) but not all studies (Goncharov et al., 1998).

Fukushima Daiichi nuclear power plant accident.

In addition to TMI and the Chernobyl power plant accident, a more recent nuclear power plant incident occurred which must be discussed. The Fukushima Daiichi power plant accident in 2011 resulted in psychosocial effects described to be devastating (Kamiya et al., 2015), despite no deaths directly caused by acute radiation exposure (Steinhauser et al., 2014) nor any evidence of adverse health effect directly attributed to ionising radiation exposure (UNSCEAR, 2020). While a correlation was observed between living in higher areas of contamination (albeit negligible doses) and psychological distress (Kunii et al., 2016), it is generally held that there was no association between ionising radiation dose and psychological effects (UNSCEAR, 2020). Therefore, the psychological effects can occur regardless of dose. Like the Chernobyl accident, evacuees (Yabe et al., 2014), pregnant women and mothers of young children (Goto et al., 2015) were particularly at risk of mental health and lifestyle problems.

Some emerging evidence demonstrating the extent of the psychological impact shows changes in lifestyle behaviours. For example, psychological distress was observed to be a risk factor for

smoking initiation amongst Fukushima evacuation area residents (Nakano et al., 2018), and psychological distress responses may be associated with increased alcohol consumption in nuclear workers (Komuro et al., 2019) and continued drinking in newly-started drinkers following the accident (Orui et al., 2017). One could speculate that these lifestyle behaviours function as a coping mechanism for the psychological impact of exposure.

Of course, in the context of nuclear accidents it may not solely be the anxiety regarding the radiation itself which is causing distress. As we have seen, there are multiple levels of uncertainty which may contribute to the psychological impact of ionising radiation exposure (Vyner, 1988). The process of evacuation for example, is particularly stressful. To illustrate, Yabe et al. (2014) reported that the percentage of evacuee adults (21.6% in 2011 and 18.3% in 2012) scoring above the cut-off point (≥44) on the PTSD Checklist was comparable to the percentage (20.1%) reported in clean-up workers following the 9/11 World Trade Centre Attacks. Interestingly, any increased incidence of cardiovascular and metabolic conditions observed in evacuees have been attributed to psychological stress, and lifestyle and social changes, rather than ionising radiation exposure (UNSCEAR, 2020). Overall, it is evident that the Chernobyl and Fukushima power plant accidents were characterised by widespread psychological impact even in areas of low doses, and factors such as evacuation and radical social change appear to play a key role in any psychological impact following these scenarios.

Other populations of interest.

Although relatively less academically examined, particularly in comparison to atomic bomb events and nuclear power plant accidents, there are a few other incidents of ionising radiation exposure which warrant acknowledgement in relation to their psychological impact. In 1987, a radiological source was stolen from an abandoned hospital in Brazil which resulted in four deaths. Collins and de Carvalho (1993) observed increased psychological stress and systolic blood pressure in both exposed and nearby ‘potentially-exposed’ individuals three and a half years following the accident.

Another cohort examined in relation to radiation and its possible psychological impact are the residents living around a radiologically, albeit low-dose (mean cumulative dose = 0.049 mSv), contaminated road in Seoul, South Korea, In a large sample of 8,875, although Ha et al. (2018) found no relationship between health problems and cumulative radiation dose (apart from hypertension in females), the researchers observed increased anxiety and decreased

psychological wellbeing correlated with increasing radiation dose (range of 0.00002 mSv to 35.32 mSv), despite the perceived risk regarding the contaminated roads being relatively low.

There is also recent research on the residents living in the areas surrounding the Semipalatinsk nuclear testing site in Kazakhstan. Semenova et al. (2019)observed higher rates of mild anxiety scores on a generalized anxiety disorder measure in the exposed group compared to residents in ecologically safe territories. The authors speculate the role of risk perception in this elevated anxiety, but it is unclear how radiation risk perception translates to the generalized anxiety disorder measure used in this study (Semenova et al., 2019). None the less, the study further indicates that anxiety-related issues are relevant to low- and moderate-dose exposure scenarios.

Much of this literature review has focused on the psychological impact of perceived ionising radiation exposure, but there are some parallels with perceived chemical agent exposure. While the two exposures are not wholly comparable because IR is 'invisible' without dosimetry whereas chemical agent exposure can often be detectable through physiological sensations (e.g. burns, smell), few studies from the Bhopal disaster indicated psychological effects relating to reproductive health. For example, Kapoor (1992) presented case studies highlighting the potential psychosocial issues regarding the inability for women to conceive, and impotence in men. Similar psychosocial issues may also be present in nuclear test veterans if they attribute any reproductive issues to ionising radiation.

Furthermore, other scenarios such as occupational asbestos exposure can lead to considerable psychological effects, particularly in individuals who develop asbestos-associated disease (Bonafede et al., 2018). Importantly, Njoya et al. (2017) demonstrated that the prevalence of probable anxiety and depression is associated with perceived levels of asbestos exposure but not expert assessment, highlighting that psychological impact can occur regardless of level of exposure (similar to ionising radiation and negligible dose levels).

Theories of emotional and psychological responses to threats

This chapter has demonstrated why 'worry' is an appropriate response to perceived ionising radiation exposure due to the inherent uncertainties (which operate on multiple levels). It has also demonstrated, with reference to multiple radiological events, that perceived ionising radiation exposure can result in considerable psychological effects, namely worry and generally psychological stress. Generally, worry about adverse health effects in oneself and

one's family members (as a result in genetic disease) is central to the possible psychological impact which may be exacerbated by factors such as evacuation in certain contexts. This psychological impact may be especially persistent, given the prolonged uncertainty about potential future consequences across generations.

It is important to examine the key theories of emotional and psychological[11] responses to threat, which do not pertain specifically to radiation exposure contexts. These theories explain why some individuals react differently in certain scenarios and experience psychological stress (of varying degrees). This thesis describes two approaches: the cognitive approach to emotional responses and psychological stress, namely *risk perception* (Slovic, 1987) and *appraisal theory* (Lazarus & Folkman, 1984), and a sociological approach namely *the stress process model* (Pearlin, 1999)

Cognitive approach to emotions and psychological stress (appraisals and risk perception).

Risk perception.

In the radiation literature regarding psychological responses, psychometric models of risk perception have been central to understanding how individuals respond to radiation scenarios. For example, as reviewed by Takebayashi et al. (2017), some measures assessing anxiety about radiation are based on psychometric models of risk perception. One predominant psychometric model of risk perception is that of Slovic (1987) which posits two psychological dimensions: *dread risk* and *unknown risk*. Dread risk, in this context, typically refers to the negative health effects of radiation exposure and negative health effects on future generations. The unknown risk, in this context, refers to the possibility that scientists do not fully understand the full health consequences of radiation exposure or the duration for symptoms to develop. Naturally, fallout from nuclear weapons testing is rated relatively high on both these dimensions in the lay person (Slovic, 1987). The purpose of such models is to forecast the public's acceptability of certain risks.

[11] To reiterate, 'psychological impact' is concerned with negative thought processes or emotions in response to perceived ionizing radiation exposure, which may result in a feeling of emotional or psychological strain (i.e. psychological stress).

The role of emotion is entwined in risk perception (Sjöberg, 1998), for example dimensions such as 'dread-risk' are inherently emotionally-laden (Böhm, 2003; Loewenstein et al., 2001) and emotions such as feeling anxious about hazards have often been used interchangeably with 'risk'. However, a key debate amongst social scientists is establishing the extent that risk perception precedes emotions, and vice versa (Johnson & Tversky, 1983; Keller et al., 2012; Loewenstein et al., 2001; Slovic et al., 2007). The traditional cognitive-consequentialist view of risk perception would hold that humans are rational and evaluate risks before arriving at certain emotions, but it is now accepted that humans also rely on emotions when making risk judgements (Loewenstein et al., 2001)[12]. In other words, the relationship between emotion and risk perception is likely bidirectional (Loewenstein et al., 2001). Nevertheless, much of the literature concerning psychological outcomes in the context of ionising radiation exposure examines risk perception as a predictor variable.

For example, the relationship between radiation risk perception and psychological distress has been demonstrated in relation to those affected by the Chernobyl accident (Havenaar et al., 2003), the Fukushima accident (Oe et al., 2016) and the TMI accident (Goldsteen et al., 1989). To illustrate, Havenaar et al. (2003) found higher levels of psychological distress in residents living in Gomel (contaminated region) than Tver (comparably unexposed region), and cognitive factors such as radiation risk perception, sense of control, and radiation hazard perception significantly predicted these psychological distress levels. Oe et al. (2016) found four trajectories of varying distress levels over 3 years in residents affected by the Fukushima disaster, and observed that the genetic effect risk perception was associated with the most severe distress trajectory. And lastly, risk perception was associated with psychological distress in residents around the TMI facility, albeit the association was non-significant when reanalysed at a later time point (Goldsteen et al., 1989).

Risk perception has also been associated with stress and anxiety in the context of technological risks, even in those which are non-radiological (Lima, 2004). It is suggested that technological risks cause greater distress than natural risks due to invisible effects as well as scientific uncertainty (Baum et al., 1983; Lima, 2004). Sjöberg (2000) posits that 'interfering with nature'

[12] It is uncertain whether specific emotions (e.g. anxiety, anger) predict risk perceptions, but it is more plausible that it is rather general affect which predicts risk perceptions (Rundmo, 2002). The hypothesis that emotions may precede risk perception is especially plausible in scenarios with limited information available (Slovic et al., 2007).

is an important factor to account for in risk perception, supporting the suggestion that technological risks are related to higher levels of discomfort.

But there are studies which have not observed an association between radiation risk perception and psychological distress. For example, in non-evacuated Fukushima residents, it has been observed that there was no association between risk perception measured five years after the accident and psychological distress two years later after controlling for baseline psychological distress, but associations were observed for risk perception and PTSD symptoms (Fukasawa et al., 2020). An earlier longitudinal study involving Fukushima evacuees observed that radiation risk perception predicted psychological distress two years later, but these associations were rendered insignificant after controlling for other variables (Miura et al., 2017). Drawing on this, (Sjöberg, 1998) found evidence indicating that worry and risk perception are statistically independent (albeit weakly correlated), suggesting that an individual can feel worried about a particular risk despite believing that the particular risk is small, and *vice versa.*

I argue that a weakness of psychometric models of risk perception is that they focus on the characteristics of the scenario, rather than understanding how different individuals perceive risk or construe the scenario. Moreover, risk perception appears to be a poor predictor of long-term psychological stress. Therefore, while risk perception can be a useful construct to predict psychological reactions in the short term, it is not a comprehensive explanation. Moreover, while psychometric models of risk perception provide good insight into how people perceive certain hazards, the psychometric models are simplistic and do not adequately explain the processes leading to the specific emotions and behaviours associated with the risk perceptions.

Rather than examining risk perception, which does not appear consistently correlated with psychological outcomes (e.g. worry, psychological stress), I propose that psychologists in the field of radiation research may find appraisal theory (Lazarus & Folkman, 1984) to be more useful in explaining individual differences in the psychological outcomes of perceived exposure. In short, appraisal theory suggests that emotional responses are an outcome of perceived threat and the perceived adequacy of coping resources to deal with the threat (Lazarus & Folkman, 1984).

Appraisal theory.

Before describing this key theory, it is worth examining how the theory arose from the state of understanding at that time. Before the initial posit of this theory (Lazarus, 1966), emotion tended to be viewed under the concept of drive, or rather physiological arousal (i.e. increased heart rate, blood pressure, sweating etc.), but it was later argued that this simplistic view cannot explain emotion without the acknowledgment of cognitive processes (Klein, 1958, as cited in Lazarus & Folkman, 1984). Thus, psychologists began examining the role of cognition mediating the link between arousal and emotion. One example of this is (Schachter & Singer, 1962) who argued, based on their classic experiment, that arousal is cognitively labelled according to the available information in the environment. That is, emotion is a result of cognitive processes acting on the awareness of arousal. This view that emotion arises when one's consciousness detects an objective physiological state and this state is subsequently labelled remains a prominent contemporary contextualisation of emotion (LeDoux, 2012; LeDoux & Hofmann, 2018).

Related to this idea of cognitive experience, Lazarus and Folkman's appraisal theory (Lazarus, 1966; Lazarus & Folkman, 1984) argues that emotion (and psychological stress) arises based on the personal values and beliefs brought by the individual which then influence how the situation is construed. Appraisal theory (Lazarus, 1966; Lazarus & Folkman, 1984) also accounts for coping in response to certain events and can be used to explain the varying responses (between individuals) to the same situation.

The model describes two basic forms of appraisal: primary and secondary. Primary appraisal involves the evaluation of the specific event to judge whether the individual has anything at stake. For example, judging whether there is any harm or benefit in relation to their goals and values. The primary appraisals can be organised into 1) irrelevant (the encounter has no implications for a person's wellbeing), 2) benign-positive (the encounter is construed as having a positive impact on a person's wellbeing), and 3) stressful.

For this thesis, and since I focus on negatively-valenced thought processes and emotions, I briefly outline stress appraisals, namely harm/loss, threat, and challenge. Harm/loss appraisals refer to damage to one's wellbeing having already occurred and can be characterised by emotions such as sadness. The threat stress appraisal refers to harms or losses that have not yet taken place but are anticipated. This is characterised by emotional responses such as fear and

anxiety. These threat appraisals are unique to harm/loss in that they permit anticipatory coping behaviours. Lastly, the challenge appraisals, which are like threat appraisals in that they also permit anticipatory coping behaviours, differ in the sense that they focus on the potential for positive gain. Appraisals such as threat and challenge are not mutually exclusive, and they can occur simultaneously (Lazarus & Folkman, 1984).

If a situation is appraised as a threat or a challenge, then a further appraisal occurs which is labelled *secondary appraisal*. Secondary appraisal involves evaluating different coping strategies to help reduce future harm or to improve the prospects for benefit (challenge). These coping strategies often include behaviours to deal with the threat itself or its subsequent consequences. If one does not have the necessary coping strategies to handle the threat, then this will cause psychological stress. Although labelled primary and secondary, the two appraisals are not necessarily hierarchical, meaning that one is not necessarily more significant than the other. In addition to primary and secondary appraisals, if there is new information from the environment then the individual can reappraise the situation. All appraisals can also occur beyond the awareness of the individual.

The role of appraisal theory has been incorporated into, to my knowledge, only a few studies of ionising radiation exposure. Cwikel et al. (2000) found that the negative appraisal of the Chernobyl event was significantly associated with anxiety even after controlling for physical exposure, highlighting the role of negative appraisals on psychological outcomes. Furthermore, secondary appraisals such as trust in experts and perceived control were found to be associated with a global measure of psychological symptoms in residents who stayed in the TMI area during the restart (Prince-Embury & Rooney, 1988).

Overall, this theory explains, by acknowledging perceived adequate coping resources and the relevance of the situation to the individual, *how* one individual may construe a situation as threatening while another individual may construe the same situation as relatively innocuous. Psychologists have drawn on this influential theory and posited cognitive factors to explain *why* one individual may construe a situation as threatening while another individual does not. One cognitive factor central to the aetiology of worry is 'intolerance of uncertainty', which is "a cognitive bias that affects how a person perceives, interprets, and responds to uncertain situations on a cognitive, emotional, and behavioural level" (Dugas et al., 2004, p.835). Related to this, it has been suggested that ambiguity may amplify the threat and subsequent stress on the grounds that ambiguity renders an individual's control of the situation difficult and reduces

the potential to cope with the threat (Lazarus & Folkman, 1984; Vyner, 1988). Note that 'uncertainty' was the predominant term to describe perceived exposure. Until recently, uncertainty and ambiguity have been used interchangeably in the literature (J. T. H. Chen & Lovibond, 2016). Some researchers now argue that uncertainty refers to when the probability of an outcome is known, while ambiguity is a 'higher-order' uncertainty and refers to no knowledge of an outcome (J. T. H. Chen & Lovibond, 2016). Therefore, they are both similar constructs and likely relevant to radiation exposure contexts. Cognitive factors such as intolerance of uncertainty may influence the way individuals appraise uncertain (Koerner & Dugas, 2006), and perhaps more so ambiguous scenarios (J. T. H. Chen & Lovibond, 2016). Specifically, individuals high in intolerance of uncertainty are more likely to appraise uncertain and ambiguous scenarios, such as perceived exposure, as threatening. Indeed, intolerance of uncertainty has been identified as an important trait influencing psychological distress in other invisible exposure scenarios, specifically pandemics (Taylor, 2019).

Unfortunately, aside from the above studies with relatively simplistic application (Cwikel et al., 2000; Prince-Embury & Rooney, 1988), there has been relatively little application of appraisal theory to the context of ionising radiation exposure. Rather much of the literature is grounded in the realm of risk perception, as we have seen above. Nevertheless, risk perception must play a role in the appraisal of situations, to some extent. That is, situations (or hazards) perceived as high risk are more likely to be appraised as threatening (and elicit an emotional and psychological response) because they are more likely to exceed the individual's resources required to deal with the threat.

Environmental risk theorists have incorporated cognitive appraisals into risk research which led to considerable advancements in our understanding of how individuals respond to hazards (though this does not appear to be applied to ionising radiation exposure but rather natural and technological hazards generally). Drawing on appraisal theory, Böhm and Pfister (2000) posit that we engage in two types of evaluative processes (appraisals) when attending to risk (not limited to anthropogenic risks, but natural risks too), which give rise to specific emotions: consequential evaluations (referring to past and future consequences of the risk) and ethical/deontological evaluations (whether the risk violates ethical principles; for example, who is responsible?); the latter appearing salient especially when the risks are anthropogenic.

Consequential evaluations tend to relate to emotions such as fear, sadness, and worry, while ethical evaluations tend to relate to anger and guilt. Böhm and Pfister (2000) then further

distinguish consequential based emotions into prospective (future-oriented) emotions, such as fear or worry, or retrospective (past-oriented) emotions, such as sadness or sympathy (Böhm, 2003; Böhm & Pfister, 2000). We can go further in distinguishing between fear and worry in response to hazards which is noteworthy since the discourse regarding the psychological impact of ionising radiation exposure is often couched in terms of fear and anxiety. While Böhm and Pfister (2000) distinguish fear and worry in terms of the magnitude of anticipated consequences, the present thesis adopts the perspective that fear and worry are also distinguished in terms of the space and time that the consequences may be realised (LeDoux & Pine, 2016). If the threat is imminent, rather than distant, then this will elicit fear. While if the threat is distant (in space and time) then worry (or anxiety as an emotion) is relevant.

Regarding ethical-based emotions arising from ethical/deontological evaluations of risk, these can be further distinguished based on who is responsible for the potential consequences: the self, or the other. The former tends to relate to feelings such as guilt or shame, while the latter tends to relate to anger (Böhm, 2003).

Overall, appraisal theory (Lazarus and Folkman, 1984) and appraisal-type theories (Böhm, 2003; Böhm & Pfister, 2000) provides an insightful account into the role of emotions and how individuals respond to a given hazard. It is also a valuable theory in the sense that it accounts for coping resources to deal with perceived threat. If coping resources are not perceived as adequate, then the emotions (e.g. worry, fear) elicited by a threat will persist and the individual will experience psychological stress.

Sociological approach to emotions and psychological stress.

Stress process theory.

But theories of psychological stress are not limited to the cognitive perspective. The cognitive accounts are useful in understanding individual stress and emotional reactions to environmental stressors, but while it is *a* perspective, a single perspective cannot provide a comprehensive account of the phenomena of interest. What is required is a cross-disciplinary understanding within the social sciences. Therefore, separate from the cognitive theories of worry and stress, but equally as important, is the sociological 'Stress Process Theory' (Pearlin, 1999) which emphasises the role of social systems and institutions in psychological stress, with a focus too on coping resources. Indeed, it is not a singular stress process for all individuals but rather a

general orienting framework (Pearlin, 1999). It should also be noted that this theory does not explain the specific emotions elicited given a certain hazard, but rather can explain why certain groups of people experience psychological stress (emotional or psychological strain) following a perceived threat by acknowledging the social and economic context. Like cognitive theories, this sociological approach emphasises the role of coping resources to deal with a threat.

There are two general assumptions which underlie this model:

Firstly, the model acknowledges several factors which are all interrelated and influence stress outcomes. Pearlin lists factors such as the social statuses of individuals, the contexts that envelope their daily lives, their exposure to stressors, and the resources available in responding to the stressors. An implication of the interconnections is that one factor can influence another and so forth, which Pearlin (2009) describes as proliferating stress. Secondly, Pearlin (1999) emphasises that the model is concerned with 'normal' features experienced in everyday life, as opposed to an earlier presumption that stress-induced psychopathology is abnormal and therefore has abnormal causes.

To begin, the social and economic statuses of people and subsequent inequalities are influential in all components of the model. The first component influenced by social and economic inequalities to be described is the neighbourhood context (Aneshensel, 2010). For example, when a neighbourhood is characterised by low social and economic capital then this can be related to subsequent health status, irrespective of individual social and economic status (Pearlin, 1999; Pearlin et al., 2005), due to increased exposure to what Pearlin and colleagues (2005) label 'ambient stressors'. Such ambient stressors can include, but not limited to, difficulties in accessing services and transport, and traffic.

Pearlin (1999) then argues that the neighbourhood context may lead to an increased risk of exposure to primary stressors, and indeed the social and economic inequalities are also implicated in the likelihood of exposure to stressors. For example, an unskilled worker can be expected to be more likely to experience economic hardship (and subsequently psychological stress), than a skilled worker. Such stressors can be characterised as either life events, or more chronic stressors. To highlight the differences and characteristics of these two types of stressors, I include an extract from Pearlin's (1999) work:

> "*an event is an event by virtue of having an identifiable point in time at which it occurred; this is in contrast to chronic stressors, which are likely to emerge more insidiously and be more persistent. The differences between events and strains need to be underscored, for there is some confusion surrounding the use of these constructs, most apparent in instances where events are viewed as coextensive with the entire universe of stressors. Moreover, many critical events are episodes that bubble up along the trajectory of chronic stressors, leaving us unsure as to whether it is the event or the continuing problems from which the event stemmed that accounts for the stressful impact."* (Page 400; Pearlin, 1999).

Examples of life event stressors, particularly events which have a profound disruptive effect, are 'loss events' such as the death of a loved one. Regarding chronic stressors, researchers tend to examine institutional roles of people such as marriage, parenthood, job, and finances (Pearlin, 1999), as they are all enduring.

As mentioned above, Pearlin (1999) refers to the term 'stress proliferation' which describes subsequent stressors (secondary stressors) resulting from a single stressor (primary stressor). The distinction between primary and secondary stressors can ultimately help understand why certain individuals experience negative outcomes to a single stressor while other individuals are unaffected. As Pearlin (1999) states, we tend to address this by examining the individual's moderating resources (moderating in conceptual terms rather than empirical/statistical terms), for instance, effective coping. Again, the overarching role of social and economic inequalities is argued to be pervasive here (Pearlin, 1999). To provide an example, a traumatic event may lead to subsequent proliferating stressors, but this description is insufficient without accounting for the social and economic contexts in which the stressors occur in (e.g. dysfunctional homes, dangerous neighbourhoods; Pearlin et al., 2005). Traumatic events or adversity is more likely to lead to psychological stress in individuals of a low socioeconomic status, but this is proposed to be moderated by personal (e.g. perceived mastery, self-esteem; (Frankham et al., 2020; Pearlin & Schooler, 1978) and social (e.g. support networks; Mickelson & Kubzansky, 2003; Thoits, 1995) coping resources used to deal with the stressor. Indeed, socioeconomic status also influences these moderating coping resources which buffer against the effects of a stressor (Pearlin, 1999).

Having outlined the fundamental theory and assumptions of Pearlin's Stress Model, it is important to apply this to the unique scenario of ionising radiation exposure. Much of the

research examining the role of socioeconomic status in psychological stress following radiation exposure pertains specifically to nuclear power plant scenarios, but they are useful to examine, nonetheless. Several studies have identified the role of finances or socioeconomic status in anxiety and psychological distress following nuclear power plant incidents (Beehler et al., 2008; Fukasawa et al., 2017; Kusama et al., 2018; Viinamäki et al., 1995), and can be contextualised under Pearlin's (1999) stress model. For example, higher socioeconomic status, particularly measured by income but not educational attainment, also appears to be associated with lower radiation anxiety following the Fukushima accident (Kusama et al., 2018). Similarly, Fukasawa et al. (2017) also observed that low and middle income was associated with higher levels of radiation anxiety, compared to high income. Kusama and colleagues (2018) postulate that those in a lower socioeconomic status hold higher perceived risk for radiation and subsequently experience greater anxiety but, as we have seen, perceived risk and worry/anxiety are weakly correlated (Sjöberg, 1998). Thus, one speculates that such individuals have fewer coping resources to deal with adversity, thus experience greater levels of anxiety.

Other studies have observed higher educational attainment (a proxy indicator of socioeconomic status) to be associated with lower psychological distress following the Fukushima disaster (Suzuki et al., 2015) but comparison between studies may be limited given the inconsistent outcome variables. Furthermore, Viinamäki (1995) found higher education levels and better financial situation to be associated with lower general distress in women living in contaminated areas following the Chernobyl accident, compared to women from uncontaminated areas, although such findings were not observed in the male participants. Educational attainment has also been examined in the context of more benign radiological incidents and could be speculated to be related to anxiety mediated by differing perceptions of risk. For example, in residents living near a low-dose radiologically contaminated road in South Korea, those with the lowest education level (less than 6 years education) had the highest perceived risk for the contaminated roads (Ha et al., 2018) but the authors did not analyse relationships between educational attainment and anxiety.

Summary

To summarise this chapter, we have examined the uncertain nature of exposure to invisible contaminants (in this case ionising radiation), and I have demonstrated why worry is an

appropriate and common response. Aside from worry (a thought process) in the face of uncertainty (and ambiguity), we have also examined the popular general theories of emotion and psychological stress in response to threat. By combining cognitive approaches (Böhm & Pfister, 2000; Lazarus & Folkman, 1984) and sociological approaches (Pearlin, 1999, 2010) we can understand how and why individuals respond in different ways to perceived threat: influenced by the way the situation/risk is appraised and the (perceived) coping resources used to deal with the threat, but also how psychological reactions to adversity can be influenced by the social and economic conditions that people live in. This chapter has also demonstrated that worry and, more generally, psychological stress is a significant public health issue in the context of perceived ionising radiation exposure, as observed in populations such as Japanese atomic bomb survivors, populations affected by nuclear power plant accidents, and US nuclear test veterans. Since, British nuclear test veterans are a relatively unexamined population who may perceive themselves to have been exposed to ionising radiation, this raises the prospect that worry about potential adverse health effects in themselves and in family members may be present and continue to persist in British nuclear test veterans.

Chapter 3 – Project Overview

The literature review of the preceding chapter demonstrates that this nuclear test veteran population are relatively unexamined with regards to the psychological impact of perceived exposure. In addition, aside from the atomic bombings of Hiroshima and Nagasaki, the nuclear testing programmes were some of the earliest instances of technological ionising radiation exposure. Thus, the research on the psychological impact of ionising radiation exposure in older adults has been relatively little studied and generally has only been conducted in the context of Japanese atomic bomb survivors (Honda et al., 2002; Kim et al., 2011; Knowles, 2011; Ohta et al., 2000; Sawada et al., 2004). Therefore, the participants in these testing programmes are unique in the fact that they are an aged cohort and present an opportunity to examine the psychological impact of perceived exposure over a life course.

Moreover, anxiety-related mental health research in older adults is relatively understudied and poorly understood (Kiely et al., 2019; Schuurmans & Van Balkom, 2011) and this population are all male which can complicate the identification of anxiety-related mental health issues (Smith et al., 2018). The fact that this study population are all male warrants further acknowledgement, with regards to masculinities. Morioka (2014) qualitatively explored the possible gender differences in radiation risk perception following the Fukushima disaster, drawing on notions of hegemonic masculinity (see page 151 for details on this concept). In essence, the apparent lower perceived risk in males compared to females was attributed by Morioka (2014) to the male role in Japanese society. Morioka highlighted the notion of 'breadwinner' where the male individual's work-life was paramount relative to any concerns regarding their children being exposed to ionising radiation. Applying this to British nuclear test veterans, the 'breadwinner' mentality may have operated in British culture during the 1950s and 1960s when the veterans returned from abroad, which leads one to consider how this might impact on perceptions of risk and worry or concerns about health. This 'breadwinner' mentality could extend to the traditional role of the father figure in looking after their family members. For example, one may suspect that the perceived risk of physical health effects may result in further worry about being unable to survive into older age and look after their partners and descendants. Therefore, being male (and the associated masculinities) make this population particularly interesting to examine in relation to the psychological effect of perceived ionising radiation exposure.

To achieve the broad aim of examining the extent of exposure worry in British nuclear test veterans, and to explore the broader psychological impact of the British nuclear testing programme, this thesis addressed the following three research questions:

Research questions

I. What are the levels of exposure worry in a sample of British nuclear test veterans?
    a. What specific aspects of exposure worry do British nuclear test veterans report?
    b. To what extent do British nuclear test veterans report feeling stressed as a result of their worry about ionising radiation exposure?

II. What are the mechanisms and dynamics of exposure worry?
    a. How has it developed over time?
    b. What is the broader psychological impact of involvement in the testing programme, and how is this influenced by time?

III. What factors are associated with exposure worry in British nuclear test veterans?
    a. How does exposure worry relate to the belief that a physical health condition is caused by ionising radiation exposure?

Before proceeding, a brief description of the respective methods[13] used to address these research questions must be highlighted:

Research question I is addressed by primarily quantitative methods in Chapter 4 and Chapter 5. To address this research question, a scale was developed to measure exposure worry in British nuclear test veterans (Chapter 4). This scale development was informed by a single focus group (qualitative data but not analysed using any rigorous qualitative methods) and by gathering quantitative data on scale responses. To measure the extent that they were worried, basic quantitative analyses were used on scale item responses after the scale(s) had been finalised. Details of this analysis are the focus of Chapter 5.

Research question II is addressed by purely qualitative methods in Chapter 6, namely semi-structured interviews followed by thematic analysis of the recorded data. The semi-structured interviews are also biographical and incorporate object-elicitation methods. The result of

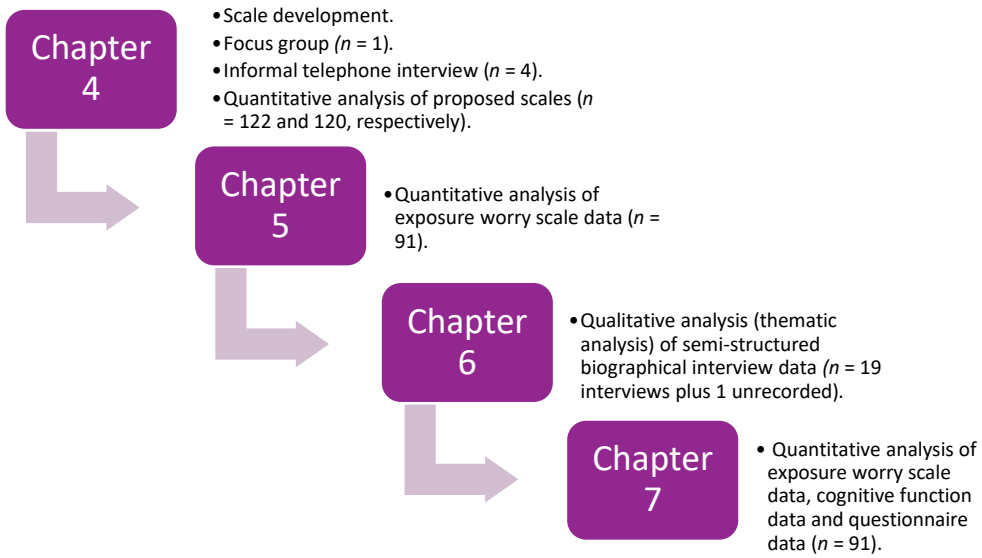
[13] The research methods are discussed in greater depth in their respective chapters.

Chapter 6 is a set of themes and a proposed conceptual model to illustrate the possible psychological impact of the British nuclear weapon testing programme.

Research question III then reintroduces the quantitative data and uses further quantitative analyses to expand on the proposed conceptual model. This chapter (Chapter 7) describes scale, cognitive test, and questionnaire data.

Figure 1.

Overview of research chapters 4 to 7 with regards to the respective methods



Paradigmatic commitment

Before continuing and presenting the subsequent research chapters, we must first acknowledge the paradigmatic commitment of this thesis, especially since this is a multiple-methods project. It is important for social-scientists to engage in philosophical discussion because certain worldviews or philosophical stances often dictate research decisions. The philosophical paradigm underpinning this project evolved as part of the learning process and, in fact, the research design was not multiple-methods when the project was initiated.

A philosophical paradigm refers to a set of beliefs and practices which influence the researcher in choosing specific research questions and methods to answer those questions (Shannon-Baker, 2016). Paradigms are generally clustered based on ontology and epistemology. Briefly, ontology refers to assumptions about the nature of reality and what exactly exists in the social world, while epistemology refers to the ways of knowing and theories about what counts as knowledge (Madill & Gough, 2008; Ponterotto, 2005). This will not be a comprehensive

overview, but positions concerning the ontological and epistemological paradigm must be acknowledged (for overview see Guba & Lincoln, 1994, 2005; Ponterotto, 2005).

At one end of the spectrum is positivism which focused on efforts to verify a priori hypotheses, usually stated in quantitative propositions of phenomena. Generally, positivism asserts that there is a single, stable objective reality available for humans to discover. Postpositivism is like positivism in that it also operates from a nomothetic perspective but acknowledges that an objective reality can only be imperfectly apprehensible (Guba & Lincoln, 1994). In contrast and at the other end of the spectrum, constructivists-interpretivists acknowledge that there are multiple, constructed realities rather than a single true reality, and influenced by the context of situation, social environment, and individual experiences and perceptions. Somewhat related, critical theory is concerned with reality influenced by cultural, social, gender, political, and ethnic values which are socially and historically constituted (Ponterotto, 2005). Traditionally these paradigms dictate the research methods used. For example, positivism and postpositivism would generally be concerned with quantitative methods, experiments, testing hypotheses, and quasi-experiments, while constructivists-interpretivists predominantly use qualitative methods to establish meaning and to examine how data is socially 'constructed'.

'Purists' would regard the above philosophical paradigms as static which may be unhelpful in mixed- or multiple-methods research, and rather, paradigms should be regarded more as general 'stances' which guide the researcher through the inquiry process (Shannon-Baker, 2016). The reason being is that adhering to a static paradigm will limit the researcher in their methods used and constrain 'intellectual curiosity' (Feilzer, 2010). Mixed-methods and multiple-methods approaches complicate the traditional paradigmatic debate since the approach utilises both quantitative and qualitative methods. Mixed-methods and multiple-methods approaches can use any philosophical paradigm but, most often, these approaches are associated with pragmatism (Weil, 2017), which emphasises the research question and practical solutions to resolving issues without adhering to an all-encompassing worldview (Shannon-Baker, 2016).

When this project was initiated, the initial aim was to measure levels of exposure worry and establish whether there was a significant relationship between exposure worry and cognitive functioning in British nuclear test veterans. To address this aim, feasible and logical methods to gather cognitive data and levels of worry are to conduct cognitive tests and self-report scale data, respectively. Thus, it can be argued that a pragmatist approach to the research was

conducted since the methods were chosen specifically to answer research questions with the resources available, with generally little consideration for epistemological and ontological underpinnings. While, in truth, I did not initially scrutinise worry in terms of ontology and epistemology to a great extent, I had regarded worry as an apprehensible and universal concept which could be accurately measured throughout self-report scale methods. But as is evident throughout the chapters, undertaking this doctoral research project led to an evolving paradigmatic commitment. This will be later addressed in more detail in the qualitative chapter (Chapter 6).

Of course, alternative approaches to epistemology such as phenomenology are relevant to this topic, especially given the significant qualitative component to this thesis. A phenomenological approach would seek to understand the subjective meaning of exposure worry, and understand the nature and quality of the phenomenon as it presents itself (Silver, 2013). In other words, phenomenology requires returning the phenomenon to how it presents itself and separating what we think we know about the phenomena already. This approach was not chosen in this thesis (thematic analysis was chosen for qualitative analysis). The phenomenological process can be arduous and is not suitable when the qualitative study is concerned with various aspects of the nuclear testing experience, nor when exposure worry is presumed to be a central phenomenon to the nuclear test veteran experience but is not concretely established.

Chapter 4 – How Can We Measure Exposure Worry?

Before addressing the first research question and its relevant sub-questions, the present chapter details the development of a scale to measure the levels of exposure worry in British nuclear test veterans. While many quantitative studies examining the psychological impact of ionising radiation exposure use a combination of clinical anxiety, depression, and PTSD measures (Beehler et al., 2008; Bolt et al., 2018; Cwikel et al., 1997, 2000; Foster, 2002; Miura et al., 2017; Semenova et al., 2019) or non-specific psychological distress scales (Davison et al., 1991; Goldsteen et al., 1989; Kunii et al., 2016; Oe et al., 2016; Suzuki et al., 2015), only few studies implement anxiety scales specific to ionising radiation exposure (Fukasawa et al., 2017; Hidaka et al., 2016; Shimotsu et al., 2010).

Such radiation-specific anxiety scales are, understandably, only relevant to their unique contexts. For example, the Radiation-Anxiety Scale has been developed in the context of the Fukushima power plant disaster (Fukasawa et al., 2017). Another such scale is the Radiotherapy Categorical Anxiety Scale (RCAS; Shimotsu et al., 2010) which was developed to measure the anxiety regarding adverse health effects, the procedure itself (in terms of radiotherapy environment and equipment), and whether the treatment is effective or not. Since these scales are context-specific, both the Radiation-Anxiety Scale and RCAS contain items which cannot be applied to other radiation exposure contexts. For example, in the Radiation Anxiety Scale (Fukasawa et al., 2017), item four reads "I feel strong anxiety when I see news reports concerning the nuclear power plant accident" which is clearly only applicable to nuclear power plant accidents. This leaves a challenge where there is no current scale measuring radiation-specific worry in British nuclear test veterans, and without this scale, we cannot answer research questions detailed in the previous chapter.

The process of developing an exposure worry[14] scale comprised three stages:

1) A single focus group discussion to evaluate the appropriateness of the language and items proposed for the exposure worry scale.
2) Subsequent telephone discussions to give a further indication of content validity on the amended scale.

[14] The term 'worry', rather than 'anxiety', was chosen for reasons highlighted in Chapter 2.

3) Examining the distribution of responses and construct validity on the proposed exposure worry scale(s).

I now present these stages of scale development:

Stage I

The initial proposed exposure worry scale (Figure 2) consisted of items based on existing radiation anxiety scales (Fukasawa et al., 2017) and Slovic's (1987) model of risk perception. For example, most of the proposed items (Figure 2) represent dread risk-type items, but there is also the inclusion of an unknown risk-type item. In addition to this, some items were suggested based on anecdotal reports of the nature of nuclear weapons testing during that period. For example, articles reported by tabloid newspaper *The Mirror* describe the perceived lack of protective clothing against ionising radiation exposure, and the potential for radiologically-contaminated soil contaminating food, in addition to the obvious perceived risk of adverse health effect. Thus, items reflecting these reports were included in the initial scale to capture the potential range of worries in the context of British nuclear weapons testing. Lastly, the 10th item was included in an exploratory attempt to indicate changes in exposure worry over time.

The proposed scale items were differentially framed in the context of worry and concern to examine the relevance of such terms. The reason for this is because worry and concern are often used interchangeably, perhaps because they are spatio-temporally similar, but expressed in varying magnitude. Indeed, concern can be framed rather as a matter of interest or importance. For example, I suggest that one can be concerned about climate change but does not experience worry but increasing concern may elicit feelings of worry.

Fear is also sometimes used interchangeably with worry and anxiety (Le Doux & Pine, 2016), but it was not used in the proposed 'exposure worry' scale based on the view that fear and worry are spatio-temporally distinct and because fear is presumed non-applicable to the context of perceived radiation exposures which have already occurred. To elaborate, fear is presumed applicable in exposure contexts primarily when the threat is imminent, for example emergency workers may experience fear when dealing with an accidental exposure source because the threat is close in space and time. But for individuals potentially exposed many years ago, fear

is unlikely to reflect the process of considering retrospective events nor the potential for future adverse health effect.

It is also worth commenting on the number of points on the proposed scale, since it would be natural to question why each item is rated along seven points, in contrast to the Radiation-Anxiety Scale (Fukasawa et al., 2017) which is rated along four points. There are several reasons for using seven points. First, since the initial purpose of this scale was to measure exposure worry and its relationship with cognitive functioning, a spread of varying responses was needed to capture the fine differences in levels of worry. These differences may not be adequately captured with 3 or 4-point scales. Moreover, there was some concern that too many points (above 10) may be overcomplicated. Preston and Colman (2000) demonstrate that 7-point, 9-point, and 10-point scales are most preferable in the context of attitude rating, and that these scales hold better validity in comparison to 4-point scales in the context of rating service experiences, for example. Based on this, the initial proposed scale is a 7-point scale end-anchored with 'strongly disagree' and 'strongly agree', and 'neutral' representing the 4th point.

It should be noted that the proposed exposure worry scale is not a Likert scale like that of the Radiation-Anxiety Scale (Fukasawa et al., 2017), where total scores are calculated by adding each item score together (essentially providing the equivalent of a mean score). This distinction is underpinned by differences in the way radiation-anxiety or exposure worry is conceptualised. Given that the Radiation-Anxiety Scale has 7 items on a 4-point scale, producing a total score out of 28, I ask how confident one can be in stating that an individual who scores 13 (two items rated 4 anchored 'strongly agree', and five items rated 1 anchored 'do not agree at all') is less anxious than an individual who scores 14 (rating each item as 2, below the mid-point indicating relatively little radiation-anxiety). This example demonstrates why the Likert approach was not taken. Rather, to gauge the extent of exposure worry in this sample, the intention at this point of the research project was to take the highest single score across each of the items.

The aim of this first stage of scale development was to gain an insight into whether or not my proposed scale items were valid to the target population (i.e. establishing content validity), and we can do this by consulting with 'experts' on the topic (Vogt et al., 2004), namely the test veterans. A second aim was to establish whether there are further items relevant to exposure worry which had not initially been considered. A third aim was to gain insight into the appropriateness of the language used, which would eliminate the possibility of participants being offended by any scale items.

Methods

Participants.

Study participants had all witnessed one or more nuclear tests. Six BNTVA test veteran members and two wives were recruited at the BNTVA Annual General Meeting (AGM) on 20th May 2018. The project was advertised via a presentation given by the current principal investigator at the time, poster boards, and through flyers distributed at the AGM. Participants were recruited voluntarily by approaching the research team at the AGM. Written informed consent was gained prior to taking part. The study was approved by the University Research Ethics Committee (Appendix A).

According to Hertzog (2008), 10 or fewer respondents is adequate for assessing the clarity of the language used and the acceptability of scale formatting. As mentioned above, I regarded my participants as 'experts' because they have experienced/witnessed nuclear weapons testing, have reported concerns about their health because of the nuclear tests, and so are crucial in helping me understand how exposure worry should be conceptualised (Vogt et al., 2004). Witnessing a nuclear weapons test or being involved in clean-up operations are particularly unique experiences, so it would be unwise to develop scale items without consulting the nuclear veterans. This is particularly important given that there is limited research examining the psychological impact of real or perceived exposure in nuclear test veterans relative to the psychological impact following nuclear disasters.

Materials.

The proposed 'exposure worry' scale items (Figure 2).

Procedure.

A single focus group design was chosen. Focus groups are moderator-facilitated group discussions organised to explore a specific set of issues and are distinguished from group interviews in that there is a component of 'group interaction' which contributes to the research data (Kitzinger, 1994). Indeed, focus groups have been argued to be a useful (and perhaps underused) tool to enhance content validity of psychological scales (O'Brien, 1993; Vogt et al., 2004). Because the topic of exposure worry is a sensitive issue, focus groups are appropriate because the interpersonal dynamics can provide participants with mutual reassurance, despite

the common misconception that sensitive information could be supressed in a group context, due to concerns of confidentiality (Wilkinson, 1998). However, this latter point was deemed unlikely to occur due to participants sharing the commonality of being a nuclear veteran and being supported by wives, creating a 'safe-space' environment for sensitive discussion to occur. Separately, a single focus group was a convenient method to understand multiple veterans' perspectives in a quick timeframe. This was appropriate because it is uncommon to have multiple test veterans in the same location at the same time, thus conducting the focus group at the BNTVA annual general meeting where many nuclear test veterans were present was ideal for data collection.

Participants in the focus group were presented with the proposed 'exposure worry' scale items (Figure 2). The participants were asked not to rate their levels of agreement to each scale item but to discuss the scale items in terms of the language (e.g. using terms like worry or concern), relevance and appropriateness. Participants were also asked to propose any other items that would help assess exposure worry. The focus group was led by me and a female supervisor. The focus group lasted for one hour and was audio recorded.

Figure 2.

Proposed items for exposure worry scale

If you do not have children then skip question 2 and 3
If you do not have grandchildren then skip question 3

#	Question	Strongly Disagree			Neutral			Strongly Agree
1	Whenever I am ill, I am concerned that it may be a result of exposure to ionizing radiation	1	2	3	4	5	6	7
2	I am concerned that my exposure to ionizing radiation may have affected my children	1	2	3	4	5	6	7
3	I am concerned that my exposure to ionizing radiation may have affected my grandchildren	1	2	3	4	5	6	7
4	I am concerned that scientists are not explaining fully the effects of exposure to ionizing radiation	1	2	3	4	5	6	7
5	I am concerned that I should have been given protective clothing at the nuclear testing sites	1	2	3	4	5	6	7
6	I am concerned that my children are worried about my exposure to ionizing radiation	1	2	3	4	5	6	7
7	I am worried about the lack of protective clothing given to me at the nuclear testing sites	1	2	3	4	5	6	7
8	I am worried that I have eaten food contaminated with ionizing radiation	1	2	3	4	5	6	7
9	I am worried that my children are worried about my exposure to ionizing radiation	1	2	3	4	5	6	7
10	I am more worried now than I was in the past	1	2	3	4	5	6	7

Analysis.

The focus group was transcribed and analysed at a descriptive level meaning that illustrative quotes are included to support content validation, with a limited level of interpretation (Vogt et al., 2004). While Vogt et al. (2004) recommend that themes are generated in conjunction with illustrative quotes, themes were not generated in this study since this is beyond the scope of this work. Additionally, only one focus group was conducted so the purpose of theme generation is less relevant because any themes will not be generated *across* data. Normally, one could expect between three to five focus groups to ensure coverage of the range of opinions on a given topic (Morgan, 1997). Similarly, codes were not applied to the focus group transcript but quotes that were deemed relevant were highlighted.

My approach to the analysis can be described as liberal (Vogt et al., 2004). This means that the scale development is open to the inclusion of new content based on the focus group, but with care taken to not narrow conceptualisations based solely on a single focus group. That is, the omission of existing items and the addition of new items were considered based on the focus group discussion, but care was taken to avoid weighting each decision on the perspective of the single focus group.

Results

The consensus of the focus group participants was that worry was not an accurate representation of their thoughts regarding the tests, and instead preferred the term concern. As mentioned, worry and concern are likely closely related in the context of everyday language, but differ in terms of magnitude. This also occurs in academic research. For example, a recent systematic review of the conceptualisation of health anxiety (Lebel et al., 2020) appears to use ‘worry’ and ‘concern’ interchangeably. If they are indeed interchangeable terms, then why might the participants in the focus group prefer the term concern over worry when describing their perceived ionising radiation exposure? One could argue that worry describes intrusive thoughts, while concern relates more as an awareness or a topic of importance without worrisome/intrusive thoughts. However, I decided that debating whether to frame the items as ‘worried’ or ‘concerned’ was rather unimportant. Rather, what is needed is a scale that allows participants to evaluate the severity of the construct along a continuum.

Participants also discussed how their levels of worry for different items was not consistent over their lifetime. Particularly referring to items about the health of their descendants, some participants described how they were not presently worried but had been worried in the past. The following extract illustrates this effectively:

> *When they've been born I was worried, but once they've grown up a bit then the worry- When you know that they're not affected but they seem to be normal as normal can be.* (Participant 1)

Aside from the reported dynamics of exposure worry which suggested amendments (or a separate mid-life scale) were required, the focus groups provided insight into which items were perhaps not relevant. One example of this is 'item 8' regarding contaminated food:

> *The people in Cumbria might be worried about that, when Chernobyl blew up, they were blasted and told not to eat the food for a couple of year. They were breeding sheep, lambs, and the farmers were being paid for it but they were being disposed of for 2 or 3 years.* (Participant 2)

The above extract from participant 2 was in response to asking about the relevance of worry for contaminated food during the nuclear testing programme. It was apparent that it was not particularly relevant in terms of worry, and the participant states this by describing its relevance to other exposed populations.

Discussion

The consensus of the focus group was that concern was more appropriate than worry to describe their perceptions of ionising radiation exposure, but since these are assumed to lie on a single continuum (concern and worry differing in severity) a decision was made to retain the framing of items as 'worry'.

As mentioned above, the single focus group was a convenient way of gaining multiple veterans' perspectives on exposure worry, since this took place at a BNTVA annual general meeting where the veterans had busy schedules and it would have been difficult to conduct a series of individual interviews in a short space of time. A consequence of this, however, is that the data is unlikely to capture the potential nuanced discussions of multiple focus groups. Drawing on

this, I decided to not place too much weight on the findings of a single focus group and referred to the theory detailed in chapter 2 as to why worry should remain the focus of the scale.

But we must also be cautious of the fact that the participants may have been unwilling to openly relate to 'worry' because of their characteristics of being older male veterans. In Western cultures, it has been common for men to follow traditional masculine gender roles, which endorse emotional toughness and stoicism. For example, men are often exposed to 'boys don't cry' mentality as a child (Branney & White, 2008). Interestingly, it has also been suggested that men are more likely to internalise the public stigma that mental health issues are a sign of 'weakness' (i.e. believing that oneself is inferior for having mental health issues; Vogel et al., 2007). Additionally, it is known that military culture also endorses emotional toughness (Jakupcak et al., 2014), which may be relevant to this population. The role of masculinities is examined in further detail in Chapter 6.

Overall, the results of the focus group were insightful and aided our understanding of what items the scale should contain and provided the first indications of the magnitude of any exposure worry. In addition, the focus group was the first indicator that 'exposure worry' is not necessarily stable and can change in severity with respect to different life events. Therefore, a decision was made to create two separate exposure worry scales for the purpose of the project: the Current Exposure Worry Scale (Figure 3) and the Mid-Life Exposure Worry Scale (Figure 4).

While the content of the items is the same between the proposed Mid-Life and Current Exposure Worry Scales, the primary difference is the tense in which the question is presented. For example, the Mid-Life Exposure Worry Scale equivalent of 'item 1' of the Current Exposure Worry Scale would be "At a point in my life, I had been worried that my illness had been caused by my exposure to ionising radiation and/or chemical agents." This was because any relationship between worry and cognitive functioning is concerned with chronic psychological stress, hence the inclusion of a Mid-Life Exposure Worry Scale to gain an indication of worry in previous years. I remind the reader that at this point in the project, the intention was to address the hypothesis that exposure worry is associated with cognitive functioning in British nuclear test veterans.

For the Mid-Life Exposure Worry Scale, I included sub-items for each item to gather data on the duration that their worry regarding a specific aspect lasted, but only if they had rated their

worry as “5” or above because rating such a score would indicate that they agree with the item statement.

Stage II

The aim of this stage of scale development was to further validate scale items in the modified exposure worry scales in a one-to-one telephone interview scenario. A secondary aim was to gain further insight on the formatting of the scale and appropriateness of the language used.

Methods

Participants.

Four participants took part in this stage of scale development. Participants were drawn from the BNTVA. Non-BNTVA members were also eligible for participation but must have witnessed at least one nuclear weapons test. The reason is because it was initially presumed that such individuals would be worried. Therefore, these individuals were presumed the most relevant individuals to comment on exposure worry scales. A pack containing the materials was distributed to 16 test veterans (facilitated by the BNTVA). Aside from the four veterans who agreed to participate, one further nuclear test veteran had completed and returned the scales but had not consented to the telephone interviews.

Materials.

Participants were sent the proposed Current Exposure Worry Scale (Figure 3) and Mid-Life Exposure Worry Scale (Figure 4) to review prior to the telephone call.

Figure 3.

Proposed Current Exposure Worry Scale after reducing items

If you do not have children then skip question 2, 3, and 6
If you do not have grandchildren then skip question 3

#	Question	Strongly disagree			Neutral			Strongly agree
1	Whenever I am ill, I am worried that it may be a result of exposure to ionising radiation and/or exposure to chemical agents	1	2	3	4	5	6	7
2	I am worried that my exposure to ionising radiation and/or chemical agents may have affected my children	1	2	3	4	5	6	7
3	I am worried that my exposure to ionising radiation and/or chemical agents may have affected my grandchildren	1	2	3	4	5	6	7
4	I am worried that scientists are not explaining fully the effects of exposure to ionising radiation and/or chemical agents	1	2	3	4	5	6	7
5	I am worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites	1	2	3	4	5	6	7
6	I am worried that my children are worried about my exposure to ionising radiation and/or chemical agents.	1	2	3	4	5	6	7

Figure 4.

Proposed Mid-Life Exposure Worry Scale

Please circle the number that corresponds to your response
If you do not have children then skip question 2 and 3
If you do not have grandchildren then skip question 3

Please write the number of years that your worry lasted

#	Question	Strongly disagree			Neutral			Strongly agree
1	At a point in my life, I had been worried that my illness had been caused by my exposure to ionising radiation	1	2	3	4	5	6	7
	How many years did this worry last?							
2	At a point in my life, I had been worried that my children may have been affected by my exposure to ionising radiation	1	2	3	4	5	6	7
	How many years did this worry last?							
3	At a point in my life, I had been worried that my grandchildren may have been affected by my exposure to ionising radiation	1	2	3	4	5	6	7
	How many years did this worry last?							
4	At a point in my life, I had been worried that scientists were not fully explaining the effects of ionising radiation exposure	1	2	3	4	5	6	7
	How many years did this worry last?							
5	At a point in my life, I had been worried that I should have been given protective clothing at the nuclear testing sites	1	2	3	4	5	6	7
	How many years did this worry last?							
6	At a point in my life, I had been worried that my children were worried about my exposure to ionising radiation	1	2	3	4	5	6	7
	How many years did this worry last?							

Procedure.

Each interview was unrecorded and lasted a maximum of 20 minutes. During the interviews, each item was individually read aloud to the participant so that they had the opportunity to voice their opinion about each item. Participants were asked if they had any comments regarding the appropriateness of the scale. Participants were also asked about whether or not the scale items were relevant with regard to their worry and why, and if not, whether they believed that the items would be relevant to other test veterans and why. Participants were also asked if there was anything else that had not been included on the scales. While these interviews were unrecorded, hand-written notes were made in real-time to capture participants perspectives of the scales (Appendix B).

Results/discussion

Instructions appeared easy to follow, indicated by the completed and returned exposure worry scales and this was confirmed by the veterans who took part in the discussions. Therefore, no further changes to scale content or formatting were made to the Current Exposure Worry Scale (Figure 3) following this stage of development.

Regarding language, one participant suggested that concern may have been a better word than worry which was consistent with the focus group findings. According to one participant, ‘worried’ is a term used to describe a thought that is constantly on your mind whereas ‘concerned’ is regarded as less intrusive. This is consistent with the way I conceptualised worry and concern in the previous section, highlighting the difference in magnitude. Despite this, I maintained that worry should be used instead of concern due to the same reasoning mentioned in Stage I.

Regarding item content there was variation in which items were relevant to each veteran. For example, two participants stated that ‘item 6’ regarding descendants’ worry was not particularly relevant but acknowledged that it could be relevant to other veterans. Two participants also stated that worry was dynamic: one participant highlighted the role of child and grandchild’s development in any worry that he experienced, while the other participant highlighted the role of BNTVA meetings in his worry.

Aside from being an initial indicator of the dynamic of exposure worry, these telephone interviews were an early indicator of broader sociopsychological issues. For example, one participant was concerned about the intentions of the research institution where I was based and was concerned about a perception that the government were concealing information. Another participant was concerned about his experience with medical doctors and a perception that the doctor did not want to take responsibility for his issues. These issues will be later addressed in Chapter 6.

While not informed by these interviews, further modifications were made to the formatting on the proposed Mid-Life Exposure Worry scale where, rather than having participants report worry duration for each aspect of exposure worry (which may become convoluted in any future analysis), a single worry duration item was included instead to cover all mid-life items (Figure 5). For further context I added an item asking when their worry began (i.e. what year/decade), and an exploratory item asking for three most important events significant to any exposure worry.

Figure 5.

Updated Mid-Life Exposure Worry Scale following Stage III

Please circle the number that corresponds to your response

If you do not have children then skip question 2, 3, and 6

If you do not have grandchildren then skip question 3

#	Question	Strongly disagree			Neutral			Strongly agree
1	At a point in my life, I had been worried that my illness had been caused by my exposure to ionising radiation and/or chemical agents	1	2	3	4	5	6	7
2	At a point in my life, I had been worried that my children may have been affected by my exposure to ionising radiation and/or chemical agents	1	2	3	4	5	6	7
3	At a point in my life, I had been worried that my grandchildren may have been affected by my exposure to ionising radiation and/or chemical agents	1	2	3	4	5	6	7
4	At a point in my life, I had been worried that scientists were not fully explaining the effects of ionising radiation exposure and/or chemical agents	1	2	3	4	5	6	7
5	At a point in my life, I had been worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites	1	2	3	4	5	6	7
6	At a point in my life, I had been worried that my children were worried about my exposure to ionising radiation and/or chemical agents	1	2	3	4	5	6	7
7	*If you selected '5' or higher for any question, please specify how many years that your worry lasted for:*							
8	*When did this worry start?*							

9	Please list the three most important events following the nuclear testing programme that were 'sources' of your worry about the effects of radiation (e.g. the birth of your grandchildren)

Stage III

The aim of this stage of development was to examine the distribution of responses and the relationships between items on the proposed scales. The purpose of examining the relationships between items is to indicate whether certain items are underpinned by some common component. Ultimately, addressing this aim will determine the suitability of the scale for use in measuring levels of exposure worry in this sample of British nuclear test veterans.

To address this aim, an analysis of response frequencies, bivariate correlations between items, and a principal component analysis (PCA) were conducted.

Methods

Participants.

A total of 124 veterans participated in this study, completing and returning 124 Mid-Life Exposure Worry and 120 Current Exposure Worry Scales. Of these 124 participants, 66 completed the scales online while the rest had completed them in physical form and returned via post.

British nuclear test veterans from the wider nuclear community who had witnessed at least one nuclear test or were involved in the clean-up operations were eligible for participation. Research packs containing Current Exposure Worry and Mid-Life Exposure Worry scales, information sheets, and consent forms were distributed to 246 veterans listed on a GDPR-compliant NCCF mailing list. Of these 246 veterans, 146 of these were sent the scales in the format of an online survey while 100 were sent via postal.

An advert was also distributed via a quarterly magazine run by the NCCF and test veterans were able to register their interest using the contact details provided.

Materials.

The proposed Mid-Life Exposure Worry Scale (Figure 5) and proposed Current Exposure Worry Scale (Figure 3).

Procedure.

Participants who registered their interest or had been registered on the NCCF mailing list received a pack containing the two exposure worry scales, consent and information forms, and a stamped envelope. Participants used the stamped envelope to return their completed scale responses and consent forms. Participants who registered their interest online and prefer to receive information through email received an online version of the scale (see Appendix C).

Analysis.

Since the data was obtained through ordinal scales, the question of normality is not applicable. Nonetheless it is useful to examine the frequency of responses and the skew, therefore median and mean values, frequencies, percentages, and skewness for each item were calculated (Table 2). A Spearman's rho correlation analysis was conducted to explore the relationships between items on their respective scale, and PCA[15] using SPSS was also conducted to explore the extent these relationships indicated a common component between items.

Results

Overall, the pilot data for the pilot Current Exposure Worry Scale and the pilot Mid-Life Exposure Worry Scale shows, on average, that the responses are generally rated towards "strongly agree" for each item (Table 2). This is evident by the measures of central tendency being above the mid-way point and the considerable amount of negative skew. Generally, it appears that item four (scientists not fully explaining effects) and item five (lack of protective clothing) are considered more worrisome relative to worry about descendants' health (item two and item three), descendants' worry (item six), and their own health (item one).

Out of the 120 respondents who completed the pilot Current Exposure Worry Scale, a considerable percentage of valid respondents (excluding missing values) rated themselves as '7 – strongly agree' for each item (a range of 30.4% to 60.8%; see Appendix D), particularly item 4 ("I am worried that scientists are not fully explaining the effects of ionising radiation/chemical agents") and item 5 ("I am worried that I should have been given protective clothing at the nuclear and/or chemical agent testing site"), where 57.5% and 60.8% of valid

[15] PCA is typically conducted when looking to reduce scale items. Conducting a PCA for this purpose is a superfluous exercise because the scale already consists of six items proposed to measure unique aspects of exposure worry.

responses were ‘7 – strongly agree’, respectively. Furthermore, a considerable percentage of valid respondents rated themselves as ‘7 – strongly agree’ in response to item 2 (“I am worried that my exposure to ionising radiation and/or chemical agents may have affected my children”) and item 3 (“I am worried that my exposure to ionising radiation and/or chemical agents may have affected my grandchildren”). This was 45.1% and 46.8% of valid responses, respectively.

Out of the 124 respondents who completed the pilot Mid-Life Exposure Worry Scale, a considerable percentage of valid respondents (excluding missing values) rated themselves as ‘7 -strongly agree’ for each item (a range of 30.8% to 60.3%; see Appendix D). Like the Current Exposure Worry Scale, item 4 and item 5 were scored particularly high, with 56.9% and 60.3% of valid responses were ‘7 – strongly agree’, respectively. Item 1, item 2, and item 3 of the Mid-Life Exposure Worry Scale also appeared of concern, where 41.8%, 45.4% and 44.7% of valid responses were ‘7 – strongly agree’.

Table 2.

Measures of central tendency and skewness for each item on the pilot Current Exposure Worry Scale and pilot Mid-Life Exposure Worry Scale

Item	N (= 124)	Mean	Median	Std. Deviation	Skew	Skew Std. Error
Current Exposure Worry						
Item 1	119	5.28	5.00	1.63	-.82	.22
Item 2	113	5.66	6.00	1.70	-1.44	.23
Item 3	109	5.56	6.00	1.76	-1.14	.23
Item 4	120	6.08	7.00	1.33	-1.54	.22
Item 5	120	6.13	7.00	1.34	-1.60	.22
Item 6	115	5.16	5.00	1.63	-.53	.23
Mid-Life Exposure Worry						
Item 1	122	5.61	6.00	1.60	-1.11	.22
Item 2	119	5.70	6.00	1.59	-1.29	.22
Item 3	114	5.67	6.00	1.63	-1.26	.23
Item 4	123	6.04	7.00	1.39	-1.61	.22

Item 5	121	6.13	7.00	1.34	-1.70	.22
Item 6	120	5.17	5.00	1.63	-.57	.22

Note. The difference in valid scores between item two (children health), item three (grandchildren health), and item six (children's worry) of both scales is explained by the fact that not all test veterans in this sample had first generation and second-generation descendants.

The Spearman's rho correlation analysis for the Current Exposure Worry Scale items indicated that all items were significantly correlated (Appendix E). Similar findings were obtained for the Mid-Life Exposure Worry items (Appendix E). Due to the significant inter-item correlations observed, a PCA was conducted to see which items might be underpinned by principal components. To reiterate, this was exploratory to gain further insights into the nature of exposure worry, rather than to reduce scale items. As standard procedure, I set the eigenvalue level to 0.7[16], meaning that the PCA will extract components with an eigenvalue equal to above 0.7.

The PCA for the Current Exposure Worry Scale indicated one initial principal component with an eigenvalue of 1 or above, explaining 64.6% of the variance. There was also a second component with an eigenvalue of 0.72, explaining 12.0% of the variance. Although all items correlate well with one component, the rotated[17] component matrix for the Current Exposure Worry Scale suggests that items one, two, three, and six are correlated best with the first component, while items four and five are correlated best with another component (Table 3).

[16] An eigenvalue represents the amount of variation explained by a factor. It has been suggested that a criterion value is an eigenvalue greater than 1 but it has also been suggested that 0.7 is acceptable (a more liberal approach; Field, 2013).

[17] Rotation allows us to discriminate item loadings on components. It is normal for all items to load highly onto the single most important factor which makes interpretation difficult, hence why we use rotation. Here I use direct oblimin rotation because it is an oblique rotation. Oblique rotation is theoretically correct when examining variables which are, to some extent, correlated with each other (Field, 2013).

Table 3.

Pattern matrix showing pilot Current Exposure Worry Scale item loadings, and component eigenvalues and variance

	Component	
Item	1	2
Item 1 (veteran health)	.53	.36
Item 2 (children)	.88	.05
Item 3 (grandchildren)	.94	-.03
Item 4 (scientists)	-.12	.89
Item 5 (protective clothing)	.02	.85
Item 6 (children's worry)	.89	-.06
Eigenvalue	3.87	.72
Percent variance	64.6	12.0

Note. Extraction method: Principal Component Analysis. Rotation method: Oblimin with Kaiser Normalization.

Table 4.

Pattern matrix showing pilot Mid-Life Exposure Worry Scale item loadings, and component eigenvalues and variance

	Component	
Item	1	2
Item 1 (veteran health)	.55	.36
Item 2 (children)	.95	-.05
Item 3 (grandchildren)	.98	-.07
Item 4 (scientists)	-.07	.99
Item 5 (protective clothing)	.08	.89
Item 6 (children's worry)	.86	.04
Eigenvalue	3.87	1.06
Percent variance	64.4	17.7

Note. Extraction method: Principal Component Analysis. Rotation method: Oblimin with Kaiser Normalization.

Discussion

Overall, the frequency and distribution of responses for the Current Exposure Worry Scale suggests that a considerable proportion of this sample of British nuclear test veterans strongly agree that they are worried about various aspects pertaining to ionising radiation exposure. Similar observations can be made for the Mid-Life Exposure Worry scale, where most participants responded with '4 – neutral' or higher for each item. Further examination of scale responses is required with a modified scale intended to reduce any potential skew, to elucidate the extent that participants are worried about the various aspects of perceived ionising radiation exposure.

I decided that both the Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale would be extended to 8-point scales. This is because an 8-point scale should increase response variation by removing a 'safe' middle option so that participants are forced into agreeing or disagreeing with each statement. While normal distribution is irrelevant to ordinal data, examining the high negative skew (Table 2) for both scales may suggest that the scale format influences participants to respond in a certain way. It was anticipated that removing "Neutral" (the 'safe' middle option) from the scale should help further adjust the negative skew. At this point in the project, I decided that it is not sensible to include a "Neutral" response for rating worry statements because it is difficult to distinguish between feeling neutral/indifferent and disagreeing with a worry statement (i.e. not being worried).

Finally, a 7th item was added to the Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale to capture the extent that exposure worry causes stress. This is because it is likely the stress associated with excessive worry which impacts cognitive functioning (Aggarwal et al., 2014; Munoz et al., 2015). Additionally, rating exposure worry along a scale labelled with levels of agreement may not capture the extent of the worry. For example, rating oneself as "Strongly agree" would indeed indicate that there is worry about a particular item, and another individual may also rate oneself as "Strongly agree" but their worry may be far more excessive than the first individual. Therefore, rating oneself on an item about the extent to which it makes one feel nervous or stressed is a way of distinguishing excessive worriers from non-excessive worriers.

While the intention was not to reduce scale items, the PCA findings must be commented on because they shed light regarding what the items may actually be measuring. For both the

Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale, the analysis suggested that the scale could be reduced to two components which would account for between 75% and 80% of the variance. This could be interpreted in the following way: the first component (item one, two, three, and six) is likely to relate to worry about the health in themselves and the physical and mental health of their family members (perhaps termed 'wellbeing'), while the second component (item four and five) is likely to relate more to some other component (perhaps a sociopsychological component relating to the role of authorities and scientists). One could posit that this second component may not be wholly relevant to exposure worry; a consideration made in hindsight following the qualitative study of Chapter 6 whereby anger and frustration regarding perceived deception was a pertinent discussion and appeared to contribute to the psychological impact.

Despite this, any benefit of reducing items might not outweigh the potential loss of validity and as such a decision was made to retain all six items on the Current Exposure Worry Scale based on the following reasons. Firstly, the introduction of a new unified item will not have received the same validation or scrutiny word-for-word that the other items had received during the focus groups and telephone interviews. Secondly, although worry about the effect on themselves (item one), children (item two) and grandchildren (item three) would be logical to combine into a single item (e.g. worry about health effects), there remains the possibility that worry about the effect on children is temporally distinct from worry about the effect on their grandchildren. For example, one may be worried about the effect on their children because of developed health conditions but may not be worried about the effect on their grandchildren because any illnesses (related or unrelated to radiation exposure) have not been developed yet. It could also be that there is little worry about the effect on their children if their children have grown to be illness-free, but worry about the effect on their grandchildren may persist because the long-term health status of their grandchildren is yet to be realised. The same can be said for worry about the effect on themselves compared to children and grandchildren.

To summarise, this chapter has presented three stages of scale development, involving a single focus group discussion with six nuclear test veterans and two of their wives to determine the inclusion and relevance of scale items (and appropriateness of the language used), four informal individual telephone discussions providing further insight into the language and scale format, and quantitative data collection serving to pilot the scale and examine the skew of responses. The output of this chapter is two scales: the Current Exposure Worry Scale to

measure exposure worry at present, and the Mid-Life Exposure Worry Scale to measure exposure worry over the lifetime. The final Current Exposure Worry Scale (Figure 6) designed to capture British nuclear test veterans' level of agreement to worry statements pertaining to 6 different components, along with the aforementioned 7th stress item to capture the extent that radiation-related worry causes stress, is shown below. The final Mid-Life Exposure Worry Scale (Figure 7) includes a further exploratory item (item 8) to examine the duration (in years) that their worry lasted for. This question was included to limit the ambiguity of the mid-life questions ("At a point in my life…"). The purpose of this item was to gain a quantitative measure indicating the persistence of exposure worry across a lifetime, which could then be examined in relation to cognitive functioning. These two scales will now be used in the subsequent chapter to address the first research question comprising this thesis.

Figure 6.

Final Current Exposure Worry Scale

	1 Strongly disagree	2	3	4	5	6	7	8 Strongly agree
1. Whenever I am ill, I am worried that it may be a result of exposure to ionising radiation and/or exposure to chemical agents.	O	O	O	O	O	O	O	O
2. I am worried that my exposure to ionising radiation and/or chemical agents may have affected my children.	O	O	O	O	O	O	O	O
3. I am worried that my exposure to ionising radiation and/or chemical agents may have affected my grandchildren.	O	O	O	O	O	O	O	O
4. I am worried that scientists are not explaining fully the effects of exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
5. I am worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites.	O	O	O	O	O	O	O	O
6. I am worried that my children are worried about my exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
7. My worry about my exposure to ionising radiation and/or chemical agents makes me feel nervous or stressed.	O	O	O	O	O	O	O	O

Figure 7.

Final Mid-Life Exposure Worry Scale

	1 Strongly disagree	2	3	4	5	6	7	8 Strongly agree
1. At a point in my life, I had been worried that my illness had been caused by my exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
2. At a point in my life, I had been worried that my children may have been affected by my exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
3. At a point in my life, I had been worried that my grandchildren may have been affected by my exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
4. At a point in my life, I had been worried that scientists were not fully explaining the effects of ionising radiation exposure and/or chemical agents.	O	O	O	O	O	O	O	O
5. At a point in my life, I had been worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites.	O	O	O	O	O	O	O	O
6. At a point in my life, I had been worried that my children were worried about my exposure to ionising radiation and/or chemical agents.	O	O	O	O	O	O	O	O
7. At a point in my life, my worry about my exposure to ionising radiation and/or chemical agents has made me feel nervous or stressed.	O	O	O	O	O	O	O	O

8. If you selected '5' or higher for any question, please specify the number of years that your worry lasted for:

Chapter 5 – Measuring Exposure Worry in British Nuclear Test Veterans

The previous chapter detailed the process for developing two exposure worry scales which will be used in the present chapter. This will address the first research question of this thesis:

I. What are the levels of exposure worry in a sample of British nuclear test veterans?
    a. What specific aspects of exposure worry do British nuclear test veterans report?
    b. To what extent do British nuclear test veterans report feeling stressed as a result of their worry about ionising radiation exposure?

The preliminary data obtained using the pilot versions of the Current Exposure Worry Scale and the Mid-Life Exposure Worry scale indicated that a considerable number of participants agree (to varying extents) that they are worried about various aspects of perceived ionising radiation exposure at present but also earlier in life. The scale formatting may be one factor influencing the skew of responses and this has been addressed by modifying the scale. Moreover, the preliminary analysis is somewhat limited because it does not provide an indicator as to what types of British nuclear test veterans (i.e. their roles, location, or national service status during the tests) are worried about regarding perceived ionising radiation exposure. This is important because veterans in the programme had various roles and may have different perceptions of any exposure, for example due to the nature of the role or the proximity to the test sites. Analysing the differences in worry scores based on their role in the testing programme, their location during the testing programme, and their national service status, also begins to address the third research question of this thesis: understanding the factors associated with exposure worry in British nuclear test veterans.

The initial rationale for measuring exposure worry was to examine the relationship between exposure worry and cognitive functioning. Such an analysis would originally have formed most of this chapter, but as described previously, the caveats of a design aiming to address this led the research down a different path. Therefore, the aims of this chapter are as follows:

1) To re-examine the frequency of worry scores in terms of distribution and skew of responses, and to examine the frequency of participants who feel stressed because of any worry, using the finalised Current Exposure Worry Scale.
2) To determine the usefulness of the Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale.

3) To examine average scores in categories of British nuclear test veterans, based on where they were stationed, their role in the programme, and whether they participated in the programme through national service. These aims are exploratory, serving to provide further insight into exposure worry and psychological stress in British nuclear test veterans.

To address these aims, this chapter presents a quantitative study examining the responses of 91 British nuclear test veterans using the final Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale. This chapter then examines the differences in responses in the context of the British nuclear test veterans' role, location, and national service status during the nuclear testing programme. Lastly, I reflect on the usefulness of the Current Exposure Worry and Mid-Life Exposure Worry scales to measure worry in British nuclear test veterans.

Methods

Participants.

A total of 91 test veterans participated in this study (see Table 12 on page 178 for details on sociodemographic characteristics of the sample). The participants were test veterans from the wider nuclear community who had witnessed at least one nuclear test or were involved in the clean-up operations. Research packs were distributed to the same 246 test veterans listed on a GDPR-compliant NCCF mailing list who had been contacted in the previous scale development stages of this project. One-hundred and forty-six of these were in the format of an online survey and 100 were postal. An advert was also distributed via a quarterly magazine run by the NCCF and test veterans were able to register their interest using the contact details provided. The study was approved by the University Research Ethics Committee (Appendix F).

There are two possible reasons for the smaller sample size in this study compared to the piloted work in Chapter 4. Firstly, the final Current Exposure Worry and Mid-Life Exposure Worry scales have subtle amendments to the piloted versions of the scales, so it is possible that some participants thought that they were being invited back to the same study. Secondly, in addition to rating levels of worry along such scales and completing a sociodemographic questionnaire, the present study involved a cognitive assessment which is effortful and not necessarily a

benign task either. Therefore, some participants may have been deterred from participation in that regard.

Materials.

Both online and physical research packs contained a consent form, information sheet and debrief (see Appendix F). The physical research packs also contained a spare stamped envelope for the participant to return their consent forms and data.

Both research packs also contained the final Current Exposure Worry (Figure 6) and Mid-Life Exposure Worry scales (Figure 7). A questionnaire was included which gathered data on age, sociodemographic information, details about their involvement in the nuclear testing programme, lifestyle factors (alcohol consumption and cigarette smoking), and illness beliefs (Appendix G).

It must be noted that the original intention of examining cognitive functioning naturally dictated the type of data collected. For example, sociodemographic information such as principal lifetime occupation, educational attainment, and index of multiple deprivation (indicated by postcode matched with government statistics) served as proxy measures of socioeconomic status, which is known to be associated with poorer cognitive functioning in later life (Künzi et al., 2021; Yang et al., 2016; Zhang et al., 2015; Zhao et al., 2005). Moreover, current smoking (Anstey et al., 2007), excessive alcohol consumption (Sabia et al., 2014), general anxiety (Gulpers et al., 2019), and of course age (Salthouse, 1994, 2012), have been identified as predictors of cognitive functioning and thus data was collected on these as further covariates. Since cognitive functioning is not analysed in this chapter, these covariates were not analysed either.

Procedure.

Research packs were returned physically and online along with a signed consent form to mark their participation, and an option to participate in a telephone cognitive assessment (Montreal Cognitive Assessment-BLIND; MoCA-BLIND; Nasreddine et al., 2005).

Analysis.

To examine whether extending the scale items to 8-points reduced skew (thus removing the 'safe' middle option), an analysis of frequency and skewness was carried out for each of the six worry items and for the new 7th item. The purpose of this was also to examine the extent this sample are worried about various aspects of ionising radiation exposure, and the extent that this worry is excessive to the point that it makes them feel nervous or stressed.

To further understand the relationship between items constituting exposure worry and the possible components which underlie these items, a PCA was conducted using the same parameters as the PCA of Chapter 4.

Median worry and stress scores were calculated for each category of test veteran. The purpose of this was exploratory, and to begin gaining insight into exposure worry. As such, there was no directional hypothesis to expect certain groups of test veterans to have a higher tendency to agree that they feel stressed because of their exposure worry. The participants were organised into the following categories: the role in the testing programme, the location of where they were stationed, and lastly, whether they were in the programme because of national service. This data was gathered using open-ended questions such as "Where were you stationed?" and "What was your role in the testing programme?".

Regarding the locations where these veterans were stationed, the categorization of responses is self-explanatory since most participants stated, "Christmas Island" or "Maralinga". A third category was used labelled "Other" used for participants stationed at the Montebello Islands, Malden Island, and individual cases such as Kwajalein.

Regarding the roles of these veterans during the programme, since the purpose was to capture the nature of the tasks involved, environments and possible modes of exposures, roles were categorized into 'Ship', 'Clean-up', 'Plane', and 'Ground'. The justification for this is that it was suspected that different roles (and their associated tasks) may be related to different modes of exposure, based on anecdotal evidence. For example, newspaper articles by *The Mirror* reported that veterans flying in planes or being stationed on ships have described travelling through the cloud to collect samples. Those categorized in 'Ground' may not have undertaken such activities but may perceive their exposure through other forms such as walking on ground perceived to be contaminated or handling contaminated materials.

Regarding national service status, the data was elicited through a closed yes/no question and categorized as such.

The median scores in relation to the veterans' role, location, and national service status were examined using the Kruskall-Wallis test.

Results

A total of 91 Current Exposure Worry and 90 Mid-Life Exposure Worry scales were completed (total $n = 91$ participants). Of course, median scores of the scales cannot be compared to median scores obtained in scale piloting because the scale length is different, but median scores for each scale item are at least 5 and above (Table 5). Therefore, on average there is a tendency to agree that worry is experienced in relation to varying aspects of exposure worry. The skew statistics indicates that the extension to an 8-point scale for both the Current and Mid-Life Exposure Worry Scales was relatively effective in reducing skew, when compared to the skew statistics obtained in scale piloting.

Regarding the frequency of responses for Current Exposure Worry items (See Table 6), 16.5% strongly agreed with the statement for item 1 "Whenever I am ill, I am worried that it may be a result of exposure to ionizing radiation and/or chemical agents". For item 2, 31.3% strongly agreed with the statement "I am worried that my exposure to ionizing radiation and/or chemical agents may have affected my children". For item 3, 28.0% strongly agreed with the statement "I am worried that my exposure to ionizing radiation and/or chemical agents may have affected my grandchildren". For item 4, 51.6% strongly agreed with the statement "I am worried that scientists are not fully explaining the effects of ionizing radiation/chemical agents". For item 5, 56.7% strongly agreed with the statement "I am worried that I should have been given protective clothing at the nuclear and/or chemical agent testing site". For item 6, 27.4% strongly agreed with the statement "I am worried that my children are worried about my exposure to ionizing radiation and/or chemical agents". Each of these percentages are lower than the percentages rating '7-strongly agree' in the pilot stages of the scale. Taking the maximum score across each item, 67.0% of all respondents responded '8- Strongly agree' to at least one item on the Current Exposure Worry Scale (Appendix H). Regarding the stress item, 13.5% strongly agreed while 24.7% strongly disagreed with the statement "My worry about my exposure to ionizing radiation and/or chemical agents makes me feel nervous or stressed". If we dichotomise the stress item into 'disagree' and 'agree', 53.9% of valid respondents

disagreed, while 46.1% of valid respondents agreed that their exposure worry makes them feel stressed. I regard the stress item as a more accurate measure of actual worry, and these findings indicate that exposure worry may indeed be a significant issue in roughly half of this sample.

Table 5.

Measures of central tendency and skewness for each item on the final Current Exposure Worry Scale and final Mid-Life Exposure Worry Scale

Item	N (= 91)	Mean	Median	Std. Deviation	Skew	Skew Std. Error
Current Exposure Worry						
Item 1	91	4.74	5.00	2.26	-.10	.25
Item 2	83	5.54	6.00	2.34	-.66	.26
Item 3	75	5.36	6.00	2.40	-.57	.28
Item 4	91	6.42	8.00	2.24	-1.37	.25
Item 5	90	6.43	8.00	2.26	-1.29	.25
Item 6	84	4.90	5.00	2.56	-.22	.26
Item 7 (Stress)	89	4.08	4.00	2.46	.15	.25
Mid-Life Exposure Worry						
Item 1	89	5.58	6.00	2.49	-.67	.26
Item 2	83	5.66	6.00	2.40	-.65	.26
Item 3	76	5.36	6.00	2.59	-.59	.28
Item 4	90	6.57	8.00	2.10	-1.49	.25
Item 5	87	6.34	7.00	2.18	-1.22	.26
Item 6	82	4.95	5.00	2.56	-.28	.27
Item 7 (Stress)	89	4.58	5.00	2.47	-.11	.26

Note. The difference in valid scores between item two (children health), item three (grandchildren health), and item six (children's worry) of both scales compared to the other items is explained by the fact that not all test veterans in this sample had first generation and second-generation descendants.

The responses on the Mid-Life Exposure Worry scale (Table 7) are comparable to the Current Exposure Worry Scale, but generally it appears that higher percentages of this sample report being more worried regarding the different items in the past (mid-life) compared to present day (current). Generally, higher percentages of this sample regarded themselves as currently less stressed in comparison to being stressed because of their worry at a point in their life.

Table 6.

Percentages of valid responses for Current Exposure Worry Scale items

	Extent of agreement							
	1	2	3	4	5	6	7	8
Item 1	11.0%	9.9%	8.8%	14.3%	19.8%	13.2%	6.6%	16.5%
Item 2	10.8%	4.8%	2.4%	12.0%	12.0%	18.1%	8.4%	31.3%
Item 3	13.3%	4.0%	2.7%	13.3%	13.3%	14.7%	10.7%	28.0%
Item 4	7.7%	4.4%	0.0%	4.4%	12.1%	4.4%	15.4%	51.6%
Item 5	6.7%	4.4%	2.2%	5.6%	8.9%	7.8%	7.8%	56.7%
Item 6	16.7%	8.3%	4.8%	9.5%	20.2%	7.1%	6.0%	27.4%
Stress	24.7%	9.0%	10.1%	10.1%	14.6%	12.4%	5.6%	13.5%

Note. 1 and 8 and end-anchored with "strongly disagree" and "strongly agree", respectively. Percentages out of valid responses only (excluding missing data).

Table 7.

Percentages of valid responses for Mid-Life Exposure Worry Scale items

	Extent of agreement							
	1	2	3	4	5	6	7	8
Item 1	11.2%	7.9%	4.5%	3.4%	15.7%	11.2%	10.1%	36.0%
Item 2	9.6%	6.0%	1.2%	15.7%	10.8%	9.6%	9.6%	37.3%
Item 3	17.1%	5.3%	0.0%	9.2%	14.5%	11.8%	9.2%	32.9%
Item 4	5.6%	4.4%	0.0%	5.6%	7.8%	10.0%	12.2%	54.4%
Item 5	5.7%	4.6%	2.3%	5.7%	10.3%	10.3%	11.5%	49.4%
Item 6	15.9%	9.8%	3.7%	11.0%	14.6%	9.8%	9.8%	25.6%
Stress	19.1%	6.7%	9.0%	10.1%	14.6%	16.9%	4.5%	19.1%

Note. 1 and 8 are end-anchored with "strongly disagree" and "strongly agree", respectively. Percentages out of valid responses only (excluding missing data).

Due to the similar distribution of responses regarding the Mid-Life Exposure Worry Scale and Current Exposure Worry Scale, a Spearman's rho bivariate correlation analysis was conducted on each item of their respective scales (Appendix I). The analysis indicated a high correlation between each Current Exposure Worry item scores and Mid-Life Exposure Worry item scores (Spearman correlation coefficient = > .50, $p < .01$). The importance of this is addressed in the discussion, and the Mid-Life Exposure Worry Scale is omitted from any further analysis.

A PCA was then conducted using the Current Exposure Worry Scale data. As standard procedure, I set the eigenvalue level to 0.7, meaning that the PCA will extract components with an eigenvalue equal to above 0.7.

Table 8.

Pattern matrix showing Current Exposure Worry Scale item loadings, and component eigenvalues and variance

	Component	
Item	1	2
Item 1 (veteran health)	.68	.01
Item 2 (children)	.89	-.01
Item 3 (grandchildren)	.93	-.02
Item 4 (scientists)	.03	.88
Item 5 (protective clothing)	-.03	.92
Item 6 (children's worry)	.88	.01
Eigenvalue	3.73	.81
Percent variance	62.09	13.42

Note. Extraction method: Principal Component Analysis. Rotation method: Oblimin with Kaiser Normalization.

The PCA for the Current Exposure Worry Scale indicated one initial principal component with an eigenvalue of 1 or above, explaining 62.09% of the variance. There was also a second component with an eigenvalue of 0.81, explaining 13.42% of the variance. The rotated component matrix for the Current Exposure Worry Scale suggests that item one, two, three,

and six are correlated well with one component, while item four and five are correlated well with another component (Table 8).

Table 9.

Summary of role, location, and national service status in British nuclear test veterans during the nuclear testing programme (n = 91)

Categories	N (= 91)	%	
		Percent	Excluding MD
Role			
Clean-up	4	4.4	4.9
Driver	5	5.5	6.1
Ground	58	63.7	70.7
Plane	2	2.2	2.4
Ship	13	14.3	15.9
Location			
Christmas Island	60	65.9	72.3
Maralinga	13	14.3	15.7
Other	10	11.0	12.0
National service			
Yes	31	34.1	35.6
No	56	61.5	64.4

Note. 'Other' location category includes Malden Island, Montebello Islands, and Kwajalein.

Descriptive statistics for location, role, and national service status are provided in Table 9. Most test veterans were classified as ground crew in this study, which consisted of veterans who were involved in engineering, communications, and RAF ground crew (forming 70.7% of participants after excluding missing data). There were relatively fewer test veterans in other roles which is representative of the proportion of test veterans in each role at the time of the testing programme. Most test veterans in this sample were involved in the programme through enlistment (64.4%), as opposed to involvement through national service (35.6%). Most veterans in this sample participated in the nuclear testing programme at Christmas Island (72.3%), while relatively fewer at Maralinga (15.7%). Relatively fewer were involved at

Malden Island, Montebello Islands, and individual cases such as Kwajalein which form a group labelled 'Other' (12%).

A Kruskall-Wallis test (Table 10) for differences on each Current Exposure Worry item (item 1 to item 6) and stress item (item 7) across role (Ground vs. Driver vs. Clean-up vs. Plane vs. Ship), location (Christmas Island vs. Maralinga vs. Other), and national service (yes vs. no) indicated no significant differences on any item ($p > .05$). Thus, no post-hoc tests were conducted.

Table 10.

Kruskall-Wallis test summary for role, location, and national service status

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Stress
Role	.231	.385	.551	.081	.153	.223	.504
Location	.214	.671	.988	.246	.967	.506	.726
Nat. Serv.	.525	.175	.146	.438	.932	.504	.731

Note. Asymptotic significance values (2-sided) are displayed for each item in relation to different categories. The significance level is .05.

Discussion

There are concerns regarding the Mid-Life Exposure Worry scale suggesting limited value which must be acknowledged first before discussing the findings. This in turn will address the research sub-question regarding the usefulness of the exposure worry scales.

To begin, one should consider the accuracy of retrospective accounts of worry when asked to reduce experiences of worry to numbers on a scale. In particular, the vague framing of the items (e.g. "At a point in my life…") could lead to inaccuracies between participants. For example, the participants are older adults and have many years of experiences, so it is difficult for participants to summarise a lifetime of thought-processes where levels of worry are likely to differ, especially when the items do not specify *when* they had been worried.

The Mid-Life Exposure Worry scale is also likely irrelevant in relation to cognitive functioning, since it is persistent worry which is of interest and not specific points in time, which might be captured by the mid-life scale. The vague framing of the Mid-Life Exposure Worry scale leads one to question whether it includes how the individual feels *now*, since it is

framed as "At a point in my life…" which may be interpreted as including the present. A quick Spearman's rho correlation analysis of Current Exposure Worry stress scores and Mid-Life Exposure Worry stress score indicated that they were significantly correlated ($\rho = .856$; $p < .001$; see Appendix I). This level of correlation is especially high which leads one to consider that the Mid-Life Exposure Worry scores are, to an extent, rated based on how a participant feels more recently (i.e. Current Exposure Worry scores).

Conversely, this high degree of correlation between stress scores could lead one to interpret that the veterans who scored high on both scales were persistently stressed (and worried) across a lifetime. To counter this argument, we can briefly examine data from an item not used in any analysis on this chapter. As described on page 80, an 8th item (Figure 7) was included to the Mid-Life Exposure Worry scale to gain an indication of the number of years a veteran's exposure worry lasted for. This was intended to be examined in relation to cognitive functioning and provide insight into the persistence of the worry. But, importantly, this item further presents a limitation of the Mid-Life Exposure Worry scale. Since the item was an open question[18], not all participants provided a quantitative response (i.e. years of worry) but rather responded qualitatively which may capture the complex nature of exposure worry. Out of 65 valid responses, 41.5% of responses could be regarded as a qualitative response while 58.5% of responses are regarded as a quantitative response (Appendix J). Furthermore, 18.5% of the total responses could be interpreted as 'sporadic' in their worry duration descriptions (primarily from the qualitative responses). This demonstrates that the persistence of exposure worry is beyond measurable through quantitative means, especially when examining worry (or lack of) over a lifetime using the Mid-Life Exposure Worry scale.

Due to these limitations regarding the Mid-Life Exposure Worry Scale, the Current Exposure Worry Scale is likely to be more useful in comparison, and we can obtain relatively more meaningful findings. As such, the Mid-Life Exposure Worry scale data was omitted from the Kruskall-Wallis test across groups and omitted from any subsequent analysis in this thesis due to a lack of confidence in what the scale is measuring.

[18] The open-question formatting of this item was not a necessarily a hindrance but demonstrates that such a closed item on the Mid-Life Exposure Worry scale could misguide the research if participants are reducing the length of their worry into the number of years (issues pertaining to quantitative measures in the construction of data is discussed on page 98).

Now that the issues concerning the Mid-Life Exposure Worry Scale have been dealt with, we must turn our attention to the Current Exposure Worry Scale. Of note, the degree of skewness is reduced for each item in the final Current Exposure Worry Scale, compared to the piloted version. It cannot be concluded that extending to 8-points was solely responsible for reducing skew, since we could not guarantee that the same participants took part in both the previous stage of scale piloting and this present stage of study. Despite this, the present 91 respondents might be primarily comprised of respondents participating in the earlier stages of study because many will have maintained their interest in the project. Nevertheless, the relatively low amount of skew in the final Current Exposure Worry Scale indicates that this is a balanced scale to measure the extent one agrees that they are worried about various aspects of exposure worry. I will now discuss the findings obtained using the Current Exposure Worry Scale.

One aim of this chapter was to examine the extent that veterans were worried about their perceived ionising radiation exposure. It appeared that this sample were more worried about aspects relating to a lack of protective clothing and scientists not explaining the full effects of exposure, then worry about their descendants' health, followed by worry about one's own health. While statistical significance was not analysed, these findings regarding descendants' health and their own health is consistent with the age-trends of worry content in general older adults (Gonçalves & Byrne, 2013; Miloyan et al., 2014) and in the context of the Fukushima accident (Suzuki et al., 2015), whereby older adults generally report being more worried about the welfare of loved ones (e.g., family members) compared to their own welfare. The observation that this sample are predominantly worried about scientists not fully explaining the effects of ionising radiation exposure (item 4) and about insufficient protective clothing during the testing programme (item 5), may be unusual since the presumption (based on the literature review) is that worry in the context of radiation exposures should primarily be related to adverse health effects in themselves, and more so in their descendants.

One possibility for this is that item 4 and item 5 are representing attitudes towards authorities who were overseeing the nuclear weapons testing programme, namely scientists and the government. Since worry that scientists are not fully explaining the effects of ionising radiation and worry about lack of protective equipment (item 4 and 5, respectively) should relate to adverse effects on health (as presumed), one would expect each item to be scored similarly to item one, item two, and item three. Therefore, item 4 and item 5 could be relating to some underlying component in the realm of perceived deception or negligence. This was evident in

the PCA analysis of the piloted 7-point Current Exposure Worry Scale in Chapter 4 and indeed evident in the PCA analysis of the 8-point Current Exposure Worry Scale in the present chapter. In other words, one may perceive that their efforts in the testing programme were operating under deception which may lead to one experiencing anger, frustration, and shame (the latter described by one participant in the qualitative study of Chapter 6) which one wishes to voice through the scale. Further examination, through in-depth qualitative methods, was required to understand whether items 4 and item 5 are representing worry or rather other thought-processes (and emotions) in the context of perceived ionising radiation exposure.

It is difficult to compare the distribution of responses with worry data obtained in other contexts. There are very few anxiety or worry scales in the context of ionising radiation exposure. One is the Radiation-Anxiety Scale (a 4-point 7-item scale; Fukasawa et al., 2017) which was distributed to populations residing in the Fukushima prefecture and showed mean total score for older adults (65+) to be 14.4. This could indicate an average response of about 2.1 per item (just above the mid-way point of the scale). Regarding the Current Exposure Worry Scale, the mean responses for each item were also above the mid-way point, but could be considered in excess of the average score for the Radiation-Anxiety Scale (Fukasawa et al., 2017) for some items. I urge caution when comparing these findings to Fukasawa et al. (2017) for the following reasons: firstly, one item of the Radiation-Anxiety Scale (Fukasawa et al., 2017) is framed as 'fear' ("I am afraid…") which may lead to underestimations when reporting worry (or in Fukasawa et al.'s case, 'anxiety'), due to differences in the meaning of fear and anxiety (and worry, for that matter). Secondly, two items from the Radiation-Anxiety Scale are framed as 'concern' which may lead to overestimations of anxiety. Thirdly, while the Radiation-Anxiety Scale is also end-anchored with 'strongly disagree' and 'strongly agree', the scale length and item content are different to the Current Exposure Worry Scale, which is self-explanatory. Lastly, Fukasawa et al. (2017) combine responses to produce a mean total score and it is uncertain what the average responses are for each specific scale item; this is a method I have critiqued earlier in this thesis. Nevertheless, in comparison, the British nuclear test veteran data indicates that a substantial proportion are worried about varying aspects of perceived ionising radiation exposure and could be cause for concern.

However, since worry is a normal thought process found in all individuals and some individuals may equate worry to concern, it is difficult to identify which individuals are excessively worried based on the initial six items alone. Therefore, we must examine the 7th item which

measures extent that the worry makes one feel nervous or stressed. Excessive worry is of course of greater importance than normal worry since excessive worry (or clinically relevant worry) can cause functional impairment (McKnight et al., 2016). Compared to the six worry items, there was a greater variation in responses regarding the extent that radiation-related worry makes them feel nervous or stressed. The average score for the 7th item of the Current Exposure Worry Scale is 4.08, which may in fact be a better indicator of excessive worry and could be more comparable to Fukasawa et al.'s (2017) report.

We can also use these scale findings to extend our understanding about the mental health issues faced by nuclear test veterans indicated by previous quantitative survey studies such as the health needs audit (Miles et al., 2011), the recent BNTVA-commissioned Nuclear Families report (Alexis-Martin et al., 2019), and the recent survey study of New Zealand nuclear test veterans (Dockerty et al., 2020). While all three survey studies (Alexis-Martin et al., 2019; Dockerty et al., 2020; Miles et al., 2011) present basic quantitative self-report evidence for general anxiety and as such are not comparable to the present exposure worry data[19], the present study goes further and quantifies the specific content of their worry. This is the first study to do so with British nuclear test veterans.

The final aim of this chapter was to identify whether some types of nuclear test veterans report being more worried or stressed due to exposure worry than other types of nuclear veterans. There was no significant difference in worry scores or the extent to which their worry made the individual feel stressed, between those who participated in the nuclear testing programme through national service compared to those who were not enlisted through national service. While the analysis was exploratory with no directional hypothesis, one might have suspected that those who participated through national service may experience higher levels of stress compared to those who were not enlisted through national service. A possible rationale for this was based on the findings from the later qualitative work in Chapter 6 where some veterans emphasised the lack of choice due to national service, leading to a sense of resentment. There are two possibilities for this non-significant finding: Firstly, participants are indeed measuring levels of worry and are not influenced by emotions such as anger (one could presume those involved through national service may show more resentment due to lack of choice). Secondly, an alternate view is that ratings of worry are indeed influenced by other emotions such as anger

[19] The findings of these previous survey studies will be discussed later in Chapter 7 in relation to general anxiety.

and that there are no differences in the extent of worry and anger experienced by those enlisted through national service or not.

Regarding roles, the analysis suggests that there is no significant difference for each worry item or stress item between the different roles of the veterans during the testing programme. The primary issue with examining role is that there are highly unequal numbers of participants assigned to each role, and some roles have so few participants (see 'Plane' category) that no meaningful conclusions can established from this analysis (this is also applicable to location and national service to a relatively lesser extent). This is unfortunate since the veterans who were aircraft crew members ('Plane') may perceive themselves to have been exposed through modes unique to their role, but as expected there were few aircraft members in this study which is representative of the number of aircraft crew members involved in the testing programme and who were alive at the time of data collection. Drawing on this, the roles and associated tasks of the veterans in the testing programme may overlap and any modes of exposure may not be adequately captured in this quantitative work merely by examining role and location. A qualitative approach is required to explore the in-depth experiences of the testing programme and how this relates to any exposure worry.

Regarding the location where the veterans participated in the nuclear testing programme, the analysis indicated no significant difference in worry scores or the tendency to agree that any worry made them feel stressed, between those stationed at Christmas Island, Maralinga, or other locations (primarily Malden Island or Montebello). Like the analysis regarding role and national service, this analysis was exploratory in that there was no directional hypothesis prior to analysis. One might have suspected that those who participated at Maralinga may be more worried due to higher perceived exposure, since the environment at Maralinga was dusty and detonations often occurred at or near ground level (Maclellan, 2017), therefore there is the increased risk of inhaling radioactive material (G. M. Kendall et al., 2004). The fact that there was no significant difference in any worry (and stress due to worry) between locations suggests that location is unimportant in the psychological impact. Noted above, one may perceive greater exposure due to the dusty conditions of Maralinga compared to the Pacific Island tests, but numerous tests of various types (altitude, type of detonation, magnitude) and perceived modes of exposure may differ between individuals. After all, ionising radiation is considered 'invisible' without dosimetry (Vyner, 1988) thus is it impossible for potentially exposed individuals to determine where and what is contaminated.

While the following studies do not look at worry or anxiety regarding radiation specifically, they are worth examining with regards to location. In the context of the Chernobyl power plant accident, Havenaar et al. (1997) and Beehler et al. (2008) found no significant difference in general anxiety between regions differing by contamination level, but higher depression subscale scores were observed in residents living in more exposed (Gomel) compared to less exposed region (Tver; Havenaar et al., 1997). This finding regarding depression may be explained by difference in perceived health status between the Gomel and Tver (Havenaar, Rumyantzeva, Kasyanenko, et al., 1997). Indeed, general psychological distress was higher in the Gomel region (Havenaar, Rumyantzeva, Kasyanenko, et al., 1997). A recent study by Bolt et al (2018) observed no difference in anxiety disorders (social phobia, agoraphobia, generalized anxiety disorder and panic disorder) between those who had lived in the disaster-affected zone and those who did not. Regarding non-radiological contaminants, Gallacher et al. (2007) demonstrate using survey data from individuals in areas near the Sea Empress oil tanker spill that is it not the location which is important (living in an oil-exposed community compared to an unexposed community), but rather the general belief that one is exposed to a contaminant which is important in predicting psychological effects, namely anxiety and depression.

Conversely, Cwikel et al. (2000) and Foster (2002) found significantly higher levels of long-term general anxiety in immigrants from more exposed areas/closer in proximity to the accident compared to immigrants from less exposed areas/further away from the accident. The inconsistent findings in the context of proximity/contamination level are likely explained by difficulties in accurately assessing proximity to radiological hazards (amount of time passed since the accident and the inability to determine dose levels on an individual basis), differences between proximity thresholds, and differences between studies in anxiety-related measures (e.g. clinical diagnoses vs. subclinical scale measures). Moreover, these studies examine general anxiety rather than anxiety or worry regarding radiation exposure, and there is likely a multitude of factors (not related to contamination level) impacting on general anxiety considering the time elapsed since Chernobyl. Similarly, there is likely to be a multitude of factors impacting on exposure worry considering the time elapsed since the British nuclear testing programme. An in-depth qualitative study could shed light on the relevant factors occurring over the life course which may impact on exposure worry.

Conclusion

Due to the lack of significant differences between categories within national service status, location, and role, accompanied by methodological concerns due to limited sample sizes for certain categories, no conclusions can be drawn to suggest that certain groups of nuclear test veterans are more worried than other groups. Moreover, it appears that not all the British nuclear test veterans in this sample are worried to the extent that it makes them feel stressed, and that responses on this particular item are rather diverse. It is therefore important to conduct further research to examine in-depth why certain test veterans are worried about their perceived ionising radiation exposure, since it is speculated that 'exposure worry' is a phenomenon too complicated to be measured accurately using quantitative methods. Following this, it would be inappropriate to use this quantitative scale in a study examining the impact of exposure worry on cognitive functioning, despite cognitive functioning data having already been collected. It was deemed sensible to later decide on, if at all, the most appropriate way of incorporating the cognitive functioning data in the analysis following insights from a qualitative study. Described in the following chapter, this qualitative exploratory study would also provide insight on the broader psychological issues relevant to British nuclear testing programmes, since it may not be solely exposure worry that is the central issue, as indicated by the PCA analysis findings.

Chapter 6 – Exploring Exposure Worry

This chapter details an in-depth exploratory study involving semi-structured interviews with 20 British nuclear test veterans and analysed using thematic analysis. The primary output of this qualitative chapter is a collection of themes describing exposure worry, the broader psychological impact of the tests, and perceptions of health in nuclear veterans and their family members. These themes will ultimately be represented in a conceptual model describing the potential psychological impact in British nuclear test veterans. This present chapter addresses the second key research question of this thesis:

II. What are the mechanisms and dynamics of exposure worry?

    a. How has it developed over time?
    b. What is the broader psychological impact of involvement in the testing programme, and how is this influenced by time?

Based on the sample of 91 British nuclear test veterans in Chapter 5, it is evident that there is a large variation in agreement regarding certain aspects of exposure worry. It is also evident that there is large variation regarding the extent that these aspects of exposure worry make one feel nervous or stressed both at present (Current Exposure Worry) and in the past (Mid-Life Exposure Worry). Analysing differences in levels of agreement for each Current Exposure Worry item (including the stress item) between participants categorised by role, location, and national service did not provide any further insights into the nature of exposure worry. Furthermore, the PCA analysis of the Current Exposure Worry Scale data indicated that, while all items correlated well with a common component, item four and item five were also correlated with another component which warrants exploration. One may suspect that this component relates to anger and attitudes towards authorities. Therefore, it is unclear whether exposure worry is central to any psychological impact in British nuclear test veterans, or whether there are other issues relating to the psychological impact besides exposure worry.

It is also unclear, using retrospective scale data, how persistent exposure worry is across the life course[20]. Participants in the quantitative study described in Chapter 5 would sometimes

[20] Recall that this thesis was initially based on the hypothesis that exposure worry is associated with decreased cognitive functioning; a hypothesis relating to evidence that *persistent* psychological stress is associated with decreased cognitive functioning. If any exposure worry is not persistent, then the cross-sectional research design intending to address this hypothesis is limited.

remark on the limited persistence of radiation-related worry. For example, when asked (an open question) about the duration of their worry on the proposed mid-life exposure worry scale, some veterans would respond with "on and off", "within the past five years", and "more than 30 years". Supporting this, informal discussions with the nuclear test veteran community suggested that exposure worry is not as persistent or excessive as it was presumed at the beginning of the project. This raises the prospect that exposure worry is nuanced and changes over the life course. Drawing on this, any exposure worry may only be experienced following certain life events. For example, the worry that a grandchild's health might be affected by the veteran's radiation exposure might only be salient prior to and immediately after the birth of a grandchild but diminishes as the grandchild develops without apparent health defects. Therefore, this chapter explores the nuances and nature of exposure worry over the life course, and its relatedness to any life events following the nuclear testing programme.

In addition to exploring exposure worry and the broader psychological impact using qualitative methods, it is important to explore British nuclear test veterans' perceptions and beliefs about health conditions in themselves and family members. This is because the presumed psychological impact (particularly exposure worry) is generally underpinned by the perceived potential adverse health effects in themselves or family members. Previous epidemiological studies of British nuclear test veterans examining cataracts (Boag et al., 1983) and cancer mortality (Knox et al., 1983a, 1983b) have been conducted but more recent and larger epidemiological studies suggest no significant increase in mortality rate or total risk of the veterans developing cancer compared to the general population (Darby et al., 1988, 1993; Muirhead et al., 2003, 2004). The risk of health conditions such as cancers, cardiovascular diseases, and cataracts are multi-factorial and modifiable in their aetiologies, but they are also age-related (North & Sinclair, 2012; Seddon et al., 1995; White et al., 2014). This means that the risk of developing these health conditions appears to increase with age. While perceptions and causal attributions of health conditions have been examined in general populations (Shiloh et al., 2002) or populations sampled based on a specific health condition (Dumalaon-Canaria et al., 2014; French et al., 2001; Friedrich et al., 2020; Furness et al., 2018; Koffman et al., 2015), there is little research examining causal attributions of health conditions and illness in a cohort which shares the experience of a singular profound event, namely potential ionising radiation exposure from nuclear weapons testing. Since British nuclear test veterans are an aged cohort and are likely to have experienced age-related health conditions, it is of interest to examine their perceptions of their health and their family's health, and to understand the

processes that they use to determine which health conditions are attributed to ionising radiation exposure and which are attributed to age. To my knowledge, this is the first in-depth study investigating health beliefs in (potentially) radiologically exposed populations

Therefore, this chapter presents a qualitative study to achieve the following research aims:

1. To explore the psychological impact of perceived ionising radiation exposure (particularly exposure worry), and the broader psychological impact of being involved in the British nuclear weapons testing programme.
2. To explore how this psychological impact changes over the life course.
3. To explore how British nuclear test veterans, perceive and attribute causation to health conditions in themselves and in their family members, in the light of being an aged cohort and their previous involvement in nuclear weapons testing.

Paradigmatic commitment

As described in Chapter 3, this project is a multiple-methods thesis comprising qualitative and quantitative methods and is committed to pragmatism: a paradigm concerned primarily with answering the research questions in a practical fashion without adhering to an all-encompassing worldview (Shannon-Baker, 2016). Philosophical stances or paradigmatic commitments are not fixed, and it can be presumed that these evolve with experience. Thus, the process of carrying out this qualitative study exposed me to other philosophies which may not have been incorporated otherwise. Because of this, it is important to revisit this paradigmatic commitment and how this evolved throughout the research process.

In the previous chapters, despite the overall project being pragmatist, my worldview leaned somewhere towards post-positivism in the sense that quantitative scale measures (i.e. the exposure worry scale) were able to 'capture' a relatively apprehensible reality of exposure worry, and that I perceived no epistemological issues in reducing exposure worry to quantitative figures. But my first inclinations of the limitations of using quantitative scales to measure exposure worry arose from reading to work of Feilzer (2010). Feilzer discusses how, in a positivist view, quantitative scale measures imply that each participant (and the researcher) interprets the scale items in the same way (Feilzer, 2010). Feilzer also discusses how participants often include scribble notes outside of the framework provided for them to provide scores, and indeed this was observed in the present study on a couple occasions regarding worry

scores[21]. For example, one participant replaced 'protective clothing' with 'radiation badge' under item 5 of the Current Exposure Worry Scale and added further notes regarding the focus of his worry (which extended beyond what was captured by the scale items). As discussed by Feilzer (2010), these scribbles might suggest that while two participants tick the same box/number, the questionnaire items can be interpreted differently, and answers can have differently explanatory value. In other words, there are limits in the extent that scale methods can apprehend the reality of exposure worry.

These considerations that exposure worry may be more complicated than what can be captured using quantitative measures led to a focus on collecting qualitative data. Here, a decision was made to employ qualitative methods to answer a separate set of research questions and to question the value of the quantitative data. This is consistent with the pragmatist approach; whereby semi-structured interviews were deemed appropriate to gain further insight and 'paint' a fuller picture of the phenomenon. By adopting this qualitative approach, I began considering issues relating to the participants' expressions of worry and, naturally, the subjective nature of the data and of the analytical process. These issues are relevant to the paradigmatic commitment.

This thesis frames worry as a repetitive, negatively-valenced thought process about events which may happen in the future (Borkovec et al., 1998). I also regard worry as a cognition (a thought process) innate to all individuals. Inside and outside the research context however, emotions such as anxiety and fear are often used interchangeably with worry (Ledoux & Pine, 2016). This leads one to consider the epistemology of examining worry, if respondents are using varying terms to express worry, and indeed the meaning of worry may differ among participants (discussions on the meaning of worry and concern have already been provided). Furthermore, this qualitative study is concerned with the broader psychological impact, so emotions that are more distinct from fear or anxiety, such as anger or sadness, may also be relevant. Therefore, it is entirely likely that the data elicited in this study will focus on the retrospective expression of emotions, when examining exposure worry (a thought-process/cognition) and the broader psychological impact.

[21] This was only observed on the physical version of the exposure worry scale because the online version does not allow for any input outside of the given tick boxes.

There are many types of emotion. Some theorists hold that humans have a set of six basic emotions (anger, disgust, fear, joy, sadness, and surprise) which are biologically innate and serve an evolutionary function (Ekman, 1992; Matsumoto & Hwang, 2012). There are also emotions such as shame and guilt, for example, which are considered cultural emotions because the experience of these is context-specific which may vary between different cultures (Matsumoto & Hwang, 2012). Culture (and its norms and values) plays a strong rule when considering the expression and subjective meaning of emotion (Matsumoto & Hwang, 2012). A discussion on which emotions are 'natural' and the different types of emotions is beyond the scope of this thesis, but the point is that the meaning and expression of emotions, thought processes such as worry, and more generally any psychological impact are likely to be influenced by one's culture, values, and norms.

Drawing on this perspective, expressions of emotion (e.g. feeling anxious, and associated thought processes such as worry) can be gendered. In Western cultures it has been common for men to follow traditional masculine gender roles, which endorse emotional toughness. For example, men are often exposed to 'boys don't cry' mentality as a child (Branney & White, 2008). It is also known that military culture endorses emotional toughness (Jakupcak et al., 2014). Although most of these veterans were not involved in the military throughout their lives, it is possible that many would adopt these masculinities. For example, the language used to express emotion that is typical for a male of that generation and who has been involved in military life might present a challenge in understanding really what the psychological impact of perceived radiation exposure in nuclear test veterans is[22]. Therefore, the expression of emotion and thought processes (e.g. worry) can be seen to be culturally constructed.

Not only can the expression of emotions and thought processes (worry) be constructed through culture, norms, and values, but interview and data elicited are constructed. My understanding of the research draws on the work of Holstein and Gubrium (2011), discussing the critical role of the interviewer, interview, and interviewee in the subsequent construction of data. Holstein and Gubrium argue that interview data, and specifically life history/biographical data does "not simply await discovery and articulation but are constituted within the interactional context of the interview, drawing on both situationally relevant and long-standing resources" (Holstein & Gubrium, 2011, p.51). That is, the knowledge/data is constructed and influenced by a myriad of factors. As a basic demonstration of this, Heritage et al. (2007) showed that by asking "Is

[22] The role of masculinities in this qualitative research is discussed on page 146.

there *something* else you want to address in the visit today?" elicited greater information from the interviewee and resulted in fewer unmet concerns in a medical context, compared with asking "Is there *anything* else you want to address in the visit today?". The interview can therefore be viewed as an active process.

The execution of qualitative research in this thesis ultimately resulted in a perspective drawing on a constructionist paradigm, but far from adhering strictly to the commitments of constructionism (in essence the overall research process remains pragmatist). In retrospect, this constructionist perspective can also be applied to the quantitative exposure worry scale data in the sense that this data is also co-constructed. For example, the participant completing a scale provides responses bound by the constraints provided by the researcher (i.e. the format and depth of the answer is already determined by the question provided). The relevance of this constructionist perspective will be addressed in the following methods section, particular regarding the data analysis.

Methods

Participants.

This study gained ethical approval from the Brunel Research Ethics Committee (Appendix K).

Twenty participants were recruited for this study (aged between 75 and 89; all male). They were recruited through the following process:

Participants involved in the earlier stages of the project (Chapter 5) were asked if they would like to 'opt-in' to be selected for subsequent in-depth interviews. Out of the 59 participants who had opted-in for the qualitative interview study, 29 participants were sent a description of the study and an invitation to participate in either a face-to-face interview or a telephone interview. These 29 participants were identified based on geographical clusters as a convenience approach to recruitment was taken[23]. Out of these 29 veterans, 16 agreed to participate in a face-to-face interview and an additional four were selected and agreed to take part in a telephone interview giving a total of 20 participants in the qualitative research. The reason for four telephone interviews was because the 16 participants had been selected on

[23] Groups of participants residing in the same location were identified to make travel and data collection efficient.

geographical convenience and other prospective participants lived too remotely from any location where it was convenient to test. Therefore, a further nine veterans from various locations in the UK were invited to participate in a telephone interview, of which four agreed to take part.

Regarding sociodemographic status of the interview participants, the median score for index of multiple deprivation (range of 1 to 5, where 1 is least deprived) was 2, with 65.0% of participants scoring as 1 or 2 on the index. The median score for occupation index was 3 (range of 1 to 8, where 1 is most skilled occupations). For educational attainment, the median score was 2 (range of 1 to 5, where 1 is no formal qualification and 5 is degree level of higher). Based on the available data for these interview participants, 42.1% had no formal qualification. Overall, there was fairly good distribution of socioeconomic status.

Of the 20 veterans interviewed, 13 were stationed at Christmas Island (Kiritimati), four were stationed at Maralinga, two at the Montebello Islands, and one at Malden Island. Fourteen of these participants had witnessed one or more weapons tests (See Table 11 for overview).

Table 11.

Participant characteristics

Pseudonym	Age	Phys. Conditions	Test location	No. tests witnessed	Interview type
Samuel	77	Spondylitis, diabetes type 2, kidney disease, atrial fibrillation.	Christmas Island	25	Face-to-face
Jesse	80	kidney removed, heart valve replaced, pacemaker fitted, cancerous lump on nose.	Christmas Island	3	Face-to-face
Philip*	82	Joint pain.	Christmas Island	5	Face-to-face
Andrew	82	Transient ischaemic attack (x5).	Christmas Island	0	Face-to-face
Peter	81	Cervical spondylosis, spinal stenosis, duodenal ulcers, ectopic heartbeat, arthritis.	Christmas Island	0	Face-to-face
Michael	77	Keratosis, angina, acid reflux.	Maralinga	1	Face-to-face
Ronald	80	N/A	Christmas Island	0	Face-to-face

Russell**	83	Diabetes type 1, dizziness, loss of hearing.	Maralinga	4	Face-to-face
Roger	82	Skin problems.	Maralinga	3	Face-to-face
Bernard	78	Osteoporosis.	Christmas Island	5	Face-to-face
Howard†*	85	Prostate cancer, bladder cancer, hip and kidney removed.	Montebello	2	Face-to-face
Frederick	88	Arthritis, cancer, diabetes.	Montebello	1	Face-to-face
Arnold	84	Hospitalised for unknown sickness	Malden Island	2	Telephone
Glenn	80	Polyps in nasal passage.	Christmas Island	0	Face-to-face
Vincent	79	N/A	Christmas Island	6	Face-to-face
Dennis	83	N/A	Christmas Island	5	Face-to-face
Stephen*	82	Bilateral adrenal adenomas, gastrinoma, hypertension, PE, ME-1, diverticular disease, Zolling-Ellison syndrome, hyperparathyroidism,	Christmas Island	3	Face-to-face
Paul	77	Prostate cancer, deep vein thrombosis.	Christmas Island	7	Telephone
Robert	75	Prostate cancer, bowel cancer, pacemaker, type 2 diabetes, osteoarthritis.	Maralinga	0	Telephone
Charles	89	N/A	Christmas Island	0	Telephone

Note. All data in table is self-reported.

†. Interview unrecorded due to technical fault.

*. Wife or partner present in interview.

**. Wife or partner and granddaughter present in interview.

Procedure.

All 16 face-to-face interviews took place in the participants' homes, and the four telephone interviews took place in a secluded room on the university campus. The interviews took place

between 10th October 2019 and 19th February 2020. Cake was brought to each face-to-face interview as a thank you for participating in the research.

The interviews were semi-structured and loosely followed a schedule. To elaborate, semi-structured interviews are interviews which, although use a pre-determined set of open-ended questions, are flexible and allow for exploration of new topics not initially included on the schedule. This interview format was chosen because, while specific topics were deemed important to explore in-depth to answer the above research questions, there remained the potential that I did not fully understand all the possible psychological issues relevant to this population.

Each interview began with the participant telling me about themselves and about their lives in the few years leading up to the nuclear testing programme. The interviews then progressed in chronological fashion until present day, with the topics predominantly dictated by the participant. Here the role of time is central to the research and is important not to disregard in qualitative work (Sandelowski, 1999). The interviews were biographical and generally followed a narrative-style of discussing their experiences. Since many events occur through the life course and retrospection can pose a challenge to eliciting accurate data, encouraging participants to discuss their experiences as a narrative "permits participants to structure and sequence their accounts of events with minimal intrusion by the interviewer." (Sandelowski, 1999, p.82).

The interview schedule was designed to cover six topics: identity, uncertainty, risk perception, health attributions, biographical disruption (life events), and cognitive function (Appendix L). Naturally, some of the six scheduled topics arose at various points in each interview (the number of scheduled topics naturally arising varied between each participant). When a scheduled topic naturally arose in the interview, questions were asked to prompt elaboration on the topics. For example, when topics relating to perceived ionising radiation exposure arose, prompts were used to relate this to the scheduled topics of 'risk perception' and 'uncertainty'. If any of the scheduled topics were not covered by the time the participant reached present day in their biographies, then the scheduled questions were asked to ensure these topics had been covered. Each interview ended by asking the participant if there was something else that they thought should have been mentioned in the interview.

Generally, the participants were keen to discuss their biographies, especially their time during the nuclear weapons testing programme. Some participants explicitly stated prior to the interviews that they were not worried about any perceived exposure and did not consider themselves to be psychologically affected by the nuclear testing programme. It was made clear before the interviews that I still wished to interview these participants, because it is equally as important to understand why these participants are *not* worried about any perceived exposure as it is important to understand why other participants are worried[24].

Family members were also present in some of the interviews (see Table 11). The interviews were intended to be a two-way dialogue between myself and the participant, and family members present were aware that the purpose of the research was to interview the veteran, specifically. In these interviews, family members would engage in discussion during the interviews, but this generally occurred between themselves and the participant. These discussions between participants and their family members were encouraged to continue. On these occasions, I would also ask family members for their perspectives on topics such as risk and health.

Understanding family members' perspectives on the psychological impact of the British nuclear testing programme on the veterans helps provide further context and may also elicit discussion not otherwise elicited in a researcher-participant dialogue. For example, in the few interviews where family members were present, the family members would sometimes remark on their perceptions of the impact of the tests on the veterans, and remark on private discussions they had prior to the interview. On reflection, veteran-wife or veteran-descendant dyad (or veteran-wife-descendant triad) interviews would have been particularly interesting to conduct. The perceived health risk of ionising radiation exposure often includes genetic diseases, therefore the potential health risk is also of relevance to participants' wives and descendants, so it is important to listen to their perspectives too. However, recruiting dyads/triads may have been difficult considering several of the participants in the present study lived alone (for dyad/triad interviews in clinical health research see M. Kendall et al., 2010).

Nineteen of the interviews were audio recorded (one unrecorded due to a technical fault) and ranged from 45 minutes to 2 hours 17 minutes in duration. Regarding the unrecorded interview,

[24] Exploring why these participants are not worried provides a more comprehensive understanding of the processes leading to worry. It also provides opportunity in the interviews to explore any other possible psychological impact relevant to nuclear test veterans if worry is not relevant.

notes were taken about topics discussed and the contribution of the veteran's partner who was present for this interview. Of course, the use of direct quotes from this unrecorded interview was not appropriate and the coding of unrecorded data is an impossible task without inaccuracies. None the less, notes on the discussions which took place during the unrecorded interview contributed to the generation of themes.

Object elicitation.

Longitudinal work across a life course is not feasible especially in a doctoral research project. Furthermore, the phenomena of investigation occurred over a lifetime which would not be captured by a typical longitudinal study (e.g. 5-year study). This study is capturing the veterans' current perspectives and the perspectives of events occurring in this past. These perspectives are influenced over a lifetime of experiences. Thus, this study relies on retrospection.

The following methods were considered to enhance the validity of the retrospective findings. Timeline interviews (Adriansen, 2012) were considered since this method encourages effective organisation of life events structured in a chronological order. Generally, timeline interviews involve drawing a timeline on a sheet of paper which the interview and interviewee then work together to place significant life events along the timeline (the timeline is not analysed but rather a tool to elicit life history data; Adriansen, 2012). Complementing this method, I thought that it would be a useful exercise for participants to bring their own photographs and place them along the timeline, drawing on aspects of photo-elicitation (Silver, 2013). While timelines may have been a useful method to facilitate retrospection, I decided to maintain the more orthodox semi-structured interview on the presumption that semi-structured interviews are a more familiar method for participants and, as such, the interview may be more fluid and organic.

While I decided not to use the timeline interview method, I maintained my decision to incorporate the use of photographs. I asked the face-to-face participants that, if they wanted to, they could present some photographs bearing significance to the nuclear testing programme and related life events. The act of preparing photographs for the interview allows time for the participant to engage in retrospection. Some participants presented photographs of their friends, their camp, and any activities on during the testing programme. Some participants showed photographs of the mushroom cloud (photograph taken by others) and photographs of the natural environment during the testing programme. Two participants (Andrew and Bernard)

presented photographs taken from medical imaging of descendants, depicting certain health conditions such as brain tumours. The number of photographs in the interviews ranged from one or two photographs to large photo albums. Generally, the participants were keen to present and discuss their photographs during the interviews.

Aside from photographs, some participants presented documents such as medical documents, newspaper clippings describing claimed health effects, brochure-type documents from their service, maps, and other relevant documents (one example is a large booklet provided by the Atomic Weapons Research Establishment describing safety protocols). Although this was not the initial intention, it was beneficial not to limit specifically to photographs because firstly, it could risk formalising the interview and, secondly, it is logical to assume that individuals can find significance and meaning in objects or documents as well as the photographs. It is also important to stress that not all face-to-face participants presented photographs or objects, and indeed four interviews were conducted using telephone interviews which rendered the use of objects less useful[25].

Since items other than photographs were used in the discussions, it can be said that an adapted form of object elicitation was used to supplement the semi-structured interviews and facilitate recall about past emotions and thought-processes (Barton, 2015). Object elicitation is a method under the broader category of 'elicitation techniques' (using verbal, visual and written stimuli) which is thought to facilitate discussion regarding topics which the participant may find difficult to talk about in the formal interview setting (Barton, 2015). Indeed, the topic of worry and psychological impact may be regarded as sensitive, and the interviews focus on life events occurring many years ago which may be difficult to recall. A further benefit of this method to the research is by allowing participants to present objects that were significant to them and not dictated by me, this may attenuate any power dynamic present in the interview (Barton, 2015).

Trust and rapport.

A goal of qualitative interviews is to elicit as much relevant and accurate data as possible within the time-frame available. Trust and rapport are generally regarded as important factors which influence the amount of data elicited but also may influence participants' responses in interviews (Ryan et al., 2009; Truglio-Gallagher et al., 2006). As noted earlier, this PhD project

[25] While the benefits of using objects to facilitate discussion are not present in telephone interviews, there are unique benefits of telephone interviews to elicit sensitive information (Novick, 2008).

was funded by a CHRC studentship (funded by the NCCF and Brunel University London). As such, the NCCF also facilitated participant recruitment for this study. A goal of the NCCF is to raise awareness and address the needs of the nuclear test veteran community, so it could be argued that is in the veterans' interest to participate in such studies. This close involvement with the NCCF is also likely to play a role in establishing trust with participants.

Since rapport is critical to an effective one-to-one interview, I applied Leech's (2002) guidance to my interview style in establishing rapport. Establishing rapport may be vital for eliciting 'untold' stories (i.e. stories that the participant may find difficult to discuss outside of the interview; Dickson-Swift et al., 2007). An effort to put participants at ease by conducting the interview at their home, and by bringing cake to share to show my gratitude may also help to render the interview less formal. It seemed that rendering the interview informal and establishing rapport proved effective in eliciting sensitive discussions. For example, in one interview, the veteran's wife and granddaughter remarked that they were surprised he chose to discuss the nuclear testing programme during the interview, since he generally chose not to discuss it with others. Though it is possible that the veteran perceived the interview as a one-off occasion to discuss such topics with no potential consequence, since they have no long-term relationship with me (Dickson-Swift et al., 2007).

Ethical considerations.

While it was not anticipated that examining exposure worry would cause distress, the topic of witnessing a nuclear test (and perceived health risk) may be sensitive to some participants. Care was taken to monitor whether the discussions caused any distress, in which case the participant was free to stop the interview at any time and could withdraw their data without consequence.

There was also the potential for the interview to cause the participants to connect health conditions to ionising radiation exposure which they might not have done otherwise. Specifically, one topic probed during the interviews was the perceived impact on cognitive functioning due to its relevance to ageing and ionising radiation exposure. Despite this potential ethical issue, I believed that terrestrial ionising radiation exposure at the dose levels presumed to be exposed to the veterans is unlikely to impact on cognitive functioning (see Collett et al. 2020 for review of evidence for cognitive detriments following low- and moderate-dose ionising radiation exposure). I was attentive to the potential for this ethical issue to arise in the interviews and would reassure participants if this did occur.

In addition to any potential distress in participants, sensitive discussions may bring distress to the researcher which must also be addressed (Dickson-Swift et al., 2007). Not all participants told of emotionally distressing experiences, but such topics did arise in some interviews. I was also mindful of the potential for desensitisation should I be over-exposed to such topics, which in my view, could have hindered my ability to show empathy and demonstrate a level of understanding for the veterans' issues, and consequently a lack of rapport.

Thus, it was important to protect myself as a researcher. While protecting participants during sensitive interviews has been long established, only recently has the issue of protecting the researcher gained considerable attention (Fenge et al., 2019). While it is difficult to be prepared for sensitive topics (despite the presumption that social science researchers are resilient to the impact of sensitive topics on themselves), there are measures that can be put in place to support the researcher's well-being. In this context and like Fenge et al.'s (2019) suggestions, reflective supervision meetings can be effective and were implemented in this study. For example, every two to three weeks, I had supervisory meetings where reflecting on the interviews was encouraged.

Anonymity is a key ethical issue to consider in qualitative research. Some researchers omit all identifiable information from the original data prior to any analysis. This was not chosen due to the potential for altering the original meaning of the data (Kaiser, 2009). Rather, identifiable information was only omitted from any quotes used in final disseminated reports concerning the study. The possible issues regarding anonymity were outlined in the participant consent form and information sheet prior to the interviews taking place.

While participants consented to the interviews on the basis that their names would not be used in any report concerning the study (anonymity), there remains confidentiality issues. Deductive disclosure may occur when in-depth descriptions of participants' experiences (and their contextual references) may reveal one's identity even if personal identifiers are removed from the data (Kaiser, 2009). While names and locations (excluding nuclear test site locations) were omitted from any quotes in final reports concerning the study, participants may be identifiable due to unique health conditions in themselves or family members if they are known to other nuclear test veterans. Since most participants in this study described not knowing or being in contact with other nuclear test veterans, it was deemed unlikely that participants would be identifiable from interview quotes based on any health conditions described.

Aside from ethical considerations regarding the myself and the veterans, there are also ethical considerations regarding the presence of family members during the three interviews where this occurred. Specifically, there is the potential for unheard concerns and anxieties becoming known to the veterans' family members which may not have been made known otherwise. This could have psychosocial aftereffects on the family. I believed that it was unlikely that veterans would reveal unheard information during the interview and in the presence of a family member. Moreover, I made it clear at the beginning of these interviews that the focus is on the veteran and their experiences, so it is unlikely that I would have been caught as a mediator between disagreements between the veterans and family members.

In other interviews, the veterans' family members were present in their homes but offered to leave at the beginning of the interview and did so. In the few cases where a family member was present throughout substantial parts of the interview, the veteran had either invited their family member along, or the wife asked the veteran if they could sit in and the veteran agreed. As raised by Norlyk et al. (2016), it felt unnatural to request the participants family member to not be present in the interviews, because I was a guest in the participants' homes and I would not have been comfortable asking a partner to leave. Moreover, I believe the interview should be informalised to keep the participant at ease, particularly when discussing potentially sensitive topics.

Finally, the presence of others warrants methodological consideration. For example, the presence of others may disrupt the flow of the interviews. We must also consider how the data produced is transformed into a potentially 'shared' experience as opposed to the veteran's individual experience (Norlyk et al. 2016). Despite this latter point, I do not perceive the altered construction of data to invalidate the data and, in all, the inclusion of others in the few interviews was a valuable aspect of the research (see page 149 for insights from the interviews on the role of masculinities).

Analysis.

The interview recordings were transcribed verbatim. Since there was large variation in the type and number of objects presented, and not all participants presented objects or were able to present objects (telephone participants), I decided that it was inappropriate to draw themes based on the objects. Furthermore, the objects were merely discussion points and memory facilitators, as opposed to being used to capture meaning not otherwise able to be captured

through verbal means (see polytextual thematic analysis; Gleeson, 2011). Therefore, only interview transcripts were analysed using thematic analysis, generally following the guidelines by Braun and Clarke (2006) to generate themes giving a rich description of the verbal data.

Before presenting details of the thematic analysis, it is important to reiterate my position as a researcher involved in the analysis. My paradigmatic commitment in this project, 'pragmatism', is primarily concerned with resolving problems in research without focusing on an all-encompassing worldview (Shannon-Baker, 2016). Paradigmatic commitments can also change with experience, and as described previously, my worldview had evolved somewhat to a view drawing on the constructionist paradigm at the time of conducting the qualitative work. My present worldview applied to this qualitative study was largely influenced by the work of Holstein and Gubrium (Holstein & Gubrium, 2011, 2016; Silverman, 2017). While the research aims are not specifically concerned with understanding participant 'experiences', it is no doubt that the data elicited would appear to represent experience of emotions or the experience of certain life events (including the nuclear testing programme). Note that the data elicited in the interviews in this study are not regarded as a direct representation of the participants' experiences. Indeed, I acknowledge that it may be impossible to accurately capture experiences through retrospection in the interview setting (Sandelowski, 1999). Rather, the data elicited is considered a construction of the interview (Holstein & Gubrium, 2011, 2016; Silverman, 2017). That is, participants' experiences and perceptions are not revealed through the interview, but that they are mediated by the interview setting. Therefore, I acknowledge my role as a young male interviewer (understanding the role of masculinities and the potential for participants to respond in a way they perceive as appropriate), the presence of others (family members) in the interview, the use of objects, and my interview style, as factors constructing the data.

Because of this awareness that data is constructed, there was the natural temptation to 'standardize' the interviews. Across the face-to-face interviews, I wore similar attire (smart, office-wear) and behaved professionally in each interview[26]. I also used the same interview and conversation style across the face-to-face and telephone interviews. Despite the efforts to standardize the interviews (admittedly the 'active' nature of the interview should be embraced), the impact of this is negligible since the interviews always remain 'active', to some extent (Holstein & Gubrium, 2016). Indeed, any possible benefit to 'standardize' the interviews are

[26] Although this would occur regardless of efforts to standardize the interview.

nullified since four of my interviews occurred over the telephone. Therefore, the role of body language, my appearance, and objects for example, would play a different role in the construction of telephone interview data. Holstein and Gubrium (2016) emphasise that it is impossible to eliminate all 'contaminating' factors influencing participant responses. So, overall, my data is inherently 'unstandardized'. This is not a criticism, but it does emphasise the construction of the data and that is not a neutral artefact (Holstein & Gubrium, 2016).

The procedure of my analysis was as follows:

From when the first interview was conducted, I began a reflexive diary (Appendix M) and updated the diary after every couple of interviews and whenever relevant thoughts came to mind. The benefit of a reflexive diary is that it is useful to keep a log of my subjective view about the data, so that the analytical window is not limited to a 'snapshot' in time but is extended over a long period of time. This diary included my thoughts pertaining to potential themes or topics, and initial thoughts as to why certain topics were discussed. In this reflexive diary I also made notes of any key interactions between participants and family members present during the interview, which helped inform the way data is constructed. Other details noted during the data collection process were my ideas around perceptions of power and how this relates to emotion, and separately my reflection on the methods used (i.e. use of objects to elicit data) and interpretations on the types of objects presented (e.g. what is the significance of veterans having collections of newspaper/magazine cuttings?). Lastly, the reflexive diary included my notes on the unrecorded interview which contributed, to an extent, to theme generation.

I began transcribing the interviews as soon as I had recorded data. During the dates spanning my data collection and transcription, I had put on hold other aspects of the project, specifically the quantitative analysis of Chapter 7. The reason for this was to maintain my immersion in the qualitative research process.

I began coding my transcripts after I had recorded and transcribed the 16th interview. The reason for this is because there was a period where I had no upcoming interviews to be conducted. While interviewing after a stint of coding, I was mindful to ensure that the influence of potential patterns arising from coded transcripts on the latter interviews was limited. In other words, I ensured the interviews remained exploratory as opposed to confirmatory of any already emergent themes. In my view it is impossible to fully isolate subsequent interviews

from the influence of potential themes detected in earlier coding, therefore on reflection it may have been more appropriate to finish all data collection before beginning the coding process.

Coding was conducted by hand using highlighter pens and writing the code labels in the margin of the transcript. Codes were generated for varying lengths of transcript segments, ranging from single sentences to a full paragraph depending on the content. For example, a paragraph presenting five distinct aspects would generate five codes, but of course interview responses may not be perfectly structured or concise, therefore a paragraph may also only generate one or two codes. Codes were created with the intention of an inductive approach to analysis. That is, the codes and themes were generated with limited interpretation of the text. To elaborate, an inductive thematic analysis generally refers to coding and identifying themes without a pre-existing coding framework/dictionary. The analysis was data-driven but the coding was conducted with the key research questions in mind to avoid potential generation of themes irrelevant to the research questions and aims. An example of a coded transcript is included in Appendix N for transparency.

It is important to examine how worry and 'psychological impact' are conceptualised and the role of this in analysing the data. In this study, psychological impact is regarded as any thought process which is unpleasant to experience, in relation to perceived ionising radiation exposure. The psychological impact can be subclinical. One example of this is worry (a chain of negatively-valenced thoughts regarding events that might happen in the future; Borkovec et al., 1998) which is especially relevant to the inherently uncertain scenario of perceived ionising radiation exposure. Thought processes such as worry are closely linked to emotional affect (e.g. affect associated with worry, "I feel anxious" or "I feel nervous"). Therefore, I coded all content relevant to worry, emotions, other thought processes, and beliefs regarded as significant by the participants in the context of the British nuclear testing programme. While perceived irrelevant discussion was also coded, it was later discarded during the refining of codes. To support the coding process, a qualitative doctoral researcher also coded three pages of one transcript without examining my own codes for that portion. Our codes were then compared and showed consistency[27].

As mentioned, the interviews are considered 'active'. One action taken to account for the 'active' interview is the inclusion of the basic features of interviewer-interviewee talk in the

[27] No statistical indicators of consistency were used since the portion of the transcript coded was small.

interview transcripts (Silverman, 2017). When researchers clean a transcript, they may remove pauses, overlaps and 'response tokens' (e.g. "umm…") which construct the data. In the present study, interviews were transcribed with an effort to include these features where possible, to preserve details of how a participant's response is constructed. When analysing this data, segments of the transcript were not coded in isolation but the general context of which the content is produced is accounted for. This can be achieved by reading the interviewer-interviewee interaction and understanding how the interviewee arrive at their answers (Holstein & Gubrium, 2016).

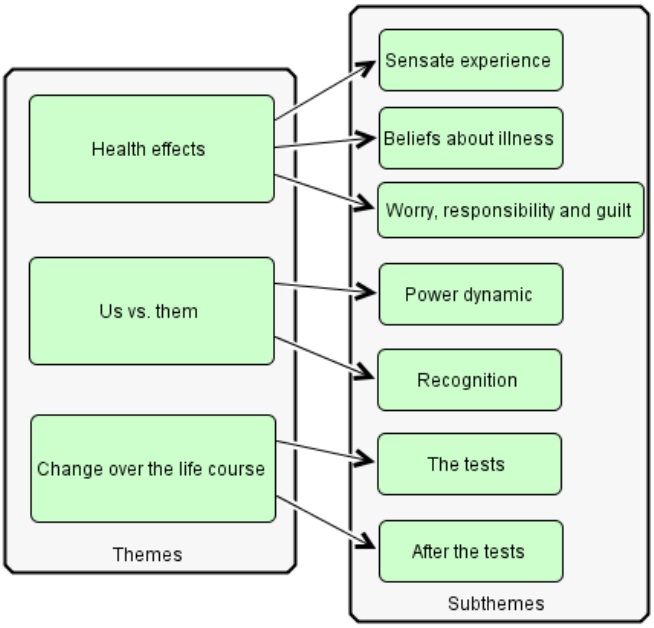
After all initial codes were completed, I reviewed and refined the codes, and began searching for potential patterns (themes) across the transcripts by using the coloured highlighters as a visual indicator. Complex and 'messy' mind maps were drafted by hand to capture all relevant potential topics, and over time this was refined by amalgamating certain topics to form broader topics. I then digitised the mind map in PowerPoint software to further refine the themes. Once I believed that the themes accurately captured the data and were of relevance to the research questions, I finalised the thematic map.

Results/themes

One might present the findings in chronological order particularly if one wishes to infer causal events regarding 'worry'. Rather, the findings are presented firstly in terms of pertinent themes relating to current health perceptions and the broader psychological impact, before presenting a final theme relating to time. Therefore, time in this analysis is not the primary organizing principle (Sandelowski, 1999). The reason for this is because the findings relate to concepts broader than worry (health perceptions, responsibility, and sociopsychological issues) and in-depth discussions about how these concepts changed over time were not held. Rather, discussions on changes over time were focused on perceptions of health risk and worry over the life course.

Figure 8.

Thematic map



The analysis generated three interconnected themes giving a rich description of the verbal data in relation to the psychological impact, namely *'Health effects', 'Us vs. them',* and *'Change over the life course'*. It should be noted that, at the time of the interviews, the participants generally reported not being worried or anxious about their exposure in the context of future adverse health effects in themselves, but some instances remained in relation to their family members' health. While worry was the central topic to be explored, it was apparent that other psychological effects marked by guilt and frustration were described by some participants, not limited to the issue of adverse health effects. As such, the themes extend beyond worry but provide a comprehensive oral account of exposure worry and the nature of the broader psychological impact of being involved in the British nuclear testing programme across the life course.

(i) Health effects.

Across the 20 interviews, the topic of health effects and beliefs in the light of perceived ionising radiation exposure was salient. I present this in the context of one's own physical health, and the physical health of their family, being adversely by ionising radiation exposure. Within this are three subthemes. The first subtheme, '*sensate experience and perceived exposure*', describes the sensate experience of ionising radiation exposure in the context of nuclear weapons testing. The second subtheme, '*beliefs about illness and perceived causality*',

describes the ways veterans attribute the health conditions of themselves and the descendants. Lastly, the third subtheme, '*worry, responsibility and guilt*', describes the psychological impact of these health perceptions, specifically the extent of the worry about adverse health effects in themselves and family members, the perceived responsibility for family members' health conditions and the subsequent guilt regarding family members' health conditions.

Sensate experience and perceived exposure.

In those who witnessed nuclear weapons tests, the experience of witnessing a test was profound and these participants were keen to describe their experiences. Recollections of the visual aspect of a nuclear weapons test were vivid and described in illuminating detail. Generally, these participants described the detonation to be an extraordinary and awesome experience. Demonstrating the significance of the event is the fact that veterans were able to recall the time of day, the weather, and other observations at the time of detonation. Furthermore, in veterans who witnessed a test, they often recalled the colours of the fireball, the shape of the cloud, and the experience of seeing their bones through their hands due to the strength of the flash. Veterans would also describe the subsequent blast and the sensation of heat. In some accounts, this sensation was described like hot irons or electric heaters near their bodies. The relevance of this, not only demonstrating the significance of the event, but the sensations were sometimes used to demonstrate being irradiated and were linked to later health conditions. The following extract illustrates this and the sensate experience of witnessing a test; this was described in the participant's narrative of being enlisted in the army and his experience on Christmas Island:

> *And that flash was terrific. I thought "oh heck this is a big one, this is." I had to close my eyes because it was so bright and then the blast came. If I hadn't got hold of that I'd have been blown away because it was trying to lift my feet off. Then the heat came and oh boy wasn't that hot. The next few seconds you were looking up at a mushroom and on top of that was a great big ball of fire. I think that's how I got all my problems because the blast came this way. I think that's how I got my knee problems.* (Bernard)

Some veterans also vividly recollected experiences of being sprayed with insecticide, specifically Dichlorodiphenyltrichloroethane (DDT). It is interesting to note how the physical sensate experience of DDT contrasted with the invisible nature of radiation. For example, one veteran (Andrew) described experiencing it as a 'fine mist' and could remember the sensation of it landing on his back 'like it was yesterday'. Of course, some veterans perceived DDT

exposure to be risk for adverse effects, and supported such beliefs using their awareness that it is a banned substance in most countries. It was, however, beyond the scope of the present study to examine in-depth the psychological impact of chemical agent exposures. Therefore, although concern for DDT effects appeared limited relative to radiation effects in this study, it is unwise to make such statements based on the present data.

Participants would also describe the non-existent sensate experience of radiation itself. Participants would describe how, while they now believe the area was contaminated with radiation, they were unable to smell, touch or see it. The relevance of this varied between participants, but the following extract illustrates the potential importance of invisibility regarding ionising radiation exposure.

> *The whole area was one complete radioactive mess. The drinking water from the sea, because the ship used to desalinate the sea water and drinking water. It was radioactive and they didn't even know. Well, that's dreadful.* (Roger)

Aside from the sensate experience of the detonation itself, the veterans would often describe their observations of the impact on the environment around them. This included observed changes in both wildlife and the trees. Generally, these descriptions were provided by veterans stationed on Christmas Island (or other pacific island testing locations), but not Maralinga:

> *Because when we went back, have you heard of Spinifex grass? It rolls up in balls and it has very nasty spikes on it, and when it's windy these balls roll along and if you're in the way you get a nasty- All that had gone. And it was, how can I put it? An eerie feeling that morning when I was on the island on my own. I looked up to see, and quite often you can see the fins of sharks and that around the island, but that morning there wasn't a fin to be seen. And there were quite a number of birds, but I couldn't hear a bird. And nature warned them, but all was left was basically barren rock and bits of sand. I thought, well, if they've done that to the island, what's it doing to us?* (Frederick)

The 'eerie' experience was alluded to by a couple of other participants in this study. While the impact on the environment surrounding the detonation zone was profound, this was not necessarily described in relation to the impact of the ionising radiation itself but rather, more generally, the power of the detonation. None the less, the extract above demonstrates that

observations of the impact of the detonation on the wildlife around them was one factor for some veterans to perceive health risk.

It was apparent that most of the veterans in this study perceived themselves to have been exposed to ionising radiation, even in those who did not have a sensate experience of the detonation, due to the invisible nature of ionising radiation. While the nuclear weapons testing programme was not especially central to many of the veterans to the extent that their identities and everyday lives revolve about witnessing a nuclear weapons test, the event and perception of exposure was central to some of the veterans in their health perceptions. This leads to the second subtheme.

Beliefs about illness and perceived causality.

This subtheme describes the veterans' beliefs about their own and their family's physical health and the extent to which they believe it is adversely affected by radiation exposure. The processes veterans engage in when determining which health conditions are attributed to their radiation exposure was a prominent topic across the interviews. A common question throughout the interviews was the veterans asking, 'why me?' That is, why should I have such an illness, but others do not? Why should I have this condition, and what makes me different to others of my age group? Why should my descendants have this condition?

Below is one extract from Andrew, an electrician (at the time of the programme) involved in the Christmas Island clean-up operation, which occurred following discussions about the invisible nature of ionising radiation. During his interview, Andrew presented a photograph from his granddaughter's brain scan to demonstrate the extent of her health condition. Prior to presenting the photograph of the brain scan, he describes the frequency of wondering why his descendants were born with their conditions:

Do you think that the fact you can't sense it, you know taste, touch, smell radiation, does this relate to the psychological impact of it all?

Well, you know I'm talking to you about it basically because of my children and my grandchildren. I can't..cite anything that's physically- I mean I've got things wrong with me but nothing that I can actually say is caused by radiation but I don't know what they have got is caused by- But it does make you think and it does..- I don't go to bed

dreaming about it but now and again I do think to myself now why, why was that lad born like that, why did she have to go through all that...no...It was horrendous at the time when she had the brain operation because for several months, she was only 11 when she'd come here on the way home, and she'd drag her right foot through, always remember it in the snow. (Andrew)

Other participants would also describe the comparative processes engaged in to understand why their descendants have health conditions. Some participants compared their situation to non-veteran friends and ask whether it is a coincidence or not. In answering this, veterans may identify ionising radiation exposure as the unique factor distinguishing themselves from others. For example, Michael draws comparisons between his immediate family and the families of his close relatives:

So in between this time of this and your involvement with BNTVA...so there was obviously a large gap between you getting involved with the BNTVA. During this time had you thought about what might have caused the miscarriages?

*Yes I had. I think probably in the late 70s, early 80s when I came back in the air force when I thought more about it. Felt more guilty being nearer her family with the children. My family with the children because *inaudible* I've got 4 sisters. Or had. I've got 3 left. They're older than me. The 3 in their 80s now. And one had 2 children, one had 3 children. Two had two children, one had three children, one had four children. Her brother had three kids. So, all our close relatives had reasonably sized families and that made me think "oh crikey, why me? Why me?". Or rather "why us?". That's me being a me, me, me. Why us? That's when I started thinking about it and started thinking more about things and looking more into it. Thinking "hang on..my medical records weren't there. Is there a connection?"* (Michael)

Michael asks the question "why us?" as opposed to "why me?" suggesting that such adverse effects are not limited to himself. He considers ionising radiation exposure as a possible explanation for his wife's ectopic pregnancies, which is reinforced by his awareness that his medical records from the nuclear tests were not available. This added to perceptions that there is suspected negligence at play. This perception relating to authorities is covered in detail later.

Continuing along this line, some veterans would ask variations of the question: 'what is normal?', when making sense of their descendants' health. Russell, who also worked at Maralinga, considers himself different to others in that a "normal father" is a father who has not been exposed to radiation. This is then used as an explanation for his descendant's health condition accompanied with worry.

> *Well yeah 'cause gotta worry about it haven't I? Yeah cause..boys got trouble, Caroline my daughters got trouble, and you've [granddaughter] got trouble. There must be something mustn't it? Because a normal father doesn't get all three kids trouble.* (Russell)

The question of what is "normal", and descriptions alluding to "normal", was also consistently applied to the veterans' own health conditions. That is, what are "normal" conditions that can be expected for a male older adult? Robert, who was involved in the clean-up operation at Maralinga, is not worried about the impact of exposure on his own health, but he provides a detailed account of how he may attribute certain conditions to alternate causes, namely age and lifestyle. As suggested throughout the other interviews, it appears that the conditions which are perceived as rare and unexpected are more likely to be attributed to radiation exposure. In the following extract, although cancers are often perceived as consequences of ionising radiation exposure, Robert explains why his prostate cancer and lung conditions could rather be due to age and lifestyle.

> ***So going back to- We mentioned the cancers were common illnesses. What do you- So obviously some veterans believe their illnesses have been caused by the testing programme, or the clean-up. Why do you think some veterans might attribute certain conditions to exposure?***
>
> *Well, you'd have to look at it from an individual basis I suppose. It depends what sort of medical problems they've experienced. I mean a lot of it is passing it on, you know, having children who were born...trying to think of the correct expression um...to put it like thalidomide children, for instance, you know you read instances and you can understand it. You know, they're probably a bit like me. No idea what caused it, what could've caused it, and of course it could've been radiation exposure. Perhaps they've suffered from diseases which are very uncommon, very rare, and what one wouldn't*

normally expect to. But in my stage, of my age, lifelong smoker..you'd expect lung problems. I say prostate cancer affects more men, I'm told, to varying degrees. (Robert)

Many of the veterans would acknowledge difficulty in attributing certain conditions or symptoms to radiation exposure as one gets older. Generally, the conditions realised in older age were accepted as being age-related because such conditions are observed in others of similar age who were not exposed to radiation. Some veterans found attributing causality to health conditions difficult because the presumed delayed health effects of radiation appear like those which are age-related. Consequentially, this blurring in causation was sometimes perceived as an excuse or 'cop-out' for government and medical staff explanations.

To further demonstrate such beliefs regarding health and age, one topic which was explored throughout the interviews was the veterans' cognitive health. Given that declining memory is often viewed as a typical sign of ageing, the veterans did not give any suggestion that they perceived it to be related to radiation exposure. Furthermore, some veterans had never considered such possibility until their interview. This was further reinforced through instances where veterans describe their wives' cognitive health as being comparable to their own, like the above processes of considering what conditions are normal for someone of that age. These comparisons also extended to identifying whether their declining memory may be hereditary by observations of their siblings or parents.

Drawing on this, any perceived link between radiation and health conditions was limited if the veteran identified that their health conditions were also present in their parents, grandparents, or siblings:

I mean obviously when I got these problems of um, you know, parathyroids, MEN-1, etcetera etcetera, I did say to the surgeon "look I was in the H bomb tests at Christmas Islands in 1957, is there any connection to what I've got?", you know, because I thought it might've been something that comes with it, I don't know. And he did say, he said, typical surgeon, he said "it could be, but I can't stand here and categorically say it did" [laughs]. So yeah, so that was it. So, as it's hereditary I guess it was from my father and that's it. So, I never thought anything more about it really. (Stephen)

Another factor involved in attributing causation to radiation was considering whether the conditions were curable. For example, it appeared that if medical staff were unable to cure it,

or in some cases unable to adequately explain it, and the condition persisted then some veterans may perceive this as a reason for attributing to radiation exposure. Following a discussion about the contaminated environment and the development of health conditions in other veterans (due to luck), Roger describes the development of a strange blister on his palms:

> ***And so, do you think about your own health to relation to this as well?***
>
> *My health has always been up and down. When I first thought that it might be something to do with that, was years ago, I worked as a shop fitter doing all this, new shops out and that sort of thing and...I was driving home one night, got flipping scratching like this in my hand. What is it? There's nothing there. Then I got home and said I've got this flipping itch and can't get rid of it. And after a few days I got a little white spot there. It grew a little bit bigger and a little bit bigger. It was like a water blister, and it burst. When that burst, it spread all around this area here and it started on this hand, all around that area there. That would- It was like uh..as if the skin would go very, very thick. Not soft like that. Thick and hard. Crack. If you do that it would crack and bleed...Consultants and all the rest of it could find nothing to what caused that. What is it? "Oh it's some form of eczema", "some form of dermatitis" and all this. What from? How can we cure it? Couldn't cure it. For 20 years I had that.* (Roger)

The persistence and incurability of health conditions plays a role in the attribution process. Indeed, uncertainty in medical explanations is significant in the attribution process, but the notion of trust in medical staff is also important. For example, a few participants described scenarios where medical staff had explanations for a condition then some veterans would not believe them. In these cases, for example Roger, his scepticism was explained by stating most medical staff (and the Government) are not old enough to be present at the nuclear testing programme and, like most of the public, they were not aware that the British testing programme existed. In addition, there were a couple of discussions showing a perception that medical staff would actively avoid the topic of radiation exposure, possibly due to the difficulty in treating radiation-related illnesses and because of the political nature of the nuclear weapons testing programme. Indeed, the perceived reluctance for healthcare professionals to consider ionising radiation as a cause for health conditions led to frustration in two participants, and one participant feeling 'let-down'. Based on these arguments, there may be distrust in medical staff contributing to the belief that their health conditions have been inflicted upon them by their

involvement in the testing programme. This issue of trust in authorities will be discussed later in the 'Us vs. Them' theme.

In addition to beliefs regarding illness causation, many participants described the notion of luck in relation to their health and health of family members. Many perceived themselves as either being lucky to be alive as most of their cohort had died, or in some cases lucky to be unaffected by ionising radiation. Again, some of the veterans acknowledged that old age is a factor explaining why fewer veterans are alive presently, while others have the perception many died younger because of ionising radiation exposure. Interestingly, this perception of luck and survival may form a central part of a test veteran identity in some participants. During the telephone interview, Arnold describes what it means to be a nuclear test veteran:

> ***Can you tell me what does it mean to be a nuclear test veteran?***
>
> *Uh the first word that came to me, the first word, it might not be what you want it to be, but it's that I've been very "lucky". That's what the first thing came to my mind.*
>
> ***So, lucky? Lucky?***
>
> *I've been very lucky. Not to be on the test but to survive it.* (Arnold)

To further illustrate this perception of luck, Roger, a veteran who did his service at Maralinga, described how everyone that was present was perceived to be vulnerable to radiological contamination, although as described above, it is down to chance whether radiation-related illnesses are developed:

> *So, no one really was what you call walking about impervious to it. You were all in the same sort of exposure. Some were lucky and some were not. And sometimes when I read about this.....you think how lucky you are really, and it does make me cry.* (Roger)

This perception of luck may be perpetuated by media reports, according to the data. Philip pointed out that it is 'bad news that sells print' and stated that the press is unlikely to print stories about a nuclear test veteran without health problems. Separately, some veterans also observed that there were fewer nuclear test veterans present at annual general meetings and reunions in recent years, and rather that the meetings are comprised more of descendants as years go by.

The importance of these health narratives and understanding the perspective of the veterans regarding their health conditions and any health conditions in family members is that they appear to partly constitute the psychological impact of being involved in the British nuclear testing programme. This leads to the next subtheme.

Worry, responsibility and guilt.

The last subtheme of the 'health effects' theme describes the extent that the participants were worried in relation to perceived ionising radiation exposure, but also highlights other possible psychological effects associated with perceived exposure and health beliefs in the veterans.

Generally, the veterans reported not being worried about their own health. One reason for the limited worry about their own health appeared to be their chronological age. For example, several veterans described how they had reached an age where they should not be worrying about their own health. Interestingly, there was also limited worry about their children's future health. The reason appeared to be linked to the life course; the fact that, generally, children of the participants had developed without serious health conditions and any children with serious health conditions had been managed. Since most of these children were mid-life or older adults, their future health may not be regarded as uncertain, so worry is less relevant. Rather, any worry tended to be directed to the participants' grandchildren.

To illustrate, Glenn, a veteran involved in the clean-up operation at Christmas Island, describes how he was 'past that stage' regarding worrying about his own health following radiation exposure, but the focus of the worry was related to the potential for 'carrying on' health effects to his grandchildren:

> *I mean I'm 81 and the other ones didn't even saw that age, you know? There's some- The ones- We're getting back to the beginning. It's when you read about the one that kidneys or something, the kidneys were welded together when it was born and things like that, and the deformity in kids and things like that. I wouldn't like the think that was my grandchildren and I wouldn't like to think- That's what worries me. The carrying it on.* (Glenn)

The severity of the worry about the health of grandchildren varied across the participants. In some cases, this was limited and phrases such as 'on the back burner' exemplified this. Of

course, not all participants had grandchildren. Naturally, there was no present concern for the health of grandchildren in the few veterans who do not have grandchildren, but it was acknowledged that the potential for their descendants to have children would otherwise bring concern to the forefront. To demonstrate the extent of the hypothetical concerns, Michael and Howard, who did their service at Maralinga and aboard the HMS Diana at Montebello respectively, stated that although it was negative to say, they were pleased that they do not have grandchildren due to the worry of passing on health effects.

Continuing along the line of perceived inherited effects, a couple of participants held the view that risk of radiation-related effects diminishes down the line if the parent has no radiation related conditions. In this case, it is possible that if he had developed health conditions then there may be more reason to be concerned about his grandchildren. In a few veterans however, there is a concern that any adverse health effects may skip a generation, which is illustrated by Peter in the following extract:

> *But [son] definitely suffered from it, [daughter] not so much but [son] is..please goddess and god it doesn't go to his children. But you never know with that do you. Can skip a generation...It worries me sick.* (Peter)

As above, the potential for adverse health effects to skip a generation indicates that the perceived risk of health effects due to radiation exposure can persist over time. That is, while one set of descendants are unaffected; there remains the worry that heritable effects may be present in the next generation of descendants. Generally, most veterans reported that their descendants' health was not impacted by the nuclear testing programme, but a few participants reported that their descendants had a physical health condition because of the testing programme. An extract from a telephone interview with Paul highlights these potential psychological effects, which he describes following discussion about his experience on Christmas Island:

> *I do wonder about certain things in life. Um I mean my daughter had breast cancer, then she's got tumours on the brain and then she died. Whether that was anything to do with it because I've read so many times that it's not always the people who witnessed..the test, it be the generation after that are affected. Also had a granddaughter with Katz disease, um that was a rare disease of the nervous system*

so..you worry about these things whether it's a contributing factor or not, but there's nothing you can do about it obviously but you just can't help wondering about it. (Paul)

Paul describes his perception of the possible impact of witnessing nuclear weapons tests at Christmas Island on his daughter and his granddaughter in terms of their physical health conditions. This extract illustrates that although descendants dying naturally has a psychological impact, the perceived responsibility for their illnesses may bring additional psychological consequences. Later in the interview, Paul states that 'until the day I die' he will 'always wonder' about whether his involvement in the testing programme was responsible for their deaths highlighting the persistence of the concerns.

Furthermore, the language used to express their concern for future generations indicated that the veteran may pass a physical illness to them which they would not otherwise develop. For example:

Grandchildren...no I think the grandchildren are all alright. [Grandson] and [Granddaughter] have always been alright.

But prior to it [having your grandchildren], did it sort of cross your mind?

Oh, it used to worry myself sick! Because if [Daughter] is like that, what are her children going to be like? And [Son] as well! Christ yeah, I pray for them all the time. And the feeling of guilt within me! What have I done to my children? I can't do anything about it. (Peter)

Peter describes the feeling of guilt and the perception that he is responsible for the conditions on his children, accompanied with a lack of control for their health. The perception of responsibility and guilt extended to other family members too. For example, Michael describes the anger, frustration, and guilt relating to his wife's wellbeing, encompassing her mental health. As such, the perceived sense of responsibility is not limited to physical health but to the broader concept of wellbeing in family members:

So, your health conditions, the wife, were there any other life events which have you related to Maralinga at all?

Apart from my anger and frustration, no. Deep down I'm very angry. Anger and guilt rather than frustration. Guilt. Because..I know you say it isn't my fault and yes I understand it isn't my fault but I can't convince myself it isn't my fault. Can you understand that? It sounds totally illogical, but I can't. (Michael)

In the above extract, Michael also acknowledges that, while it is illogical, there is difficulty in convincing himself to believe that it was not his fault. Continuing along this line, some veterans would ask themselves how life may have been different if they were not involved in the testing programme. These were asked particularly in relation to family members' health, and in a couple of cases, death. The following extract demonstrates that these thought processes can apply in context of both descendants and wives.

Do you think older adults who didn't witness a test, you know, have no involvement, do you think they think the same? You know, they think "was this caused by that?

I think they may do if they've had something like we've had, some incident in their life.

Something significant?

Yeah. But I mean I've had nothing like that. No, I mean, when my wife died...we would've had another two years we'd have had our diamond wedding and it just goes through my mind "only if I hadn't gone to Montebello would we have seen our 60 years?" it keeps- You know, it's something you just don't forget. I mean I've had chats- My wife had a chat and they all seem the same. "If only if we hadn't been at Montebello" or whatever. (Frederick)

To summarise, it was evident that the nuclear testing programme was a profound experience for some of the veterans and the event (and perceived ionising radiation exposure) was a central issue in the context of health perceptions. The event itself was not necessarily psychologically distressing, but subsequent perceptions of exposure, regardless of the sensate experience of detonation, played a role in the veterans' health narratives. Understanding health narratives and beliefs regarding the health conditions in themselves and their family members appears to link to psychological impact in the form of worry regarding family members' health conditions, and guilt relating to responsibility for family members' health conditions.

Aside from any worry about family members' health conditions and the guilt for past health issues in family members, a salient discussion and generally significant to most veterans in this study, was the antagonism between the British nuclear test veteran community and authoritative groups, primarily the Government. This forms the next theme.

(ii) Us vs. them.

This theme is comprised of two subthemes. The first subtheme, *'power dynamic',* describes the power dynamic relating to perceptions of experimentation, deception, and a lack of control, as part of scientists' and the Government's effort to develop nuclear weapons and, in some cases, to understand the impact on buildings and on humans. The second subtheme, *'recognition'*, goes further and describes the challenge for recognition from the Government, generally relating gratitude for participating in the testing programme and acknowledgement of negligence. Before describing the two subthemes in detail, the following extract from Paul is positioned here because it effectively captures the perceptions of an 'us vs. them' notion in the test-veteran population. As such, the title of the current theme was labelled accordingly:

> ***And when you read about some of the scientists having worn protective clothing elsewhere, um does this bring any feelings or any thoughts along with it?***
>
> *Well it..-It brings back, [NAME], things like 'us and them'. You hear about it and you see about it so so commonly, um..really on something like that which has such- Can have such disastrous effect on people you'd have thought everybody would be treated as a standard, by the same but uh it's- But I didn't know that at the time. It's only something I've read in the last couple of years with these various articles I get but um you get bits of information keep coming out but it's just uh bearing in mind what we had to go through or what could've happened that we'd all be treated the same.* (Paul)

Indeed, the role of time and emerging media is evident here which will be discussed in the next theme. More importantly, the above extract describes the disappointment due to perceiving themselves as being unfairly treated and marginalised by authorities with power, namely the Government. This perception leads to the first subtheme:

Power dynamic.

Under ‘power dynamic’, there were two general perceptions of the Government or, as labelled by some veterans, ‘the powers that be’. This perception differed primarily between intention and negligence. It was evident that some of the veterans perceived themselves to be victims of experimentation, provided limited information by the authorities or had been deceived regarding the risks of nuclear weapons. For some veterans, these perceptions formed a key component of the test-veteran identity. The label ‘guinea pig’ was used by several veterans to describe what it means to be a nuclear test-veteran, also suggesting that they perceived the authorities to have used them as disposable subjects for understanding the effects of radiation. The following extract captures this label effectively:

> ***So can you tell me what it means to be a nuclear test veteran?***
>
> *I think my view is, sorry got my hand over my- My view of a nuclear test veteran..is that we’re all members of the mushroom club, kept in the dark, shovelled shit from time to time. And that plaque up there tells you what else we are. Guinea pigs. Guinea pigs. That’s what we are. That’s my view of what nuclear test veterans are. A bunch of people who haven’t a clue what they are doing who were sent out there as guinea pigs to work on tests. They would never have sent us to the forward area where there’s nothing to pick up, to pick up bits, if that hadn’t been part of being guinea pigs and being part of the mushroom club. That was a tactical..move...to see what the reaction would be. And being cold-blooded and cold hearted about it, that would have been absolutely necessary. Because the powers to be would have to know what the reaction to nuclear fallout would be. They'd have to know it so they’d take precautions against it. So that’s why I think, you know, my view of what nuclear test veterans were used for.* (Michael)

Like above, the phrase ‘kept in the dark’ was also used by Samuel when detailing his awareness of the lack of radiation dosimetry (device to measure dose of radiation) available to the veterans on Christmas Island. Not all veterans identified with the guinea pig label nor alluded to the notion of experimentation. As mentioned above, another salient reason for their frustration was that they perceived to have been withheld information or, in some cases, perceived to have been lied to regarding health risk and radiation protection. The perception of authorities withholding information from the veterans may also explain the limited concern at the time of the tests and in the few years following. As Roger and Samuel stated, who were at Maralinga and Christmas Island, respectively, any thoughts relating to worry or risk were non-existent because they were told nothing to suggest there was a risk.

Further illustrating frustration, the following extract describes Frederick's annoyance at not only being used in an experiment but to be withheld information as to what was happening. Additionally, of interest here and of relevance to other veterans, was the perceived lack of choice:

> ***We'll talk about the rash on your back when you said, yeah, "the penny dropped", you "put two and two together". Can you recall any feelings when you-?***
>
> *Yes, I had a feeling of annoyance but, not just myself, but all of us had been used as an experiment. I wrote to my MP. Didn't get a lot of joy out of it but he said, you were in the army. You do as you're told, and you had no choice so yeah, I thought well they should've told us what was going to happen...but now I say, we- On the way out there, rumours were rife we were going here, going there, going here, but to think you were used as an experiment I mean, what?* (Frederick)

The above extract details the anecdotal report of an MP indicating limited autonomy in the armed forces. Despite this, Frederick believes members of the armed forces should still be informed in advance of the activities. Drawing on this, Charles, who was in the RAF and went to Christmas Island, commented on the fact that he was also given very limited information regarding his previous postings with the RAF in Libya and Egypt, indicating that limited information is a norm in the armed forces. On the other hand, it must be noted that many of the participants were involved in the testing programme through national service. Here Andrew suggests that it was a characteristic of the era to be put into national service, further demonstrating the perceived lack of control:

> *Well I'm not a nuclear test veteran by choice. It was enforced on me by the time that was my age at that particular time and that's the way the Government or the country was going through was national service was part and parcel of growing up in my era. You knew that when you weren't an apprentice you got to 18 when you went in, or if you had an apprenticeship you were deferred until you finished your apprenticeship. But then you knew very well that if you passed your medical that you were going to go in and you had no say in it. That's as far as I'm concerned and where you were sent to and what you did was also in their hands. You had no say in it.* (Andrew)

The perceptions of limited control may lead to feelings of being victimised. The notion of being a victim, that is, the risks of radiation being imposed on veterans with little choice, may form a significant component the test-veteran identity for some participants, as demonstrated by Samuel:

> *And if you say how do I identify with them, I identify as one of the 160 victims. Because we weren't given a choice.* (Samuel)

The lack of choice during national service was also perceived to lend itself into veterans being ordered into high-risk areas. As outlined by Dennis, who referred to a large AWRE booklet of instructions of what the protocol should have been for radiation protection, suggested that the combination of not being told anything about risk and the possibility of punishment for disobeying orders during national service, were two factors that led to veterans entering high risk areas without appropriate protective clothing which, in hindsight, were instructions perceived to undermine their safety.

In addition to perceived limited control, there are issues regarding trust. To demonstrate, Paul describes how his knowledge of scientists wearing protective clothing suggested that authorities were withholding information about risk:

> ***So yeah, as well as the lack of information, yeah, they didn't tell you anything? I guess they didn't tell you anything maybe because they didn't know? Or um..How do you feel about that?***
>
> *I'm sure certain people knew precisely what was going on because when you read the various articles of what happened on earlier tests in 1957, uh certain scientists had full protective clothing on and other people did not. So there is that element that certain people knew precisely what was happening..as regards to those in Christmas Island, well I was there in '62 and '63 we were not told anything and nobody had any protection other than the red disc around their neck and that was it. Full stop.* (Paul)

To further illustrate these trust issues, there were instances where seemingly trivial aspects of the testing programme are interpreted in a suspicious manner. For example, Dennis mentioned the large number of veterans required on the island for, from his point-of-view, a complex but superfluous infrastructure. Following this, he suggested that it could be interpreted under the

notion of ‘guinea pigs’, which indicates some lack of trust for those organising the testing programme. Extending beyond the potential lack of trust for those in authority, there may be suspicions regarding trivial aspects of healthcare. For example, in one case, regular medical check-ups following their service, which would normally be perceived as routine, were perceived as monitoring health under the intention of examining effects of radiation exposure on the person.

Despite the apparent significance of the perceived power dynamic (and related issues such as deception and trust), this view was not shared by all veterans in this study. Indeed, there were some veterans who did not perceive themselves as being guinea pigs when asked to share their thoughts regarding that label. For example, Vincent used more extreme cases as reference for comparison such as the human testing at Porton Down. It could be speculated that the perception of being or not being a ‘guinea pig’ is facilitated by exposure to media reports pushing this agenda. Of note, Vincent described how, up until the recent few years, he had very little exposure to articles from the BNTVA and news outlets. Another veteran suggested that the fact that the authorities had limited knowledge of what was going on detracts the guinea pig argument, both of whom were Christmas Island veterans who witnessed nuclear tests. Another who did not perceive themselves as a guinea pig was Robert, who was involved in clean-up operation at Maralinga years after the tests were conducted. Robert’ perception may be due being less closely involved and temporally distant from the primary events of weapons testing.

The relevance of this perceived power dynamic is that it seemed to be related to certain negative emotions. The primary emotion described by several veterans in this context was anger in response to the way they perceived themselves to have been treated (e.g. deception). In a couple of cases, this anger was also extended to the way the aborigines were treated by those in power. Reflecting on a photograph of a family of indigenous Australians prepared by Michael, he described how this sometimes made him feel sadness and guilt in hindsight.

Aside from anger, there is some indication that a veteran’s belief that they were a guinea pig may bring feelings of shame. For example, in the interview with Russell, he stated that he felt ashamed of being present at the testing programme and suggested that they had been used as guinea pigs. The extent of this shame was that he described how he would choose not to talk to others about this specific point in his service life. Indeed, his granddaughter was also present

at this interview, who later stated that Russell rarely talks about his time at the testing programme.

To summarise, discussions relating to a power dynamic between the veterans and those in charge of the testing programme, namely the Government and scientists, were prevalent across the interviews. Indeed some, but not all, cases described the perception that they had been used as a guinea pig which suggested intended deception and experimentation, while others described the Government and scientists' role in terms of negligence which, closely related to the theme of temporality, may be representative of the state of knowledge regarding radiation protection in that era. Such perceptions, both regarding perceived intention and negligence, were described closely regarding feelings of anger. Moving ahead, these perceptions are closely related to the desire for recognition from the Government which introduces the second subtheme titled 'recognition'.

Recognition.

Forming the second subtheme, and related to the perceived power dynamic, is the notion of recognition which was a significant issue for most veterans. Many of the veterans expressed disappointment and annoyance towards the Government and, in some cases, they felt 'forgotten' by the Government. In fact, the issue of recognition was the most widely reported concern across the interviews and even featured in participants who did not perceive themselves to be adversely affected by ionising radiation exposure. For example, as described in the 'health effects' theme, there was a perception for some veterans that they felt lucky relative to the rest of the test veteran community, and subsequently a perception that others in the community were suffering and requiring financial or emotional support. Due to financial compensation from the Government remaining a challenge for the test veteran community, some felt that they could support those suffering through other means, such as participating in research. The need for recognition was always discussed in relation to the Government, but what specifically was to be recognised varied between the veterans. For some, recognition meant authorities recognising negligence and negative health effects caused by radiation exposure, while for other participants recognition meant gratitude[28] for their service in

[28] Gratitude has been expressed, albeit relatively recently. In 2014, the then-Prime Minister, David Cameron, told the House that "the Government recognise and are extremely grateful to all the service personnel who participated in the nuclear testing programme."
See https://cratus.co.uk/prime-minister-recognises-british-nuclear-test-veterans.

developing nuclear weapons. In some cases, recognition suggested admittance and truth relating to perceived experimentation

To begin, the concept of recognition and how this is manifested will be illustrated. As mentioned above, the meaning of recognition varied to different degrees across the interviews. For example, for some veterans, the recognition related to 'doing their bit' and for their efforts in developing national defence through nuclear weapons. Furthermore, in some cases their efforts were perceived as preventing a third world war which warranted appreciation. One way in which recognition might be gained is through the provision of a medal. The topic of medals came in conversation relatively often, particularly given that campaigning for a medal is a primary agenda for the BNTVA. It appeared that the tangible aspect of a medal was not particularly significant to most of the veterans, but what was important was what the medal symbolised: gratitude for participating in the testing programme. In addition to gratitude, it was of high importance to veterans that the UK government acknowledges and accepts that the nuclear testing programme occurred, and for some, that veterans were adversely affected by ionising radiation exposure. The symbolism of, and the extent of the importance of the medal is well illustrated by the following extract:

> *All I want. All I want- I'm not too worried about a medal. I mean it would be nice to have a medal because we've served our country probably as much as some of the people in the minor infringements that went on. But having said that, all I want is the British government to say "yes we accept that" and the families around, perhaps give them a widows pension so that they look after the families that are suffering because of it. If we can prove that.* (Michael)

The above extract also demonstrates comparative processes within military groups, as was observed in several other interviews. For example, a couple of veterans showed awareness that other individuals had been awarded medals for non-combat expeditions and questioned why they had not received the same appreciation. Most of the veterans also compared the UK to other governments who had their own nuclear weapons testing programme. It was often commented on that governments of countries such as France, Australia, and the US had compensated their veterans, and by default implying recognition for their service.

Continuing along this line, some veterans also sought recognition that the authorities had failed to provide an adequate standard of protection for the veterans during the programme. In some

cases, the scientists were perceived to be in a 'cover up'. Gaining admittance was noted as particularly challenging given that the present-day government and scientists had no role in the nuclear weapons testing programme. The counter argument given by a few veterans was that if those authority figures involved are no longer alive then why is there a reluctant to recognise or admit that some veterans were adversely affected? During the interview with Roger, he presented a collection of British and Australian newspaper articles from the 1980s reporting claimed adverse health effects and the role of authorities in a perceived 'cover-up'. The following extract illustrates the negative attitudes towards authorities, drawing on notions of truth and morality:

> *Still haven't got an answer. So, it makes you think that all this time that they've been fighting, the British government, even the scientists, they're kept very, very quiet. There's only one or two that I've read about that read the book that I've read, who admitted that these things did happen and that they were all hushed up. No one has had the decency to say "yes, we did fail in that respect." no one said that. And that really is the cause that I feel is really, really bad for a modern nation like this and our government still looked back on the old paperwork and says oh yeah, yeah, yeah. But they're reading lies. They're reading lies that the scientists have told them. Scientists know what's going off. They're the ones that pulled all the strings in Australia. Everything that happened in Australia, don't know about Christmas Island, I wasn't involved with that. But Maralinga was solely controlled by those people. And the Australian government was controlled to them. If they could lie to them then they certainly could lie to us. To this day no one has owned up.* (Roger)

It is interesting to note in the extract above that scientist were perceived as primarily responsible for deception and negligence. Of course, it varied across participants as to whether the Government or scientists were primarily responsible. Pursuing truth and admittance regarding negligence was, like the above extract, central to other veterans' concerns. In many interviews, veterans referred to books and articles that they had read, often written by authors perceived to have 'inside' knowledge due to their prior role in the testing programme (e.g. ex-scientists, ex-pilots). Dennis regularly referred to a large AWRE booklet of the standard protocols during the nuclear testing programme. These materials were used in the interviews to demonstrate that there was negligence, and that the Government's current view on the testing

programme is contrasted with the experiences of the veterans, further elaborating on notion of truth-seeking.

For a couple of veterans, recognition from the Government extended beyond gratitude and negligence, and rather was admittance from the Government that the veterans were under experimentation against their consent. The following extract also demonstrates comparing the UK government to other governments and describes the perception of being 'erased':

> ***So, our government hasn't given compensation or-***
>
> *Not a thing.*
>
> ***Yeah, not even recognised-***
>
> *For some reason they've not even said thank you for what we did. Not a thank you. And don't forget, on reflection, officers and men, we were guinea pigs. You know? And because of that we're the only government involved in nuclear testing who hasn't even said thank you. That speaks for itself. French, and the Americans, and the Russians as well, they've all compensated their people handsomely. You know, I'm not chasing money now but all I'm saying is we've just been completely erased.* (Arnold)

The notion of feeling 'erased' was also alluded to in several of the interviews. In addition, some veterans described feeling 'let down' and disappointed from a moral point-of-view. Additionally, some veterans would comment on the fact that they are indeed an aged cohort and as a result there are not many surviving. The idiom 'running down the clock' may accurately describe the veterans' perception in this context. Specifically, it was sometimes perceived that the Government were waiting for the veterans to decease therefore a reduced pay-out for compensation may be given, or the issue of admittance becomes less relevant on the government's behalf, if there are no test-veterans alive.

This distinction between recognition and compensation, and the veterans' attitudes towards these two issues, is well illustrated by the above quote. Generally, financial compensation was not of great importance to the veterans, but they did state that they would like compensation to be awarded to those veterans and their families who have been affected by ionising radiation exposure. When the veterans were asked why the Government had not recognised or admitted that some veterans were adversely affected by the testing programme, the consensus was that

admittance or recognition is inextricably linked to compensation which would be a financial burden for the Government. Moreover, when veterans were asked why the Government had not provided financial compensation, the veterans believed this would symbolise that the Government have inflicted harm on the veterans through negligence. Dennis further highlights the limited extent to which financial compensation is important to some veterans. The awareness and comparison of other governments offering compensation is also demonstrated here:

> ***So, the fact that the British government haven't recognised, recognised it, is it bringing- As you can tell I'm trying to tap into emotions. Are there any-***
>
> *Well, it might be the British government. I mean let's face it, they- I mean I'm not after compensation, all I'm onto- All I want is the truth which seems to be far away from- Um I know people on Christmas Island who've had problems have been compensated by the Americans in the '62. People on the isle of man had a pay. Fijians had a pay. We had Fijians attached to us. Every country in the world recognised the errors but we don't seem to be able to and they must've spent millions and millions fighting the nuclear veterans*. (Dennis)

As indicated by Dennis, there is an interplay between recognition and compensation, and also the notion of truth regarding negligence or adverse effects on test-veterans is a particularly salient issue for the veterans.

To summarise the 'recognition' subtheme, which was closely related to the aforementioned subtheme relating to power dynamic, it is apparent that this was an important issue for some veterans both in terms of personal relevance, and in some cases, the importance was a result of the perception that other veterans and veteran families in the community had been adversely affected. Additionally, the distinction between recognition and financial compensation was discussed at great lengths, and the importance of these appeared to be increased due to awareness that other countries had already compensated their own veteran. The political significance of recognition and financial compensation, and because they are both inextricably linked, suggests that it is very difficult for the Government to provide recognition or financial compensation to the test-veteran community, and a result, may further impact to negative feelings towards the 'powers that be'.

These attitudes towards authorities were not present ever since the tests, and any potential sense of guilt, worry, and perceived risk regarding their health and the health of their descendants was generally not persistent either. For several veterans there was limited concern throughout life, while some had high concern during specific periods of their lives. This dynamic nature of the psychological effects of perceived exposure, and the broader psychological impact of the tests, leads onto the next theme labelled 'change over the life course'.

(iii) Change over the life course.

'Change over the life course' describes the role of time in exposure worry and perceived health risk and is categorised as two subthemes labelled after transitional periods. The first subtheme labelled *'the tests'* describes the point in time that the nuclear testing programme took place. The second subtheme labelled *'after the tests'* describes subsequent years with a focus on the 1980s as a central transitional period in any psychological impact. This transitional period is marked by the formation of the BNTVA and the emergence of media reports regarding claimed adverse health effects.

The tests.

It was clear that worry about the impact of ionising radiation exposure was not persistent throughout life. To understand the changes of worry over time, veterans were asked to recall their thoughts and perceptions in relation to risk and health impact at the time of their service. Many recounted vivid experiences of witnessing the tests but generally the veterans stated that, at the time, they had no initial concern or thought about any future impact on their health resulting from radiation exposure. This was also relevant for those who had not witnessed tests but were involved in the clean-up operations.

One of the most frequent explanations provided by the veterans for why they had no initial concern for any potential consequence was because of their young age. The veterans in this study were in their late teenage years or their early 20s during the testing programme, and often referred to in terms a perceived naivety. During the interview with Vincent, he presented a large photograph album of photos taken during his time on Christmas Island. Most of the photographs in the album were of him and his friends enjoying themselves during leisure activities and showing the tropical environment of the island. Before the interview was

terminated, Vincent referred to the album and summarises thoughts he had prior to going to Christmas Island.

> *Like I said, one of the chaps must've said "oh yeah, yeah they do H bomb testing" which didn't mean a lot really to an 18-year-old. It was just that we were going to a lovely little island in the south pacific. Nice weather, and all that, you know.* (Vincent)

The above extract indicates, as one would expect, that the attitude of most veterans towards going to the testing locations was generally positive. The prospect of visiting a foreign land, hot weather, and in some cases with excursions at the weekends, was sometimes described as a pleasant life. Details such as this were used as explanations by some veterans as to why, at the time, they did not consider the possibility of negative health impact resulting from radiation exposure. Furthermore, the terms 'naive' and 'ignorance' were also used by a few of the veterans to describe their perceptions at the time of their service. Two veterans used the proverb 'ignorance is bliss' when detailing the limited extent of their worry and reasons for this. These terms are suggestive of limited awareness or knowledge at the time regarding the impact of nuclear weapons and ionising radiation. Capturing this, while discussing his perception that older adults tend to worry more in general, Andrew describes the factor of being a young age in terms of his lack of concern and risk regarding nuclear weapons:

> *Yes, yes but at the time it didn't enter your head, because what the hell did I know at 21 years of age? I'd heard of a nuclear bomb, but it didn't mean anything.* (Andrew)

In the above extract it is important to note that a nuclear bomb did not "mean anything" to him at that age. It is ambiguous as to what this specifically pertains to, but it can be interpreted as an unawareness of risk from radiation exposure. Similarly, other veterans said while they were aware of what a nuclear bomb because of their awareness of the atomic bombings of Hiroshima and Nagasaki, this had limited significance to them in terms of risk. The following extract describes Dennis's response to a question asking if he knew whether it was a nuclear weapon:

> ***Did you know it was a nuclear weapon?***
>
> *Oh yes, oh yes, yeah. But we didn't really know a lot about nuclear weapons, H bombs. All we did was got this information back from the uh Japan um, you know, they were*

the only two but we were not that aware as 21-year-olds. Some a lot younger than that. (Dennis)

In addition to a perceived age-related limited understanding of nuclear weapons, examining the attitudes towards the experience of the detonation gives further insight into why there was limited concern. As noted in the first theme, most veterans who witnessed a test described the anticipation and excitement leading up to a detonation, for example asking each other 'how big the next one is going to be', with little thought as to what the potential consequences are. Some of the veterans also described themselves as naïve or ignorant. This naivety may lend itself to following orders, whereby at that age veterans are impressionable and would trust those with authority.

Further to the issue of naivety associated with their young age was the relatively limited availability of knowledge about radiation, or perhaps, limited access to the knowledge existing at the time contrasted with present day:

But now, looking back on it, can you tell me about sort of the risks or do you think there were risks?

In those days you wouldn't have expected anything, as I've just said you weren't told about anything, we hadn't read up anything. Information in those days was quite scarce. A lot of those leaflets published in the 1950s weren't available in those days. Communication was entirely different so you couldn't go with anything because that didn't exist. So as regards to us sitting over hundreds of miles away in the middle of the pacific, the information that you got or was available was very, very limited. Very limited. Whereas nowadays if you want to know anything you just google it. But in those days, you just accepted what you were told, and you did accordingly. So that was it. (Paul)

Generally, the participants in this study described how they had no concern at the time for any radiation-related risks and believed this was because of their young age, limited access and availability of radiation risk information, and the prospect of visiting a 'foreign' land with weather and environments very different from the UK. This latter point was experienced as 'exciting' to a young man at the time. The next subtheme now captures the change in

perceptions of the tests following their involvement in the nuclear testing programme, with reference to certain life events and the wider sociocultural context.

After the tests.

For most veterans, the lack of concern for any radiation-related risk persisted throughout the next decade following their service. The specific duration of this of course varied between veterans, and was primarily influenced by the specific events that followed, such as birth of descendants, physical health effects, formation of the BNTVA, and the emergence of media reports about nuclear testing effects. These events comprise the second subtheme. In one case, Vincent who witnessed weapons tests at Christmas Island, had little concern over his lifetime for the risks of radiation exposure on his health:

> ***So yeah, would you say that the reason why you didn't, you know, think about the tests when your children were born is because yeah, the secrecy? No one really spoke about it? No media reports?***
>
> *No, that's right. Yeah, no media reports. There wasn't anything in the papers and, you know, when I'd come back home and demobbed in '60 I really didn't give it another thought actually that something could go wrong with my health. That was never in my mind that because I've been out there something could happen to my health, therefore something could happen to my children if I have children. Well you know, I wasn't married then. As you say, no, that might be it. Because it wasn't in the media, newspaper or whatever, um you know we just forgot about it. It's only when you contacted me about- Or when I joined the BNTVA, I don't know five years ago I suppose? Um, you know, that people we're talking about it. Yeah, you know, my friends and relations. Um and then and you contacted me. But other than that, I've just gone through life..yeah.* (Vincent)

Likewise, many veterans primarily put the initial lack of concern down to the limited newspaper and media exposure as well as no involvement or activity in the BNTVA within the few years following deployment. For several of the veterans, the formation of BNTVA and their involvement in attending BNTVA meetings was also regularly described in the context of their concerns. Some told of their experiences socialising with other veterans at these meetings and learned of health issues in other veterans, which made them begin to wonder

about their own health. Interestingly, this concern may also be present in the veterans' wives who would also attend events. The following extract is provided by Stephen's wife during discussions about any concern for their descendants' health because of radiation.

> [directed to wife] ***Did you have any concerns or worries prior to having children or grandchildren?***
>
> (Wife) *Um...no not really. I can't say it concerned me that much. I mean we had our children quite quickly and uh-*
>
> *Yeah, they're 50 plus now, so.*
>
> (Wife) *Yeah. Yeah, so I wasn't thinking "oh dear", you know, but-*
>
> ***The oldest grandchild is about 27?***
>
> (Wife) *Huh? Oh, and the youngest is 13. But yeah and..- Yes you did- I was concerned a bit about the grandchildren thinking "I hope they're going to be alright" because of what we'd heard about, other, some children were, you know. I mean some of the men at that meeting were saying all sorts of things that had happened to their grandchildren. A lot of their grandchildren had died quite early from cancer and things, so that is at the back of your mind, isn't it?* (Wife of Stephen)

In addition to interactions with other nuclear test veterans were the interactions with individuals perceived as understanding the testing programme risks. A few of the veterans would remark on their later experiences of telling individuals about their service at Christmas Island and Maralinga. Although these interactions were not described in the context of worry, these few veterans described the interactions in relation to feeling lucky which was previously discussed within the 'health effects' theme. One case was the interaction with a worker for the AWRE who was surprised that this veteran was alive. The veteran interpreted the exchange as being reason to be concerned about his involvement in the testing programme.

Equally as important as the formation of the BNTVA and emerging media reports in the 1980s, and social interactions, were the subsequent events related to health conditions and the health of their descendants. Not only are the events alone important, but the placing of these events

in time around the emergence of media and formation of the BNTVA is important when explaining the possible psychological impact of the tests.

Most veterans in this study said that they had not encountered illnesses during the first decade or so after, therefore it is difficult to comment on the psychological impact of their own illnesses occurring before the establishment of the BNTVA and the emergence of media reports. Participants discussed their children that they had during the 1960s and 1970s. These veterans remarked that they did not have any doubts about their children's health before they were born, due to limited awareness since the BNTVA had not yet formed and media reports had not yet emerged. Having a healthy descendant prior to the emergence of the reports served as a reassurance that they had not been negatively affected by ionising radiation exposure, once they had learned about other veterans' misfortunes through media reports. Unfortunately, we did not have any examples where a first-generation descendant was born after the veteran became aware of other veterans' descendants being affected. However, it is possible that anxiety for the future would be more likely if a veteran had not had descendants by the time they had learned of the potential consequences of ionising radiation through the media and BNTVA:

> ***So I guess having the first children before these news reports was almost..you know maybe if you didn't have a child before then maybe you'd be more concerned?***
>
> *Yeah I would possibly be, yeah. But the fact I'd had the children and they'd all come through ok and the reports came up after I'd had the 3 children..then of course the effect on how I felt about it was less than what it possibly would've been if I was thinking about having one next year, sort of thing. That's not likely to happen is it?* (Ronald)

Even in the scenarios where first-generation descendants were born with defects or developed a significant health issue, or in the case of miscarriages, these few veterans said how they initially had no reason to attribute it to their prior service because the awareness of other veterans with similar problems had not come to light yet. Without the knowledge of potential ionising radiation effects then there would be no reason to link any health conditions in themselves or family members to ionising radiation exposure, specifically:

> *…1972, my wife had a- Or we had numerous miscarriages in hospital, sometimes taken children away. Lost one twin, thought we lost the other twin, lost that twin so we had numerous miscarriages which I just thought you know these things happen.* (Michael)

To summarise, the theme 'Change over the life course' describes the changes in perceived risk, emotion, and worry over time, ranging from perceptions at the time of the test to the present day. Such changes in perceptions were not universal because not all participants were exposed to the BNTVA or emerging media reports at the same time as one another. Overall, the veterans had generally positive experiences at the time, but a few veterans had a strong negative perception of the testing programme when considered in hindsight. In the interview with Michael, he first presented six photographs depicting a roadside area in Maralinga, a cargo aircraft, a transport vehicle for authorities, a family of aborigines, a photograph of him and his friends to which he notes they were not wearing protective clothing, and of him and his friend relaxing with some beers. When asked if any of these photographs was significant to him, Michael stated that none were significant at the time of the testing programme. He then describes the role of hindsight based on the information acquired and events experienced in years following the testing programme. The following extract from his interview is presented here because it captures the '*change over the life course*' theme effectively.

> *At the time you think "nah it's a pretty good posting, we have a great time, have a few drinks in the evening, really easy going. But when you actually get back and things start to occur that hindsight says 20/20 vision. It's a wonderful thing, and when you get a bit of hindsight things start do come to..affect you I think emotionally but I'm quite angry in a way. I've got more anger than anything else. Anger and guilt. Anger and guilty, those are the two things. I mean I'm ok mostly I think emotionally but..I do get upset sometimes.* (Michael)

Discussion

In all, this exploratory study of 20 British nuclear test-veterans showed three overarching and interconnected themes describing the possible psychological impact associated with involvement in the testing programme, namely '*Health effects*', '*Us vs. them*' and '*Change over the life course*'. To reiterate, worry about potential health conditions in themselves was not especially relevant in the present moment, and worry about potential health conditions in descendants did persist but only in a few cases (grandchildren more so than children). But there were other issues evidenced (perceived responsibility, guilt, and anger) which could be considered as a psychological impact. This finding was unexpected considering that worry about adverse health conditions was presumed the central issue to the psychological impact of perceived ionising radiation exposure. Socio-psychological issues appeared important to consider which do not directly relate to ionising radiation, but rather the role of authorities (detailed in the '*Us vs. them*' theme). Not only does this study provide insights into the possible broad psychological impact of being involved in the British nuclear testing programme, but it sheds light on health beliefs and narratives from the perspective of older British nuclear test veterans.

Indeed, the themes are interconnected in the sense that the perceived health risk on themselves and on family members (and the psychological impact of this) does not occur in isolation, but this matter is complicated by the perceived role of others (namely the authorities) at the time of the tests and at present day. However, we can compartmentalize the psychological impact (and elicited emotions) based on dimensions such as consequentialist and deontological/ethical emotions (i.e. who is responsible? (Böhm, 2003; Böhm & Pfister, 2000). The discussion therefore will first focus on worry (since anxiety is a prospective consequentialist emotion) and begin with explanations for why there was relatively limited worry (and anxiety) and why other emotions may be more relevant, drawing specifically on the characteristics of this test veteran sample. The discussion will then focus on anger and guilt under a separate heading (labelled *'Health perceptions, anger, and guilt'*) because these relate to deontological/ethical appraisals and are marked by a sense of responsibility for perceived health risk, differing in attributing responsibility to authorities (anger) versus oneself (guilt).

Worry.

Before discussing the findings pertaining to worry, it is important to relate to the extant nuclear veteran psychological literature. There are a few previous psychological studies of nuclear test veterans, but these were conducted more than three decades ago (Garcia, 1994; Murphy et al., 1990; Vyner, 1983). The first is that of Vyner (1983) who describes the post-test experience from a medical perspective using medical terminology. Vyner described how the USA veterans reported the initial period following the tests as 'asymptomatic', but later in life experience an undiagnosable 'symptomatic' period which precedes the onset of a 'syndrome' characterised by adverse behavioural symptoms (loss of social ties, loss of employment) because of their preoccupation of believing one's illnesses is caused by ionising radiation. This is a stark contrast to the present 'exposure worry' study. While Vyner (1983) also mentions that the veterans' belief system was influenced by media reports, my participants did not appear to be as preoccupied with their illness beliefs to the extent that it caused functional impairment. One explanation for this contrast is the age of the participants. The participants in Vyner's (1983) study were in their 40s and 50s at the time of his study (all of whom with significant health conditions), thus one can speculate that the age at which a serious health condition is realised may be a factor in becoming preoccupied with illness.

But there was some worry about descendants' future health like that of Murphy et al. (1990); another qualitative study of nuclear test veterans in the US, particularly in the context of their grandchildren. In my study, while the psychological impact was limited in those who believed their descendants had not been adversely affected, worry remained in some veterans due to the belief that genetic diseases may skip a generation.

To reiterate, the participants in this exposure worry study generally reported limited worry about potential future health effects in themselves and in their children, although in a few cases this appeared to persist with regards to their grandchildren. To an extent, this finding corroborated with the quantitative scale findings of the previous chapter, where worry about descendants' health appeared to be more salient than worry about their own health. Conversely, it was perhaps unexpected the extent that worry was not relevant to this qualitative study sample, given the considerable proportion of veterans who indicated that their worry made them feel stressed (see Chapter 5).

To explain the limited worry observed in this present sample, there are three characteristics of the test veteran population which need to be examined. The first two characteristics, namely i) being an older adult and ii) being a male armed forces veteran, are important to highlight in relation to the reporting and expression of worry. The third, namely iii) generational considerations (i.e. the period they were born in, the period the nuclear testing programme took place, and the stage in their lives when awareness of health risks became apparent through the media and the BNTVA), is also important to consider in relation to worry over the life course. These will be discussed in turn.

i) Older adults

All participants were older adults who, according to the literature of unexposed populations, tend to report generally worrying less compared to younger adults (Gonçalves & Byrne, 2013; Gould & Edelstein, 2010; Miloyan et al., 2014). For age trends regarding similar constructs to exposure worry following perceived ionising radiation exposure, Fukasawa et al. (2017) indicated that, after controlling for environmental radiation levels, age significantly accounted for radiation-anxiety with older participants (65+) reporting less radiation-anxiety than other age groups in context of the Fukushima power plant accident. Conversely, Hidaka et al. (2016) conducted a survey study on 1,505 Fukushima decontamination workers indicating that workers aged 61 and over had significantly higher degrees of anxiety about radiation than other ages. Hidaka and colleagues explain these findings by the fact that older workers tended to come from areas other than Fukushima prefecture and tended not to own a radiation passbook, suggesting that unfamiliar environments and inadequate working conditions may contribute to this unusual age-anxiety trend. Indeed, there are differences in the measurement of radiation anxiety used between Fukasawa et al. (2017) and Hidaka et al. (2016) where the former uses a Likert-type scale (Radiation-Anxiety Scale) while the latter uses a single item measure. Not only could differences in scale measures render any comparisons inappropriate but I have concern for the Likert method used by Fukasawa et al. (2017) to measure radiation-anxiety. Elaboration on this latter point has already been discussed in this thesis.

Regarding worry content, older adults report significantly higher likelihood of worrying about the health and welfare of loved ones, despite a lower likelihood of worrying about interpersonal relations, health, and work (Gonçalves & Byrne, 2013). Similarly, regarding worry content in the context of perceived ionising radiation exposure, Suzuki et al. (2015) report adults aged at least 50-years old were more concerned about the effects of radiation exposure on their future

generations, while those of reproductive age (15 - 49) were more concerned about the delayed effects on themselves. These studies in the context of the Fukushima power plant accident (Fukasawa et al., 2017; Suzuki et al., 2015) regarding age trends in worry are consistent with this test veteran study in that any potential worry was directed towards the health of family members (particularly their grandchildren).

Importantly we must consider the temporal orientations of worry in the context of ageing. As defined earlier, worry is a negatively-valenced thought process regarding events that might happen in the *future* (Borkovec et al., 1998; Watkins et al., 2005). Drawing on Tallis and Eysenck (1994) position that worry is a mental problem-solving mechanism for a possible future outcome, it might therefore be expected that worry about health effects is more relevant to individuals who are relatively early in life, whereas those later in life then the future is not regarded as uncertain and worry about their own health might be reduced. On the other hand, their descendants' future remains uncertain and this worry may then be focused on the descendent, which is consistent with previous quantitative work in those affected by the Fukushima power plant accident (Suzuki et al., 2015). In the present study the veterans' first-generation descendants had matured and were well into adulthood, and many of the second-generation descendants were will into adolescence therefore their futures may not be regarded as uncertain and subsequently worry is not as relevant. Moreover, while a couple of participants expressed a slight concern for their next generation of descendants who were not yet born, they stated that it is very unlikely that they would be alive to witness them develop anyway. Therefore, considering the temporal orientation of emotions, worry (and anxiety) may be less relevant here compared to if the sample were younger.

ii) Masculinities

Aside from the age of these participants, it is also important to consider the potential influence of masculinities on the reporting of worry. The extant literature suggests that men report being less anxious and are more likely to show psychological symptoms such as aggression than women (for review on explanations for gender differences in mental health see Smith et al., 2018). Indeed, while women do tend to report greater levels of worry than men (Gould & Edelstein, 2010), self-report studies are prone to stereotypical biases which, once removed, suggests no actual gender difference in emotional reactivity (McRae et al., 2008). Similarly, Tetzner and Schuth (2016) acknowledge that any gender difference in worry or anxiety could be a result of learned gender-specific expectations regarding emotional expression and coping

with anxiety. Of course, no comparisons between gender on exposure worry are relevant to this present study, but one can look to the role of masculinities as an explanation for the limited expression of worry.

Masculinity broadly refers to the attributes, roles and behaviours associated with men and boys which are engendered through cultural practices and institutions by reinforcement, modelling, and punishment (Berke et al., 2018). As discussed in Berke et al.'s (2018) review of masculinities and emotional expression, the socialisation processes which influence emotional expression can be categorised in two forms. The first socialisation processes being childhood socialisation of boys to behave in 'gender-appropriate' ways, for example it is suggested that parents are a strong influencer of promoting 'gender-appropriate' norms early in life (Berke et al., 2018). Later in childhood/adolescence, other influences stem from same-sex peer groups (but also influenced by opposite-sex peer groups) where boys learn to inhibit the expression of certain emotions (see Berke et al., 2018). The second socialisation processes are the factors which exert social pressures on adult men in the present moment. One example of this is gender schema theory which theorises that men (and women) readily incorporate cognitions (e.g. schemas, beliefs, norms, stereotypes) based on observations of others into their emotional and behavioural repertoire, which form one's concept of what it means to be a man or woman (Bem, 1981). Experiential factors such as the psychological stress of failing to conform to expectations (or self-perceived deficiencies in masculinities) might result in men employing strategies to suppress the expression of emotions (Jakupcak et al., 2003). As such, the expression of worry in older men may be influenced by masculinities adopted over a lifetime.

The inclusion of masculinities as an explanation for reporting limited worry was partly influenced by the participants themselves. When asked about why some test veterans may not have a strong test veteran identity, Peter highlights the role of gender in emotional expression:

> *They don't want to talk about* it*, and they don't want to people asked again because it's too bloody painful and it means they've got to open up. And men aren't often very good at doing that...they can't talk about it, not really, because nobody understands them. Only another veteran.* (Peter)

And shortly after when asked about masculinities:

Women can open up to each other. I like the company of women that's why I like the goddess temple, although it's not all women. But I like the company of women because they all open up to each other. They're totally honest... They're not afraid to open up. Men are, generally. I think we're getting better at it, generally. (Peter)

Some face-to-face interviews included family members such as their wives, partners, and in one instance a granddaughter. In this case, the input of women in the interview led to my speculation that masculinities may influence the construction of data. There may be details about the psychological impact which are not being discussed in the interview setting perhaps because I am a male interviewer, but could have been discussed between the participant and their wife in private.

And what is the extent of the worry*?*

What do you mean? I don't lose sleep over it, put it that way.

Yeah that's what I'm driving at.

I can't do anything about it, -

(Wife) *Yes, you do*.

Can I? So, what goods worrying about it? That's the way I look at it. The doctors can't do nothing can they? (Russell)

In this same interview, there was brief discussion about feeling 'shame' for being used as a 'guinea pig', when the veteran's wife and granddaughter had left the room to make refreshments. This is evidence that the presence of others in interviews may impact on participant responses (i.e. construction of data), though it is unclear whether this is merely the presence of significant others, or whether it is the role of masculinities.

The above details on masculinities generally pertains to gender (being male). But also directly related to the topic of masculinities there is the fact that they are veterans of the armed forces. Although most of these veterans were not involved in the military all through their lives, it remains possible that some veterans would adopt masculine traits perceived as desirable in the military context. Connell's (2005) concept of hegemonic masculinity ('hegemonic' meaning

dominating) should be noted here. While hegemonic status is dynamic, there is a gender hierarchy where femininity is perceived as bottom of the hierarchy even by those without hegemonic traits. Some traits of hegemonic masculinities have been argued to be found in high-ranking military staff (Connell, 2005). Furthermore, it is known that military culture endorses emotional toughness and stoicism which appear to overlap with characteristics associated with traditional masculinity traits (Jakupcak et al., 2013). In fact, a recent qualitative study of six male military and ex-military personnel showed that manliness was perceived as important to military competence and, while stress was inevitable, showing signs of stress was perceived as a negative trait (McAllister et al., 2019). Masculinities associated with military culture and implications on emotionality have also been explored in veterans in palliative care (Plys et al., 2020). In Plys et al.'s (2020) clinical recommendations they postulate that older male veterans may use terms such as 'angry' or 'frustrated' instead of 'sadness' as indicators of emotional distress. The intersection of traditional masculinities and military culture and its influence on emotional expression could therefore be argued to present a challenge of understanding really what the psychological impact of perceived radiation exposure in nuclear test veterans is. To some extent, understanding masculinities could explain the contrast between the quantitative data of the previous chapter and the present qualitative findings in the reporting of worry, where one can argue that is it easier for older men to report worry on a relatively benign scale compared to articulating experiences of worry through in-depth interviewing.

iii) Generational considerations

In addition to examining worry and emotional expression in relation to their age and gender, we can draw on Mayer's (2009) concept of the 'cohort' in life course research. The concept of 'cohort' (Diewald & Mayer, 2009; Mayer, 2009) can be an explanation (albeit tentative) for the findings of the present test veteran study, which refers to the period that they were born in and the period at which the event occurred accompanied with the sociological arrangements present at the time. That is, this cohort is unique in their experience and nature of exposure and the period that it occurred; therefore, it is logical that the findings of this present study appear unique in comparison to the extant radiation literature. For example, the veterans described how there was limited reason to worry about adverse effects because there was relatively little public understanding regarding the risks of exposure at the time. The young age of the veterans and self-described naivety, and the limited understanding and knowledge availability regarding

radiation protection at the time, all appeared to have some influence on the development of any psychological impact (or lack of).

It is also worth examining the location in time that the testing programme took place. Comparing with the psychological impact of other instances of ionising radiation exposure, such as power plant accidents (e.g. Chernobyl, Fukushima), I suggest that one reason why the veterans did not appear as affected psychologically (particularly in terms of worry or anxiety) is because the weapons tests were, to an extent, anticipated. Unlike Chernobyl where drastic financial, occupational, and social changes occurred adding to the psychological impact (Abbott et al., 2006; Beehler et al., 2008), the nuclear weapons testing also occurred in relative isolation. That is, there were relatively little economic or social repercussions of exposure from nuclear weapons testing. This distinction is important to unpick. Without drawing a distinction between the psychological impact of perceived exposure and the psychological impact of sudden societal change, this may result in being misinformed about what factors are central to any psychological stress in exposure scenarios. Thus, one must not undermine the role of factors extraneous to ionising radiation.

Following this, subsequent events important in the possible psychological impact and health perceptions included the emergence of media reports and the emergence of the BNTVA, both primarily occurring in the 1980s. Due to the period these veterans were born and the societal norms for first childbirth of their spouse, most of these veterans had their first generation of descendants over a decade prior to the 1980s. Therefore, the uncertainty regarding their health outcome is limited since their children had already developed by the time the veterans were aware of possible health risks (though worry for grandchildren remained relevant for some participants).

Overall, this section has examined three characteristics of this unique population to understand why they were generally not worried about their potential exposure to ionising radiation, namely their age, gender, and generational considerations (i.e. the period they were born in, the period the nuclear testing programme took place, and the stage in their lives when awareness of health risks became apparent through the media and the BNTVA). Indeed, worry was not the most salient psychological impact of the tests on this sample, but rather issues relating to anger and guilt appeared more significant. These broader psychological issues form the next section. I now discuss the beliefs regarding existing physical health conditions in themselves and in family members, the concept of responsibility for health impact both in the

light of authorities and oneself, and the potential psychological/emotional outcomes of this: anger and guilt.

Health perceptions, anger, and guilt.

On the whole, there was a considerable sense of perceived luck when the veterans discussed their perceptions of their health status. It is interesting to note that the role of the media might contribute to the general perception of luck regarding their health, in the sense that the media may skew veterans' perceptions of the general health status of British nuclear test veterans. For example, Philip pointed out that it is 'bad news that sells print' and stated that the press is unlikely to print stories about a nuclear test veteran without health problems. Of course, media reports are not the full story as to why this perception of luck exists. Some of the veterans also observed that there were fewer nuclear test veterans present at annual general meetings and reunions in recent years, and rather that the meetings are comprised more of descendants as years go by. This would be expected in an aged cohort where there are fewer surviving, and of those who are surviving some may have limited means of travel given that the geographical distribution of the veterans is relatively evenly spread across Great Britain.

Continuing along this line of health perceptions, the present study provided insight into how British nuclear test veterans attribute causality to health conditions, and examines the possible psychological impact related to these health perceptions. Generally, their illness beliefs appeared to be influenced by the age at which an illness was realised (i.e. illnesses such as cancers are associated with older age and may be attributed as such, as opposed to prior radiation exposure) and whether an illness is perceived to be rare for someone of that age and lifestyle. Similarly, the health conditions perceived as incurable were also more commonly attributed to ionising radiation exposure. Methods used by veterans to understand the causes of illness in themselves and in family members involved comparing with other veterans and families with no connection to nuclear testing. The implications of understanding nuclear test veterans' perceived causality for health conditions relate to two issues: firstly, the perceived role and culpability of others in one's illness narratives, and secondly, the psychological impact of perceived self-responsibility for health conditions in the family. These will be discussed in turn since they relate specifically to anger and guilt, respectively.

1) Health effects: responsibility of others (anger)

Consistent with Kleinman (1988), understanding illness narratives can illuminate how biomedical models of illness (disease) are reductionist where they undervalue an illness to a biological mechanism, while ignoring the context and meanings of the illness from the patient's perspective. This emphasis on illness narratives has previously been explored in the context of British nuclear test veterans (Trundle, 2011), which considers political culpability and the nuclear test veterans' struggle to demonstrate to authorities that they have been adversely affected by the testing programme. This role of the authorities is evident in the '*Us vs. them*' theme. For example, anger and frustration were often directed towards the Government, sometimes referred to as 'the powers that be'. Like Vyner (1983), anger towards the Government was evident but perhaps not to the extent of identity conflicts which were highlighted in Vyner's (1983) study (some veterans in his study reported guilt over their anger towards government). Indeed, the label 'guinea pig' was found in Vyner's (1983) study and in the present study, suggesting that this perception is pervasive in potentially exposed military populations. Similarly, Murphy et al. (1990) report on the notion of invalidation, where American veterans described how they were not made aware of any possible adverse health effects associated with ionising radiation exposure. One could speculate whether this is unique to the military, as Charles described in the present study, servicemen were usually not provided with information or specific details about tasks being undertaken. The continued reluctance for authorities to recognise any negligence or deception may further exacerbate any psychological impact.

The role of authorities has been applied to other exposure scenarios where individuals perceive authorities to be withholding safety information or negligence. For example, a Chernobyl residents case study by Abbott et al. (2006) described how the residents had little understanding about the adverse consequences due to limited information. Subsequently, they were angry about the authorities' lack of transparency. This bears resemblance to the participants in the present veteran study where some described limited worry at the time due to limited risk information available and access to any information and, on reflection, are angry at the authorities' lack of transparency regarding radiation protection. The role of transparency has been examined in risk perception. The social amplification of risk framework (Kasperson, 2012; Kasperson et al., 1988) suggests that factors such as limited trust in authorities, lack of transparency, scientific uncertainty, and perceived injustice drive the amplification of risk in

social groups. One could speculate that veterans may perceive, in hindsight, their exposure as higher risk because their trust towards authorities appears low. For example, risk perception is generally low when trust in relevant authorities or institutions are high (Guo et al., 2020; Siegrist, 2000), and we evaluate our trust to the relevant authorities when we have limited knowledge about the hazard (Siegrist & Cvetkovich, 2000). I suspect that anger may be increased when risks are perceived to be high.

The concept of deontological/ethical evaluations of risk and threats (Böhm, 2003; Böhm & Pfister, 2000, 2017) and its influence on eliciting anger and guilt has already been detailed elsewhere in this thesis, therefore an in-depth discussion is not required. Indeed, deontological/ethical evaluations of risk are strong particularly when the risk is anthropogenic compared to natural risks (Böhm, 2003; Böhm & Pfister, 2000, 2017). Böhm and Pfister's (2000) appraisal-based framework states that anger is strong when consequences are to be expected (or have already occurred) *and* when there is someone else or a group who is morally responsible. This was notable in the present study where veterans who were particularly angry also perceived deception and/or negligence on the authorities' behalf (i.e. attributing culpability of their health risk to authorities involved at the time).

The socio-psychological issues observed in this study are akin to those in Garcia's (1994) brief report. While not explicitly mentioned in the data of the present study, the British nuclear test veterans may have struggled reconciling their reality with a disparate reality offered by authorities, as described by Garcia (1994) in the context of US test veterans. It appears that the disparate reality may also be offered by healthcare professionals, where some participants in the present study described how healthcare professionals were reluctant to consider the potential for health conditions to be associated with the British nuclear testing programme. In one case, Roger indicated frustration, particularly when treatments offered by healthcare professionals were ineffective after discounting veterans' suggestions that the health conditions were related to the testing programme.

It is difficult for healthcare professionals to determine causality of health conditions in everyday contexts, but it may be especially difficult when many age-related health conditions (e.g. various cancers, cataracts, cardiovascular disease) have been associated with certain doses of ionising radiation (for review on this topic see Vaiserman et al., 2018), albeit at doses generally larger than what British nuclear test veterans are thought to have received during the programme (G. M. Kendall et al., 2004). This is not to say that attributing physical health

conditions to radiation exposure in this context is irrational. The crux is that dose records are unascertainable in the British nuclear test veteran cohort, so without definitive information veterans will make varying causal attributions especially considering the continued scientific debate regarding low-dose radiation health risks (Vaiserman et al., 2018). Indeed, scientific uncertainty can drive social groups to amplify risk in the context of low-dose ionising radiation exposure (Kasperson, 2012; Kasperson et al., 1988). Without definitive information regarding their health risk and the numerous known causes for some health conditions, it is therefore expected that some veterans will attribute their health conditions to ionising radiation exposure. Thus, I can offer three suggestions rooted in the issue of transparency and the marked ambiguity regarding dose levels and related health effects:

Firstly, authorities dealing with exposure scenarios must emphasise transparency to avoid amplified perceived health risk and eliciting anger in affected populations. For example, the latest International Atomic Energy Agency (IAEA; 2017) advice on transparency and effective communication states that interested parties should be involved in dialogue at the earliest possibility, and regulatory bodies should routinely make as much information as possible available to interested parties. Additionally, the IAEA (2012a, 2012b, 2017) places strong emphasis on working closely and transparently with the media because the media is the primary source of information for the public. The present exposure worry study demonstrates the impact on relevant communities if such regulatory advice is not fulfilled and highlights the role of media reports influencing veterans' beliefs regarding health conditions and health risk in themselves and in family members.

Of course, the nuclear testing programmes will have preceded the comprehensive advice provided by the IAEA in handling radiological scenarios and working with the public and media. Drawing on this, while the IAEA (2012a, 2012b) does provide some recommendations for deliberate radiological emergencies (e.g. terrorism) and highlights that some information may be restricted to the public due to special circumstances, it is unclear how these guidelines can be applied to exposure scenarios such as nuclear weapons testing. A set of guidelines for radiological and chemical exposures in the military context may be required, particularly since risk information may be withheld as a matter of national security.

Secondly, subsequent genetics research must emphasise transparency and clarity of findings to allow populations to arrive at balanced conclusions in the light of amplified risk.

Finally, the potential for narrative-based medicine to improve well-being of illness sufferers is apparent (Fioretti et al., 2016; Greenhalgh & Hurwitz, 1999) and it can be speculated that understanding the sociocultural context of illness beliefs, namely perceived ionising radiation (or other toxic exposures) and the perceived antagonisms between those exposed and authorities, may improve patient satisfaction and wellbeing in British nuclear test veterans. Thus, healthcare professionals could apply the findings of the present study in preparation for aged populations (with prior exposure to radiological or chemical agents) realising health conditions.

2) Health: self-responsibility (guilt)

The issue of perceived responsibility in authoritative groups has now been covered with reference to the 'Us vs. them' theme, but another pertinent issue relating to exploring illness beliefs (particularly family members' health conditions) relates to perceived self-responsibility. This issue of self-responsibility is a novel finding which adds to our understanding of the psychological impact of ionising radiation exposure. It is particularly interesting to note that the two perceptions of responsibility (authorities' and self-responsibility) can be concurrent but focus on separate aspects of being a nuclear test veteran. For some veterans in this study, family members with health conditions perceived to be caused by the veterans' exposure to ionising radiation may not fall under authorities' responsibility. That is, despite veterans assigning culpability to authorities in terms of negligence and/or deception, these veterans may assign self-responsibility in the context of their family members experiencing health conditions.

Of course, one's descendant suffering from an illness or dying would evoke sadness for most individuals. But the belief that it is caused by their exposure to ionising radiation may subsequently evoke feelings of guilt which may not be experienced otherwise. Of note, the uniqueness of the situation means that the guilt is a unique psychological dimension in excess of otherwise normal negative life events (for example, miscarriages and cancers do occur in family members naturally). Indeed, such life events would be psychologically distressing but it can be argued, based on the interview data, that special attention should be paid to any excess psychological consequences resulting from perceived responsibility relating to their family members health condition. The term 'genetic responsibility' has been coined in the medical sociology literature but has primarily been explored in the context of genetic screening for cancer-associated genes such as BRCA1/BRCA2. Related to this term, the notion of guilt regarding one's descendant's health has also appeared in qualitative research in men (Hallowell

et al., 2006; Strømsvik et al., 2011) and women (d'Agincourt-Canning, 2006) with BRCA1/BRCA2 mutations.

Drawing on Hallowell et al.'s (2006) study on men's perceive role in their BRCA1/BRCA2 mutation and transmission, similar observations are made with the test veteran interviews, where veterans describe responsibility regarding descendants' genetic health. The phrase 'just one of those things' was relevant to some of Hallowell et al.'s participants and indeed some of the test veteran participants (particularly prior to the advent of BNTVA and media reporting), but it appears that participating in the testing programme and knowledge of adverse radiation effects leads to veterans perceiving their descendants' condition (or hypothetical condition) as an event caused by themselves. A key difference pertaining to responsibility between the test veterans and the men in Hallowell et al.'s study could be that Hallowell et al.'s men acknowledged that their transmitted genes were inherited by their parents. Importantly, Hallowell et al.'s participants generally did not accept blame for being a carrier which contrasts with the test veteran perceptions in this study.

Limitations

This qualitative study provides an in-depth and nuanced account of 20 British nuclear test veterans' experiences, focusing on health perceptions and the psychological impact of participating in the testing programme. Due to the relatively small sample size, it is entirely possible that different findings would have been obtained, particularly regarding exposure worry, if a larger sample had been interviewed. Specifically, and considering the self-report scale findings of the previous chapter, one may be surprised that most of this sample were generally not worried about exposure to ionising radiation. Alternatively, these qualitative findings indicate that the Current Exposure Worry Scale may lack validity in the sense that respondents are not worried (despite rating oneself as 'strongly-agree' on various items) but rather they are translating feelings of guilt (pertaining to perceived self-responsibility for family members' health) and anger (pertaining to authorities), or concern (i.e. one may have doubts or interests in the topic because it is of significance to them, but not to the extent that one experiences worry) to scale items labelled as 'worry'.

Another limitation of this study is that the concept of coping resources was not explored, which was regretful since a natural progression of exploring the psychological impact is to explore how individuals cope with it. Coping resources can be categorized as personal (e.g. self-esteem,

perceived mastery; Frankham et al., 2020; Pearlin & Schooler, 1978) and social (e.g. social support; Thoits, 1995). To elaborate on personal resources, it may be difficult for participants to discuss their self-esteem in the context of coping with adversity in this scenario. Perhaps exploring financial status as a possible coping resource may have been useful since financial status has been linked with self-esteem and perceived mastery (see Frankham et al., 2020 for review). As such, socioeconomic status will be examined in the following quantitative chapter.

To elaborate on social coping resources, it is unclear in this study how these participants utilise the support from family members or through other nuclear test veterans. While not all participants described being involved in the BNTVA or NCCF (despite being members of the NCCF), it is possible that some participants may benefit from social support through experientially-similar others (Thoits, 2011). Without exploring support through experientially-similar others, I am limited in recommendations that we can make for possible interventions to alleviate the psychological impact of the testing programme.

Lastly, while this study focused on the psychological impact in the veterans themselves, there remains the question of whether their descendants (children and grandchildren) are at risk of any psychological impact of paternal ionising radiation exposure. This question arises following the consideration that adverse health effects could be perceived to be hereditary, so one considers the potential for descendants to perceive their offspring as being at risk of adverse effect. There is little work exploring this, but one study has explored the possible psychological issues in second-generation atomic bomb survivors, particularly in females, pertaining to adverse health effects in descendants (Kamite, 2017). Such considerations should be made to descendants of British nuclear test veterans.

Conclusion

This qualitative study presented the unique opportunity to examine the psychological impact of the British nuclear testing programme on veterans over the life course. Interestingly, any worry about future adverse health effects in themselves and, to an extent, in their family members was not particularly relevant. But worry regarding adverse effects in descendants was certainly relevant to some veterans, especially with regards to their grandchildren. Critically, the sense of responsibility for family health and subsequent guilt appeared to be a bigger issue, especially in those whose family members had suffered from health conditions. This must be considered in other exposed populations, especially in those who eventually have children since

health conditions do occur naturally regardless of any exposure to radiological or chemical agents. Moreover, perceived deception and negligence in authorities may exacerbate any psychological impact associated with perceived exposure, so it is important for authorities to emphasise transparency when managing health risk information in exposed populations. The potential psychological issues relevant to British nuclear test veterans are illustrated in a conceptual model detailed in the following section. This conceptual model provides a basis for further analysis in Chapter 7 where I revisit the quantitative data relevant to exposure worry.

Chapter 6 (Continued) – a conceptual model

It is clear from the themes that exposure worry (and the broader psychological impact) is complicated. It is evident that it may not be solely worry (if any worry at all) which is central to any psychological impact. Rather, issues such as guilt and anger, which were not captured by the Current Exposure Worry Scale, may contribute to the psychological impact. Thus, the broader psychological impact of being involved in the British nuclear testing programme is multi-faceted. These findings confirmed that both the Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale may not be adequate to accurately capture the relevant psychological stress. Therefore, the scales are also inadequate to address the original cognitive functioning hypothesis.

The complex nature of the possible psychological impact can be difficult to understand using themes alone. To aid the communication of the findings a conceptual model was developed. Importantly, a conceptual model also sets the groundwork for subsequent quantitative research to examine predictors of the possible psychological outcomes of the British nuclear testing programme (Chapter 7). This section now describes the process of how the conceptual model was developed, before presenting two exemplars from the raw data to describe the workings of the model.

The first drafted conceptual model resembled a timeline with 'yes/no' paths. An example of this would be a box with the question "Descendant's health condition attributed to radiation?" followed by two paths for 'yes' or 'no', respectively. This approach was deemed too specific and simplified for the phenomena examined. Furthermore, the drafted timeline included life events which would of course occur at different stages for certain participants which adds to the complexity. Therefore, the timeline model with "yes/no" paths was dropped, and I decided to pursue a more abstract model using the key constructs (Appendix O).

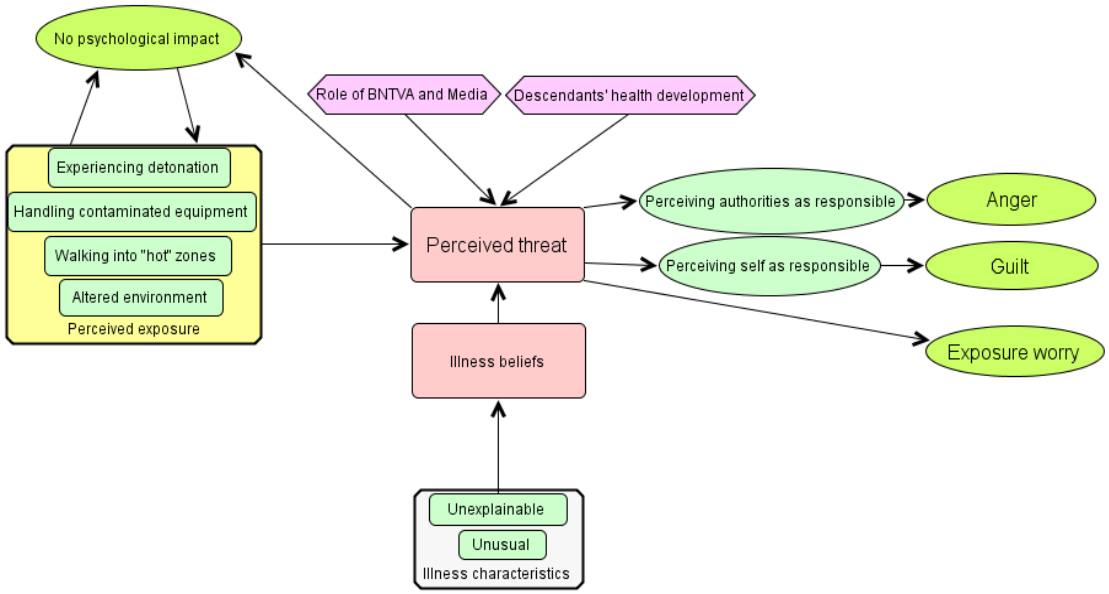
The conceptual model was formulated based on the identified themes and subthemes. These themes and subthemes were useful to identify key constructs of the model. For example, the '*health effects*' theme and its subthemes '*beliefs about illness*' and '*worry, responsibility and guilt*' constitute significant components of the conceptual model (Figure 9). The attributions of health conditions described in the '*beliefs about illness*' subtheme are illustrated in the conceptual model as 'illness characteristics' which feeds into 'illness beliefs'. Similarly, the

'*us vs. them*' theme described socio-psychological issues and experiencing anger, and this is represented in the conceptual model.

While the themes and subthemes were useful to lay the foundations of the model, I was aware of the risk of becoming too detached from the data. This is because the model would be formulated on already-interpreted findings. To address this, I revisited the raw data and began sketching out how the different key constructs interlink and to identify other factors which may influence the key constructs. Additionally, the conceptual model was theoretically-informed in the sense that, while not explicit in the data, there must be a perceived threat preceding the psychological impact (e.g. appraisal theory; Lazarus & Folkman, 1984). This perceived threat is a central component to the model and is influenced by perceived exposure, beliefs regarding physical health conditions, descendants' health development, and awareness of health risk through media and BNTVA meetings. However, the perceived threat does not always result in anger, guilt, or exposure worry but it may result in no psychological impact if coping resources are perceived to be adequate (Lazarus & Folkman, 1984). Drawing on appraisal-type theories (Böhm, 2003; Böhm & Pfister, 2000; Lazarus & Folkman, 1984), emotions such as guilt and anger are differentiated as a function of responsibility, whereby guilt is preceded by perceiving oneself as morally responsible while anger is preceded by perceiving authorities as morally responsible (i.e. socio-psychological issues such as negligence and deception) for threats to wellbeing. This is depicted in the model (Figure 9).

Figure 9.

Conceptual model



Note. Perceived exposure to ionising radiation in this context can elicit different psychological and emotional outcomes. The outcomes are not terminal nor are they mutually exclusive: one can be angry and worried, for example. Firstly, perceived exposure may result in no psychological impact, but the reverse arrow indicates this is dynamic and can change depending on life events. For perceived exposure to result in psychological impact, namely anger, guilt, or exposure worry, it is proposed that there must be a perceived threat to wellbeing. This perceived threat is influenced by the role of BNTVA and media, descendants' health development (as shown in purple hexagons) and illness beliefs. The latter describes attributing causality to physical health conditions in oneself or in family members, generally referring to unexplainable and unusual health conditions. This perceived threat may result in no psychological impact if the threat subsides (e.g. descendants' appear to develop healthily). Regarding possible psychological impact, the perceived threat can elicit anger when authorities are perceived as responsible for violating moral standards and causing threat to wellbeing (e.g. perceived deception, negligence). Perceived threat can elicit guilt if one perceives themselves as responsible for threats to wellbeing which have already occurred, particularly health conditions in family members. Finally, perceived threat can lead to exposure worry when threats to wellbeing are anticipated but uncertain.

To demonstrate the workings of the conceptual model relative to the raw data it is formulated on, I present two exemplars:

Exemplar 1 (Michael)

Firstly, start the model with yellow box 'perceived exposure'. This box describes the perception that one has been exposed to ionising radiation during the testing programme. It has already been mentioned that not all participants were present for the detonation, since some were involved in the clean-up operation.

Aside from being present for detonation, other reasons for perceived exposure included perceptions of altered environment (e.g. descriptions of eeriness, changes in wildlife behaviour), and handling contaminated equipment or being present in contaminated zones, both of which may have been realised retrospectively. As an exemplar of this box, Michael, who participated in the nuclear testing programme in Maralinga, describes with hindsight how he perceived himself to have been exposed to ionising radiation:

> *But I think that handling the nuclear material, going out to the forward area, I think just being in Maralinga to be quite honest, I reckon Maralinga would be contaminated anywhere around there. *inaudible* so I think the airfield would be contaminated because of the things like that fire engine coming in and out, not being decontaminated, sometimes they hosed them down, the guys coming in and out, I mean some of the firemen would have had their suits on when they were hosing things down but other ones like the driver and people who worked to do the hosing down would've been sitting in the sun getting a tan. Because that's what you did. When you went out in the forward area you'd walk across deserts, desolate place with these shiny things "oh that looks nice". No paper, "oh pick up some paper". How stupid was that. Well how stupid were we.* (Michael)

Naturally, 'perceived exposure' is a pre-requisite for 'perceived threat' in this context, but the perception of threat is also influenced by illness beliefs (e.g. attributing a physical health condition in oneself or one's family members to ionising radiation exposure) and by the awareness of health risk presented by the role of the BNTVA and media reports. Consistent with this, Michael then describes health conditions occurring in family members within the decade following the nuclear testing programme. He does not yet attribute these to his exposure to ionising radiation:

> *I'm using hindsight again now. But we had *inaudible* in 1965 and then from then until 1973 I think it was- 1972 my wife had a- Or we had numerous miscarriages in hospital, sometimes taken children away. Lost one twin, thought we lost the other twin, lost that twin so we numerous miscarriages which I just thought you know these things happen…* (Michael)

Michael then describes the role of media and BNTVA in learning that other veterans also had wives' who experienced similar health conditions relating to pregnancies:

> *At the time as I say you really don't think anything about it until I read something like Maralinga, things like that, the books, and getting involved with the BNTVA, you think..I don't know, and then it gets suspicious, and perhaps I'm trying to make excuses for the fact my wife had all the ectopic pregnancies, but I don't think so.* (Michael)

Thus, this participant moves into 'perceived threat', which describes the perception of radiation-related threat in the context of health conditions in oneself or one's family members, therefore the threat can be conceptualised broadly as a threat to wellbeing. In Michael's case, this is in the context of family members where his wife's miscarriages are perceived as radiation-related threat, influenced by 'illness characteristics' but also the 'role of the BNTVA and media'. These factors are shown above and below 'perceived threat'.

So far in this exemplar we have observed how one can arrive at the 'perceived threat' bubble in the model. Drawing on appraisal theory, this perceived threat is a pre-requisite for psychological stress and eliciting certain emotions if coping resources are perceived as inadequate (Lazarus & Folkman, 1984). In this case, exposure worry (and feeling anxious) may be elicited when the threat to wellbeing is anticipated (i.e. a threat appraisal) but emotions such as guilt and anger are relevant when the threat to wellbeing has already occurred (i.e. a harm/loss appraisal; Lazarus & Folkman, 1984). In this exemplar, his wife had suffered from ectopic pregnancies in the past; therefore the threat has already occurred. He describes how he blames himself for his wife's and daughter's health conditions, illustrated by the 'perceiving self as responsible' bubble:

> *…And I didn't think anything of it until I was part of the BNTVA which is the nuclear test veteran's association. People were writing in about this and I thought "blimey she's got an ectopic pregnancy, she had all these things" and that's where I blame myself because I genuinely, I might be wrong, but I genuinely believe that all those miscarriages and ectopic pregnancies were due to me being at Maralinga. I've never ever had my sperm count checked because I didn't assume anything was wrong with me, so I sort of blame myself for that and then my daughter being a nurse, had these problems, and she discovered she had, well she didn't discover, she kept getting this collapsing and heart beat racing and things like that. She was here at the time and she went to see- She knows all the consultants, she went to see the heart consultant and he said "well we have to capture you while you're having this attack". Anyhow, they*

*decided in the end we'll take you in and *inaudible* and have a look at your heart, and they found an extra pathway in her heart. Now again I blame myself for that.* (Michael)

Thus, perceiving responsibility for the threat to family members' wellbeing is likely to elicit guilt:

So you know..it must be me! So...my DNA must come from my forebears. Can't come from anywhere else. Impossible. And all my forebears had large families. Decent sized families. So that makes me believe that it is more likely to being me being at Maralinga than anything else, but I can't prove that...but that makes me feel guilty. (Michael)

Apart from my anger and frustration, no? Deep down I'm very angry. Anger and guilt rather than frustration. Guilt. Because..I know you say it isn't my fault and yes I understand it isn't my fault but I can't convince myself it isn't my fault. Can you understand that? It sounds totally illogical but I can't. (Michael)

In addition, anger may also be relevant which follows from perceived threat but is mediated by the perceived role of authorities. This is illustrated by the 'perceiving authorities as responsible' bubble, and is demonstrated by the following quote:

I'm more angry and frustrated than anything else. Angry that we didn't really know anything about it but in fairness I don't think anybody did really. I don't think even Bill Henderson, the range commander colonel in the Australian army, I'm pretty certain he didn't really have a clue what was going on. I mean he'd have known a lot more than us, but I don't think he really had a proper clue of the significance of what was going on. I think it did his career good because he ended up as a General in charge of the Aussie troops in Vietnam. I mean we weren't supposed to be there, but I think some people were there. So that's my frustrations...sad about the way we treated the aborigines and also sad about when they were decontaminated. It was just a shower. I mean that's all we had, showers. We didn't have any special decontamination after being in the forward are or anything. (Michael)

I now turn to another exemplar.

Exemplar 2 (Russell)

As always, the conceptual model begins with the box 'perceived exposure' shown in yellow. To begin, Russell, who participated in the nuclear testing programme in Maralinga, described his experiences which he perceived as being exposed to ionising radiation:

> *The other thing I remember was driving the truck after one of the explosions up to the contaminated area and I remember getting out the truck and getting told off cause I was causing dust. That's about all I can remember about it. Because the dust was highly contaminated.* (Russell)

Russell then discussed his thoughts about the experience and why he did not initially worry, thus leading to 'no psychological effect' because there was no perceived threat to wellbeing.

> *Not too much. Wasn't too worried because didn't know much about it in them days, do you?* (Russell)

He then elaborates further on this and describes the role of the BNTVA in making him knowledgeable about radiation effects (thus illustrating the 'role of BNTVA and the media' hexagon in purple). This then leads to a perceived threat:

> *No, no we didn't think there were any risks at all, we thought they wouldn't send us as guinea pigs as I call it, you know? But they definitely put us at risk after what we've heard since. At the time we didn't think about it. Didn't worry about it.*
>
> ***When you say from what you've heard, is this from?***
>
> *I belong to the veteran's association and I've been with them from since they started and I keep reading it, get the packs every month or every whenever they send them up. I read about all these different people that went on these tests. Grapple was the worst one from what I gather at Christmas Island.* (Russell)

Also in Russell's scenario is the role of descendants' health development which contributes to perceived threat. The following quote from Russell describes why he experienced exposure worry. Here, he describes how the role of descendants' health development is important in eliciting worry:

> *Well yeah 'cause gotta worry about it haven't I? Yeah cause..boys got trouble, Caroline my daughters got trouble, and you've got trouble. There must be something mustn't it? Because a normal father doesn't get all three kids trouble.* (Russell)

Above, he considers what is normal for a normal father. That is, it is perceived to be unusual for a normal father to have all his descendants with a health condition. This is illustrated by 'illness characteristics' in the model which influences 'perceived threat'.

Demonstrating the role of descendants' health development as a factor influencing perceived threat, an exchange between Russell and his wife describing how they worried more when the descendants were younger. Drawing on discussions from other interviews, it could be that there is less reason to worry since they have grown relatively ok despite their health conditions:

> *We worried more about it when the kids were younger.* (Russell)

> *And when she was little, used to a worry about it a lot.* (Wife of Russell)

To elaborate, when the descendants are young then their futures are uncertain and a threat to wellbeing may be anticipated. This would elicit exposure worry. But, as found in the data, if a descendant develops healthily or any existing conditions are effectively managed then threats to wellbeing will be anticipated to a lesser extent. In this case, the threat may be appraised as rather benign, hence why the veteran does not explicitly discuss feeling angry or guilty, as a function of externalising and internalising responsibility, respectively.

To summarise, this section presented a conceptual model derived from the qualitative findings which illustrates the possible psychological impact relevant to the British nuclear testing programme. I used two exemplar participants from the qualitative study to aid understanding of the workings of the model. Specifically, the model illustrates how anger, guilt, and worry may arise following perceived threat to wellbeing in this context. The model also accounts for the influence of illness beliefs, descendants' health conditions, and risk-related information shared through the media and nuclear veteran associations on perceptions of threat. The value of this model is that it illustrates the complicated and highly detailed qualitative findings in a concise and easy-to-understand format, and it sets the groundwork for subsequent research in this population. As such, the model will be used in the following chapter where the quantitative data will be revisited to expand the model.

Chapter 7 – What Factors are Associated with Exposure Worry in British Nuclear Test Veterans?

The qualitative findings of the previous chapter highlighted the broad potential psychological impact (manifested as anger, guilt, and worry) in the context of perceived ionising radiation exposure in British nuclear test veterans. The potential psychological impact is illustrated in a conceptual model. To extend this conceptual model, the present chapter revisits and examines data gathered in earlier stages of this project which will contribute towards delivering a more comprehensive model describing the potential psychological impact in British nuclear test veterans. While the qualitative findings demonstrated that the possible psychological impact in British nuclear test veterans is broader than worry, the present chapter describes the analysis of data collected specifically in relation to exposure worry because this is the focus of the thesis. Moreover, albeit with methodological concerns, the analysis of Chapter 5 indicated that factors such as the veterans' roles during the programme, their national service status, or the location where they were stationed were not associated with significantly different levels of exposure worry. While the qualitative chapter suggested that worry was not wholly relevant to most of the interview participants, the quantitative work of Chapter 5 demonstrates that a substantial proportion of nuclear veterans report exposure worry but it remains unclear what factors might influence one to exhibit exposure worry. As such, there could be further factors (not specific to the nuclear testing programme) associated with exposure worry which must be identified.

This chapter describes two analyses. The first analysis reports bivariate correlations between exposure worry and factors such as clinically relevant anxiety, cognitive functioning, and socioeconomic status. Examining the prevalence of clinically relevant anxiety in a sample of British nuclear test veterans also extends our understanding of anxiety-specific mental health issues in this population. The correlation analysis also examines bivariate relationships between these factors and the extent one believes their physical illness is caused by ionising radiation exposure. The second analysis tests a path analysis predicting exposure worry, using the same data set with participants reporting having a physical illness. The variables selected for the path analysis are informed by the bivariate correlation analysis.

The aim of this chapter, therefore, is to explore the possible relationships between exposure worry, clinically relevant anxiety, cognitive function, and proxy measures of socioeconomic status. A further aim is to explore the role of perceiving one's physical illness to be caused by ionising radiation in relation to clinically relevant anxiety and exposure worry in British nuclear

test veterans with at least one physical illness. Overall, the aims of this chapter address the third and final research question of the thesis: concerned with identifying the possible factors associated with exposure worry in British nuclear test veterans.

Before presenting these analyses, I first present literature relevant to my available quantitative data to demonstrate a rationale for examining whether the following factors are associated with exposure worry.

Potential predictors of exposure worry

Clinically relevant anxiety.

There are currently no quantitative psychological studies predicting worry or other psychological outcomes in nuclear test veterans. Moreover, studies examining psychological stress outcomes of ionising radiation exposure in other contexts generally do not include psychopathological measures such as generalized anxiety disorder or depression as predictors of psychological stress. Rather, these studies tend to examine socioeconomic measures such as education and income (Fukasawa et al., 2017; Kusama et al., 2018; Suzuki et al., 2015), and other individual factors such as proximity to radiation source (Foster, 2002; Havenaar, Rumyantzeva, Van den Brink, et al., 1997), perception of risk (Miura et al., 2017; Oe et al., 2016), and perceived mastery (Adams et al., 2002; Beehler et al., 2008).

Excessive, uncontrollable, and multifocal worry (worry about various events) is a hallmark of generalized anxiety disorder (Stein & Sareen, 2015), thus it is entirely likely that veterans with clinically relevant anxiety will present worry about perceived ionising radiation exposure. Moreover, since perceived ionising radiation exposure is inherently uncertain (ionising radiation is invisible without dosimetry and the health effects are often delayed; Danzer & Danzer, 2016; Vyner, 1988), and a central feature of clinically relevant anxiety (e.g. generalized anxiety disorder) is the intolerance of uncertainty (Carleton, 2012), one would expect that those who are clinically anxious are more likely to be worried about perceived ionising radiation exposure.

Cognitive theories to explain this hypothesis can be found in attentional bias research. While there are varying perspectives across the cognitive theories, it is generally held that there are differences in attentional bias between individuals with high trait anxiety and individuals with

low trait anxiety, when presented with threatening stimuli (Eysenck, 1988). Earlier models were relatively stark in their predictions: high trait anxiety individuals will orient to threatening stimuli and low trait anxiety individuals will avert attention from threatening stimuli (Williams et al., 1988). More recent and accepted accounts posit that all individuals will attend to highly threatening stimuli, but high trait anxiety individuals attend more to moderately threatening stimuli than low trait anxiety individuals, as shown experimentally (Koster et al., 2006). Of course, the attentional bias to threatening stimuli is not necessarily stable, but probabilistic (MacLeod et al., 2019), and can be influenced by task, stimuli, and setting, for example.

These biases towards threatening stimuli are thought to play causal role in exacerbating worry and further anxiety (MacLeod & Mathews, 2012; Van Bockstaele et al., 2014). This attentional bias phenomenon is robust across experimental studies of individuals with clinically relevant anxiety such as generalized anxiety disorder (Bar-Haim et al., 2007; Goodwin et al., 2017). Similar observations have been made in health anxiety studies, in both clinical groups (Witthöft et al., 2016) and non-clinical groups (Lees et al., 2005; Owens et al., 2004). Furthermore, individuals with anxiety disorders are more likely to make threatening interpretations of ambiguous scenarios, compared to non-anxious individuals where they make more benign interpretations (albeit shown experimentally using imagined scenarios and homophones; for a review on the topic see Hirsch et al., 2016). Thus, generally anxious British nuclear test veterans may interpret ambiguous or uncertain stimuli as more threatening (e.g. "my exposure *will* lead to adverse health effects in myself and my descendants") and may exhibit attentional biases towards threatening stimuli (e.g. media reports of adverse health effects, or awareness of health risk) which maintains exposure worry.

Aside from an attentional bias towards threatening stimuli in generally anxious individuals, it also appears that individuals with a heightened ruminative disposition specifically exhibit deficits in disengaging with threatening stimuli (Grafton et al., 2016). Worry and rumination are similar repetitive thought processes (McEvoy et al., 2013), and while they are predominantly observed in anxious and depressed individuals, respectively, there is generally some transdiagnostic overlap between the two (Olatunji et al., 2013). Indeed, anxious adults report greater levels of rumination as a response to daily stressors than non-anxious and non-depressed controls, and greater rumination following a stressful event predicts more negative affect, highlighting the role of rumination in maintaining generalized anxiety (Ruscio et al.,

2015). Therefore, anxious individuals are likely to exhibit attentional biases towards threat but also exhibit deficits in disengagement with threat through rumination.

I acknowledge that, earlier in this thesis, I state that worry tends to include a future orientation in its definition, in contrast to rumination which tends to focus on past events (Watkins et al., 2005). As such, my initial view of exposure worry was that it is inherently future-oriented, and therefore rumination was not initially applicable. This perception had evolved following a greater understanding of cognitive processes in emotional disorders. Besides, the items of the exposure worry scale can be interpreted as ruminative, since they refer to worrying about past events of being affected by ionising radiation (e.g. "I am worried that my exposure to ionising radiation and/or chemical agents may have affected my children"). The same item can also be interpreted as worrisome, since while "ionising radiation may have affected their children" is past tense, the potential future adverse outcomes are still applicable. Therefore, it can be argued that British nuclear test veterans with clinically relevant anxiety are more likely to ruminate about their previous ionising radiation exposure and the possible related adverse health effects on themselves and their family members.

Socioeconomic factors.

Most studies examining predictors of psychological outcomes in the context of ionising radiation exposure tend to examine socioeconomic factors. Indeed, socioeconomic status is a central construct to Pearlin's sociological stress model (Pearlin, 1999). Socioeconomic status is implicit; it refers to an individual's access to economic and social resources and the social positioning and privileges that derive from the resources (Duncan & Magnuson, 2012). Interestingly, the importance of socioeconomic status in stress has been examined in the context of nuclear power plant accidents. For example, higher socioeconomic status, particularly financial income but not educational attainment, was associated with lower radiation anxiety following the Fukushima nuclear power plant accident (Kusama et al., 2018). Similarly, Fukasawa et al. (2017) observed that low and middle financial income was associated with higher levels of radiation anxiety, compared to high financial income. Kusama and colleagues (2018) postulate that those in lower socioeconomic status have a higher perceived risk for radiation and subsequently experience greater anxiety. Viinamäki et al. (1995) also found poorer financial situation to be associated with higher general distress (measured by a version of the General Health Questionnaire covering depression, anxiety, self-esteem and daily difficulties) in women living in contaminated areas following the Chernobyl

accident, compared to women from uncontaminated areas, although such findings were not observed in the male participants. Aside from financial status, some but not all studies (Kusama et al., 2018) document that higher educational attainment was associated with lower psychological distress following the Fukushima disaster (Suzuki et al., 2015). A comparison between Kusama et al. (2018) and Suzuki et al. (2015) may be limited given the differences in stress and anxiety measures.

Socioeconomic status and its role in psychological stress is often conceptualised with reference to coping resources. For example, Matthews et al. (2010) posit psychosocial factors such as negative life events and chronic stress and the reduced access to tangible, interpersonal, and intrapersonal resources to coping with stressful events, mediates the link between low socioeconomic status and health condition morbidity and mortality. Indeed, access to greater resources may act as buffers to stress (Thoits, 1995), which are not limited to the obvious financial resources. These resources generally refer to personal and social characteristics one draws upon when dealing with adversity. One central example of a personal coping resource in the context of psychological stress often examined by social scientists is perceived mastery.

The notion of 'mastery' describes the self-belief that one can control important circumstances that are impinging on one's life (Pearlin, 2010). While this present nuclear test veterans project does not have data available on perceived mastery, factors such as socioeconomic status (indicated by educational attainment, occupational prestige, and accumulated wealth) constitute life-course mastery (Pearlin et al., 2007). In fact, controlling for mastery may reduce the association between socioeconomic status and health conditions (Bosma et al., 1999; Schnittker, 2004), perhaps indicating that the relationship between socioeconomic status and stress is partly mediated by mastery. One study has examined perceived mastery and the relationship with anxiety in the context of the Chernobyl power plant accident. Beehler et al. (2008) found that factors such as mastery (degree of perceived personal control) and chronic stressors (e.g. finance, job stress etc.), but not contamination level, were associated with state anxiety (anxiety about a particular stressor) scores in residents living in Belarus. A separate study also observed mastery to be a significant predictor of global psychological stress in Chernobyl evacuees (Adams et al., 2002). It is therefore evident that personal coping resources associated with socioeconomic status are likely to mitigate psychological stress in the context of perceived ionising radiation exposure, to an extent.

Regarding social coping resources, these usually refer to emotional, informational, or practical support from significant others (e.g. family members or partners) or co-workers (Thoits, 2011; for discussion on complexity of social coping and social status see Turner & Turner, 1999). While the topic is complex, it has been contended that individuals from lower socioeconomic strata tend to have reduced access to social coping resources (Mickelson & Kubzansky, 2003; Turner & Turner, 1999). This has been observed in terms of less contact with friends, more negative interactions, and less emotional support in individuals of lower socioeconomic status (Mickelson & Kubzansky, 2003).

It can be presumed that, based on previous literature, British nuclear test veterans of a lower socioeconomic status may have lower personal (e.g. perceived mastery) and social coping resources to cope with threats to wellbeing in the context of perceived ionising radiation exposure. As such, one could hypothesise that lower socioeconomic status is a predictor of exposure worry in this population.

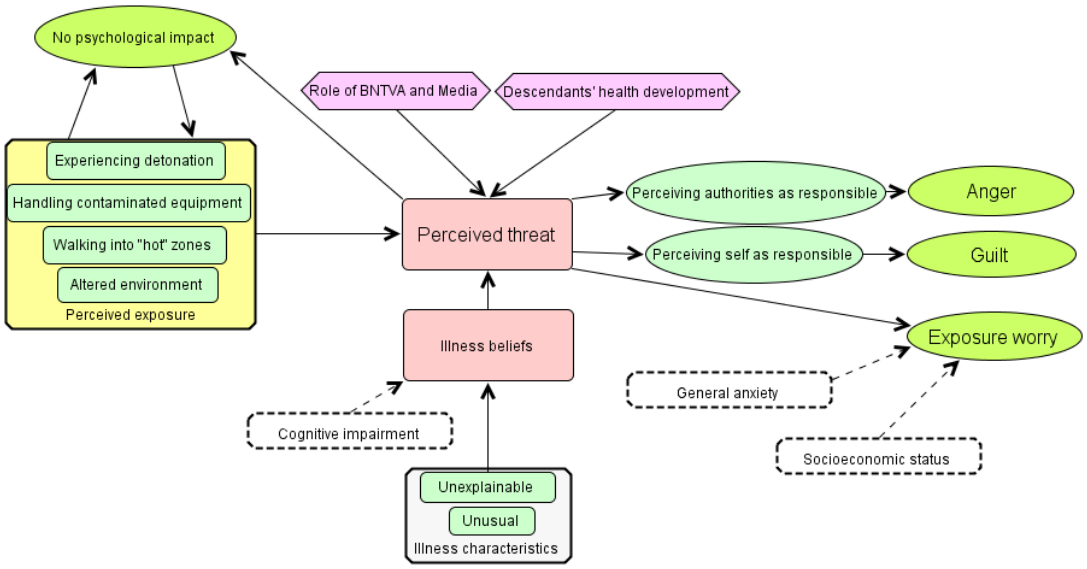
Cognitive impairment.

The question is exploratory but, considering that British nuclear test veterans are older adults, the issue of cognitive functioning may be relevant to perceptions of physical illness and exposure worry. Older adults with mild cognitive impairment may be less aware of any objective cognitive decline (Roberts et al., 2009), which may suggest that older adults with cognitive impairment may be less aware of current physical health conditions. Alternatively, autobiographical memory is largely intact in normal cognitive ageing (Glisky, 2007) and indeed the period of nuclear weapons testing likely falls within the reminiscence bump (Janssen et al., 2005; Wolf & Zimprich, 2020). Thus, nuclear veterans with cognitive impairment are likely to be aware of the nuclear testing experience and may focus on these to rationalise current health conditions. Nonetheless it is a factor that could influence the perceived associations between ionising radiation exposure and physical health which I had available data for.

These possible factors are now illustrated in the proposed conceptual model (Figure 10) of the psychological impact of ionising radiation exposure in British nuclear test veterans and will be examined in this study.

Figure 10.

Proposed conceptual model based on qualitative data, including hypothesised variables (shown with dashed lines).



As proposed in the conceptual model, a preliminary step for any psychological stress to occur because of perceived ionising radiation exposure is the belief that the exposure has caused a health condition in either themselves or in their family members (details on how veterans attribute causality to health conditions are examined in Chapter 6). This proposition is founded on the qualitative data of Chapter 6 where those who described a psychological impact (i.e., worry and guilt) often described it in the context of their family members' health being affected by ionising radiation exposure. While I have no data about beliefs that exposure caused health conditions in their family members, I do have data on beliefs regarding the veterans' own health conditions and, as such, will be examined.

To summarise, it is hypothesised that:

1) There will be significant associations between proxy measures of socioeconomic status and exposure worry. Specifically, those living in areas of higher deprivation, those who have lower educational attainment, and those with an occupation of lower skill levels will be more likely to report higher agreement of exposure worry.

2) There will be a significant association between clinically relevant anxiety and exposure worry. That is, those who screen for probable clinically relevant anxiety will be more likely to report higher agreement of exposure worry.

3) Nuclear test veterans who rate themselves higher in agreement that their physical health condition is caused by ionising radiation exposure are more likely to report higher agreement of exposure worry.

4) There will be an association between cognitive functioning and exposure worry. That is, veterans with greater cognitive functioning will report lower exposure worry.

These hypotheses will be addressed through two related analyses: (i) exploring bivariate correlations between proposed factors and (ii) analysing a regression model based on the findings obtained through bivariate correlation analysis.

Analysis One – Bivariate Correlations

The first analysis describes bivariate correlation analyses of data collected in Chapter 5. The purpose is to explore possible correlations between variables which will later inform the conceptual model following further analysis in a subsequent study.

Methods

Participants.

Research packs were distributed to 246 test-veterans listed on a GDPR-compliant NCCF mailing list. One-hundred and forty-six of these were in the format of an online survey and 100 were postal. An advert with information about the study and contact details was also placed in the quarterly NCCF magazine. A total of 91 British nuclear test veterans (mean age = 81.68; aged between 74 and 90 years old[29]) who had witnessed at least one nuclear test or were involved in the clean-up operations consented and were recruited for this study.

Materials.

The materials used are the same as outlined in Chapter 5. Both online and physical research packs contained a consent form, information sheet and debrief sheet (see Appendix K). Both online and physical research packs also contained the Current Exposure Worry Scale. Further, a questionnaire was included which gathered data on sociodemographic information, clinically relevant anxiety, and the extent one believes their physical illness was caused by ionising radiation exposure. The physical research packs contained a spare stamped envelope for the participant to return their consent forms and data.

Measures.

Exposure worry was measured using a single item from the Current Exposure Worry Scale developed in Chapter 4. The scale includes six initial items along an 8-point scale (1 = strongly disagree, 8 = strongly agree) examining worry about different aspects of ionising radiation exposure (e.g. “I am worried that my exposure to ionizing radiation and/or chemical agents may have affected my children”). These items relate to their own health, child health,

[29] Age was determined by their date of birth and the date they participated in the cognitive test. Since not all participants took part in the cognitive test, age is missing for 16 cases.

grandchild health, lack of protective equipment, lack of scientific understanding relating to exposure risks, and worry about their descendants' worry. A 7th item asks participants to rate their level of agreement that their worry makes them feel nervous or stressed (1 = strongly disagree, 8 = strongly agree). This 7th item serves as the measure of exposure worry.

Clinically relevant anxiety was measured by the number of anxiety symptoms (scored out of 5) reported using the Geriatric Anxiety Inventory-Short Form (GAI-SF; Byrne & Pachana, 2011). The GAI-SF contains 5 agree/degree items which has been shown to have good convergent validity with more commonly used measures such as the State-Trait Anxiety Inventory-State subscale ($p < .001$; Byrne & Pachana, 2011).

Physical illness belief was assessed by asking whether the participant had any physical illnesses. If the participant responded "yes", then the participant was asked to indicate how much they agree or disagree with the following statement: "My exposure to ionising radiation and/or chemical agents caused my illness". Participants responded by ticking one of four boxes, labelled "strongly disagree", "disagree", "agree", or "strongly agree". These were coded 1 to 4, respectively.

Cognitive functioning was measured using the MoCA-BLIND (Nasreddine et al., 2005). The MoCA-BLIND is based on the full MoCA but with visuo-spatial items omitted, therefore the MoCA-BLIND can be conducted over the telephone. The raw score out of 22 points was used to indicate cognitive functioning.

Socioeconomic status was measured using individual proxy indicators, namely principal lifetime occupation, educational attainment, and index of multiple deprivation:

Principle lifetime occupation was assessed by asking an open question, "what was your principal lifetime occupation?". Responses were classified into nine levels using the National Statistics Socioeconomic Classification where one = highest and nine = lowest in terms of skills and qualifications required for the occupation (Office for National Statistics, 2010). Level one describes 'higher skilled' occupations (e.g. director positions), while level nine describes elementary occupations.

Educational attainment was assessed by asking an open question, "What was your highest qualification?". Participant responses were categorised into five levels with one being highest (degree level or higher) and five being lowest (no formal qualification).

The index of multiple deprivation (IMD) was assessed by asking "What is your postcode?". Participant responses were matched with a UK governmental IMD scores (Office for National Statistics, 2010) to provide an indication of neighbourhood deprivation. The IMD scores are calculated from seven domains of deprivation, which include income, education, employment, health and disability, crime, barriers to housing, and indoor and outdoor living environment quality (Abel et al., 2016). Quintile one is the least deprived and quintile five is the most deprived). As with the other proxy measures of socioeconomic status in this study, a higher score indicates a lower socioeconomic status.

Analysis.

The statistical analysis was conducted using SPSS software. Bivariate correlations were conducted between each variable using Spearman's rho analysis. Missing data was handled using pairwise deletion to maximise the use of the dataset. Little's MCAR test indicated that the data were missing completely at random ($X^2 = 82.33$, $p = .76$).

Results

Participant demographic information is provided in Table 12.

Table 12.

Sociodemographic characteristics of the sample (n = 91)

Variables	N (= 91)	%	
		Percent	Excluding MD
Educational attainment			
Degree level or higher	3	3.3	3.8
HNC/HND or equivalent	9	9.9	11.5
GCE A Level or equivalent	10	11.0	12.8
GCE O Level or equivalent	25	27.5	32.1
No formal qualification	31	34.1	39.7
MD	13	14.3	-
Principle lifetime occupation			

Managers, directors, senior officials	14	15.4	19.2
Professional occupations	10	11.0	13.7
Associate professional and technical	10	11.0	13.7
Administrative and secretarial	3	3.3	4.1
Skilled trade occupations	23	25.3	31.5
Caring, leisure and other service	1	1.1	1.4
Sales and customer service	2	2.2	2.7
Process, plant, and machine operatives	9	9.9	12.3
Elementary occupations	1	1.1	1.4
MD	18	19.8	-
Index of multiple deprivation			
Quartile 1	20	22.0	23.3
Quartile 2	24	26.4	27.9
Quartile 3	23	25.3	26.7
Quartile 4	12	13.2	14.0
Quartile 5	7	7.7	8.1
MD	5	5.5	-
Perception phys. illness caused by IR			
Strongly disagree	5	5.5	7.4
Disagree	18	19.8	26.5
Agree	23	25.3	33.8
Strongly agree	22	24.2	32.4
MD	23	25.3	-
Probable clinically relevant anxiety			
No	59	64.8	66.3
Yes	30	33.0	33.7
MD	2	2.2	-
Probable mild cognitive impairment			
No	35	38.5	46.1
Yes	41	45.1	53.9
MD	15	16.5	-

Note. MD = Missing data.

Spearman's rho bivariate correlation analysis revealed that exposure worry was positively correlated with GAI-SF score (Spearman correlation coefficient = .587, p = .000), health belief

(Spearman correlation coefficient = .429, p = .000) and poorer educational attainment (Spearman correlation coefficient = .229, p = .022). There was a significant correlation between health belief and GAI-SF score (Spearman correlation coefficient = .228, p = .033) and a significant inverse correlation between lower skilled principal lifetime occupation and health belief (Spearman correlation coefficient = -.287, p = .018). Cognitive functioning was inversely correlated with health beliefs (Spearman correlation coefficient = -.278, p = .018).

Table 13.

Spearman's rho bivariate correlation matrix for illness belief, cognitive performance, GAI-SF, exposure worry, and proxy measures of socioeconomic status

		1	2	3	4	5	6	7
Illness belief	Coeff.	1.000	-	-	-	-	-	-
	n	68	-	-	-	-	-	-
Cognitive performance	Coeff.	-.278*	1.000	-	-	-	-	-
	n	57	76	-	-	-	-	-
GAI-SF	Coeff.	.228*	-.033	1.000	-	-	-	-
	n	66	74	89	-	-	-	-
Deprivation index	Coeff.	.183	-.163	.046	1.000	-	-	-
	n	65	74	84	86	-	-	-
Occupation	Coeff.	-.287*	-.140	-.012	.158	1.000	-	-
	n	53	62	71	71	73	-	-
Educational attainment	Coeff.	.018	-.176	.108	.228*	.439**	1.000	-
	n	59	67	77	74	62	78	-
Exposure worry	Coeff.	.429**	-.185	.587**	.158	.025	.229*	1.000
	n	68	75	88	86	72	77	90

Note. *p <.05, **p<.01 (1-tailed). Missing values removed using pairwise deletion to maximise use of data. Higher deprivation index scores represent higher deprivation. Higher occupation scores represent lower skilled principal occupation. Higher educational attainment scores represent lower highest qualification achieved. GAI-SF = Geriatric Anxiety Inventory-Short Form.

Discussion (analysis one)

Before examining the critical findings of the correlation analysis, we must first draw our attention to the GAI-SF scores indicating the prevalence of clinically relevant anxiety. In this sample, 33.7% screened for probable clinically relevant anxiety. Like Forlani et al.'s (2014) study of older adults, there was no association between GAI-SF prevalence and cognitive function or socioeconomic status. However, 15% of men in Forlani et al.'s (2014) study screened for probable clinically relevant anxiety, which may suggest excessive prevalence of clinically relevant anxiety in British nuclear test veterans.

The use of the GAI-SF in this study is the first time a validated measure of anxiety has been used in British nuclear test veterans and extends the previous quantitative findings of nuclear test veterans regarding anxiety (Alexis-Martin et al., 2019; Dockerty et al., 2020; Miles et al., 2011).

Firstly, in Miles et al.'s (2011) health needs audit, it was reported that 4% and 31% of their sample were 'extremely anxious or depressed' and 'moderately anxious or depressed', respectively. The issue with the health needs audit is that it is unclear the extent that these issues are specific to depression, anxiety, or both. Indeed, the mental health impact appears to be a considerable issue and the present exposure worry study goes further and examines anxiety specifically, using a validated measure.

Secondly, we can build on Alexis-Martin et al.'s (2019) findings where roughly 8% of veterans self-reported themselves as having anxiety. A critical issue here is that the meaning of anxiety (whether this is an anxious state or clinically diagnosed anxiety) is unclear. Nevertheless, the present findings obtained using a validated anxiety measure for older adults indicates that anxiety-specific mental health issues are higher than what was indicated by Alexis-Martin et al. (2019).

Finally, Dockerty et al. (2020) found that 19% of their New Zealand nuclear veteran sample self-reported having an anxiety condition. The prevalence of clinically-relevant anxiety in the present study (33.7%) exceeds that of Dockerty et al. (2020). This is likely reflected by using a validated measure specifically for anxiety, whereas the data in Dockerty et al. (2020) may have been obtained through a broad open question regarding health conditions generally (although this is unclear). Collectively, the use of the validated GAI-SF for clinically relevant anxiety highlights that anxiety issues are a significant issue in this population.

The Spearman's rho correlation analysis must now be discussed. Perhaps the most important correlations observed in this analysis was the fact that the number of anxiety symptoms and believing a health condition was caused by exposure were both positively associated with exposure worry. These variables will be examined in further analysis.

It is also worth commenting on the correlations pertaining to the socioeconomic status proxy measures, namely educational attainment, principal lifetime occupation, and deprivation index. While educational attainment was significantly correlated with exposure worry, meaning that lower educational attainment is correlated with a higher tendency to agree that exposure worry makes them feel stressed, educational attainment was omitted from any further analysis due to the following:

Recall that educational attainment was included in this analysis on the view that it serves as a proxy measure of socioeconomic status. Since only educational attainment, and not deprivation index or occupation, was correlated with exposure worry, it is possible that educational attainment is not an accurate proxy measure of socioeconomic status in this study. While educational attainment and principal lifetime occupation were significantly correlated with each other (as one would expect), principal lifetime occupation was not correlated with exposure worry. Therefore, if socioeconomic status is represented by educational attainment and driving the relationship between educational attainment and exposure worry as hypothesized, one would also expect to see a significant relationship between occupation and exposure worry. It is possible that the significant correlation between educational attainment and exposure worry is rather being driven by some other construct, potentially risk perception as opposed to socioeconomic status. For example, in residents living near a low-dose radiologically contaminated road in South Korea, those with the lowest education level (less than 6 years education) had the highest perceived risk for the contaminated roads compared to other education levels (Ha et al., 2018), but the authors did not elaborate on this finding to any real extent. This may be because the link between general educational attainment and risk perception has no concrete theoretical position, nor, to my knowledge, any substantial evidence for this relationship. Overall, the significant correlation between lower educational attainment and higher exposure worry is difficult to explain if discounting educational attainment as an accurate measure of socioeconomic status.

Interestingly, the bivariate correlation analysis did not find a significant correlation between educational attainment and GAI-SF score. Comparing elsewhere, a large-scale cross-sectional

analysis of 50,918 adults indicated that lower educational levels are significantly associated with higher anxiety and depression, but the strength of the relationships decreased with increasing age (Bjelland et al., 2008). But my observation could be expected since the developers of the GAI-SF (Byrne & Pachana, 2011) observed no relationship between education and GAI-SF scores in older women, and indeed Bjelland et al. (2008) did not use the GAI or GAI-SF in their study. Of course, the sample in this present thesis are all older men, but this may be irrelevant since the full 20-item GAI is not associated with gender (Pachana et al., 2007).

Acknowledging the alternate position that each proxy measure of socioeconomic status is an accurate measure of current socioeconomic status, the non-significant correlations between exposure worry and measures of socioeconomic status (occupation and multiple deprivation) could be explained by the work of Thoits (2011). Thoits describes how social coping resources associated with socioeconomic status (e.g. support networks of friends and significant others) may be ineffective as a stress buffer for unique stressful events. Rather, secondary social networks consisting experientially-similar others (Gage, 2013; Thoits, 2011, 2020) are proposed to be effective in coping with unique stressful events. In this context, BNTVA and NCCF support may be an effective stress buffer which is not reflected by socioeconomic status.

Furthermore, social conditions change over the life course. While education and principal lifetime occupation may be stable predictors of socioeconomic status, multiple deprivation is indicated by current postcode which of course is not permanent. People move between addresses and neighbourhood deprivation indices change over time. Indeed, multiple deprivation percentiles may not be entirely up to date since the deprivation data is drawn from statistics published in 2010 (Office for National Statistics, 2010). Referring to the role of personal coping resources, Pearlin et al. (2007) posit life course mastery in older adults as a coping resource and demonstrate that life-course mastery is made up of social statuses acquired over a lifetime. Therefore, present deprivation index is unlikely to indicate the personal resources (life course mastery) used to cope with adversity if postcodes were recently changed. Since the correlational analysis yields no convincing findings to suggest that the proposed measures of socioeconomic status are indeed measuring socioeconomic status, this avenue was not pursued in further analysis.

Addressing the significant correlation between cognitive functioning and health belief, this suggests that those with better global cognitive functioning are more likely to disagree that

their health conditions are caused by ionising radiation exposure. To my knowledge there is no previous research examining cognitive functioning in the context of physical health condition causal attributions but, somewhat related, evidence suggests that older adults with mild cognitive impairment may be less aware of any objective cognitive decline (Roberts et al., 2009). If individuals with cognitive impairment are less aware of their cognitive status, one could presume that individuals with cognitive impairment are also less aware of physical health conditions and any potential to associate the health conditions with ionising radiation exposure. However, since cognitive functioning is intangible, whereas physical health can be tangible (i.e. you can feel some health conditions), it is unlikely that one would be unaware of physical health conditions due to their cognitive status. In the present analysis, it appears that individuals with cognitive impairment are more likely to believe their health conditions are caused by ionising radiation exposure. Since cognitive impairment per se was not examined but rather raw scores of cognitive functioning, this relationship with a focus on impairment must be examined further.

Interestingly, there was a relationship (albeit non-significant) between cognitive performance and exposure worry (p = .056), suggesting evidence for exposure worry being associated with poorer cognitive functioning. A recent meta-analysis demonstrates that anxiety (in particular, trait anxiety) is a risk-factor for vascular dementia and Alzheimer's disease (but further work is required for clinical sub-types such as generalized anxiety disorder; E. Becker et al., 2018). The relationship between anxiety and cognitive functioning generally follows the mechanism that anxiety is a form of psychological stress which is a risk factor for cognitive impairment (Aggarwal et al., 2014; Collett et al., 2020). But this mechanism is unlikely to be relevant to the potential association between cognitive performance and exposure worry. The reason being that cognitive performance was not significantly correlated with GAI-SF score. Therefore, if psychological stress effects did underlie the relationship between exposure worry and cognitive performance, we would then expect to see a similar relationship for GAI-SF and cognitive performance.

But these correlation findings are not without their limitations. First, we must consider the sample size especially following pairwise deletion methods which will decrease statistical power. Secondly, pairwise deletion may introduce biased estimates (Berchtold, 2019), but I expect this to be limited since the data were missing completely at random (Pigott, 2001). Nevertheless, more robust methods such as multiple imputation may be more appropriate to

retain statistical power and limit any possible biases. Lastly, we must be cautious when interpreting correlation analyses handled using pairwise deletion because each bivariate correlation will include varying participant numbers and possibly different types of participants.

Overall, the bivariate correlation analysis indicates that clinically relevant anxiety and illness beliefs are likely to be associated with exposure worry and must be examined using further analysis. In addition, the role of cognitive impairment is worth examining further and could be a variable of significant interest. The proxy measures of socioeconomic status are discarded from any further analysis because they do not appear convincing or reliable variables relevant to exposure worry.

Analysis Two – Path Analysis

Based on the correlations above and the extant literature regarding attentional biases, one could justify the logical hypothesis that clinically relevant anxiety predicts the tendency to agree that their illnesses were caused by ionising radiation exposure, which in turn predicts exposure worry. Of course, this mediation is only relevant to veterans who have an existing physical health condition.

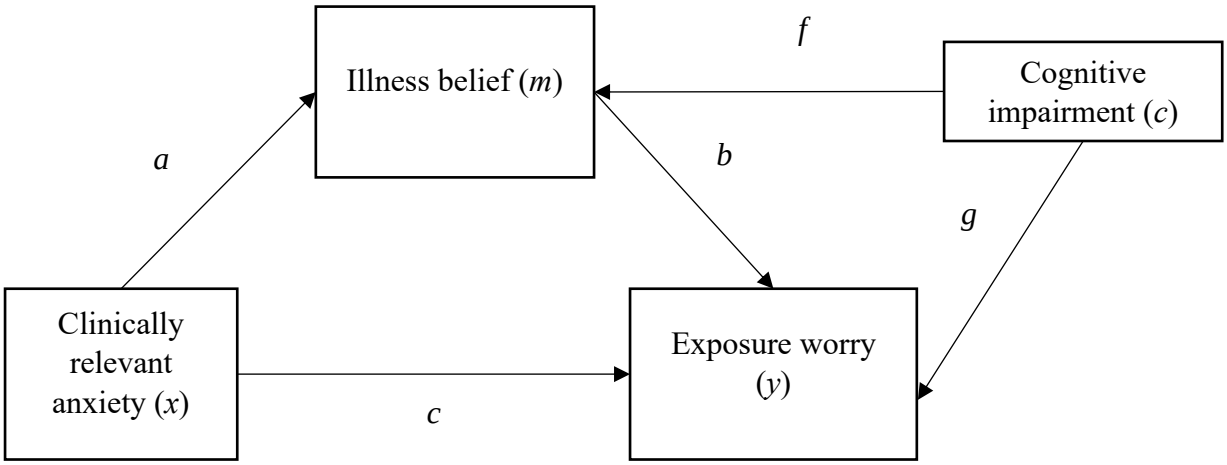
While there is no research examining the role of clinically relevant anxiety in illness beliefs in the context of ionising radiation exposure, irrational beliefs are a feature of generalized anxiety disorder and health anxiety (Leonidou & Panayiotou, 2018). This is not to say that, for a veteran, believing an illness is caused by ionising radiation exposure is irrational, because witnessing a nuclear weapons test is profound and has been associated with adverse health effects in the media and popular culture. These media reports occurred prior to the emergence of the UK epidemiological studies (Darby et al., 1988, 1993; Muirhead et al., 2003), and these epidemiological studies cannot examine every illness, but primarily focused on cancers and cataracts. Therefore, it is entirely rational for a nuclear test veteran to believe an illness was caused by ionising radiation exposure despite evidence available from their own circumstance, given that clinically anxious individuals exhibit heightened attentional bias for threatening stimuli (Bar-Haim et al., 2007; Goodwin et al., 2017). In this context, threatening stimuli could be media reports or health-risk information shared through nuclear association groups.

The presumption linking clinically relevant anxiety and exposure worry is that those who are generally anxious are, naturally, likely to have multifocal worry (including worry about ionising radiation). But for clinically relevant anxiety to extend to exposure worry in nuclear veterans with a physical health condition, I argue that this relationship is mediated by the belief that their physical health condition is caused by ionising radiation exposure.

In the proposed mediation model (Figure 11), clinically relevant anxiety is the predictor variable (*x*), and exposure worry is the outcome variable (*y*). This hypothesised relationship is proposed to be mediated by illness beliefs (*m*; the extent one believes their health condition is caused by ionising radiation). Cognitive impairment is included as a covariate (*c*) to examine its influence on illness belief and exposure worry. Further, including cognitive impairment allows us to control any influence cognitive impairment may have on the mediation model.

Figure 11.

Proposed mediation model



Note. Path *c* is the direct effect on exposure worry and path *a*b* is the indirect effect. The total effect on exposure worry = path *c* + (*ab*).

Methods

Participants.

This analysis was conducted using data from 55 participants from the above study.

Methods and analysis.

A binary logistic regression and mediation analysis using the lavaan package (Rosseel, 2012) in R software was conducted to examine the posited mediation model (Figure 11). The model was estimated using diagonally weighted least squares (DWLS) method which provides accurate parameter estimates when data is ordinal or normality is severely violated (Mîndrilă, 2010). The total, direct, and indirect effects were analysed using bootstrapped[30] standard error and bootstrapped 95% confidence intervals using the percentile method.

Since the data is inputted into a binary logistic regression model, the data was handled accordingly. Illness beliefs were treated as ordinal where 0 = strongly disagree, 1 = disagree, 2

[30] 5000 bootstrap draws were requested, and 4924 bootstraps were successfully drawn.

= agree, and 3 = strongly agree. GAI-SF score were treated dichotomously in accordance with the cut-off score for probable clinically relevant anxiety (≥ 3), coded 0 and 1, respectively.

Cognitive functioning was included as a covariate to examine whether it is a predictor of illness beliefs and exposure worry. Raw T-MoCA scores were dichotomized based on the validated cut-off score equal to 17 and below out of 22 (Nasreddine et al., 2005). Scores of 18 and above indicate no cognitive impairment while 17 and below indicates possible cognitive impairment. The dichotomies received a code of 0 and 1, respectively. Nasreddine et al. (2005) advise to add a point to each raw score from those with equal to or less than 12 years of education, and indeed some participants are likely to have had less than 12 years of education since some participants reported having left education at 17 years old, but I did not verify the age at which participants started formal education. Therefore, I retain the original cut-off score of 17 and below out of 22 (normal = 18 and above) for possible cognitive impairment.

Exposure worry, like the correlation analysis above, was measured using the stress item of the current exposure worry scale. This stress item was dichotomized into 'disagree' and 'agree' based on whether participants responded 1, 2, 3, or 4 (categorized as 'disagree') or 5, 6, 7, or 8 (categorized as 'agree').[31]

Results

The analysis indicates that the presence of clinically relevant anxiety influenced the extent that they agree their illness was caused by ionising radiation exposure (a = 0.707, $p < .01$) 95% CI [0.196, 1.185], and the extent that they agree their illness was caused by ionising radiation exposure influenced exposure worry (b = 0.322, $p < .05$) 95% CI [0.122, 0.621]. The presence of clinically relevant anxiety also significantly influenced exposure worry (c = 1.217, $p < .001$) 95% CI [0.707, 1.970]. There was no significant indirect effect (ab = 0.228, $p = .083$) 95% CI [0.044, 0.549]. Overall, the model shows a significant total effect on exposure worry (total = 1.445, $p < .000$) 95% CI [1.082, 2.106]. Therefore, there is evidence that clinically relevant

[31] There are three reasons for dichotomizing the exposure worry measure: Firstly, dichotomizing the outcome variable is required for a binary ordinal regression analysis. Second, having multiple levels of an outcome variable complicates the ability to interpret outputs of ordinal regressions. Third, it is important to consider the magnitude of the exposure worry scale. One should consider what the difference is between a score of '5' and '7', or '6' and '8', for example. The scale is measuring the strength of agreement, hence '8' is labelled 'strongly agree', but the other points along the scale must be questioned in their meanings. Naturally, '5' would indicate less agreement than '8' but it is still 'agree', none the less. Therefore, accounting for the variability in agreement on the scale is overly complicating the key purpose of the measure in the analysis, that is, whether participants experienced stress due to exposure worry.

anxiety influences exposure worry independent of the effect of believing an illness is caused by ionising radiation exposure. The presence of cognitive impairment had no significant influence on exposure worry (*g* = -0.311, *p* = .222) 95% CI [-0.838, 0.162], nor had a significant influence on believing an illness is caused by ionising radiation exposure (*f* = 0.412, *p* = .134) 95% CI [-0.122, 0.949].

Table 14.

Results of standardized estimates for the mediation model in which the direct path from X (clinically relevant anxiety) to Y (exposure worry) is not necessarily mediated through M (illness belief), with covariate C (cognitive impairment) (n = 55)

		Illness belief (*m*)				Exposure worry (*Y*)		
		B	SE	*P*		*B*	SE	*p*
X (clinically relevant anxiety)	*a*	0.707	0.255	0.006	*c*	1.217	0.304	0.000
M (illness belief)	-	-	-	-	*b*	0.322	0.129	0.012
C (cognitive impairment)	*f*	0.412	0.275	0.134	*g*	-0.311	0.255	0.222

Note: Total effect of *X* on *Y* = 1.445 (bootstrapped SE = 0.244, *p* < .000) with bootstrapped 95% LLCI = 1.082 and ULCI = 2.106. Direct effect of *X* on *Y* = 1.217 (bootstrapped SE = 0.304, *p* < .001) with bootstrapped 95% LLCI = 0.707 and ULCI = 1.970. Indirect effect of *X* on *Y* = 0.228 (bootstrapped SE = 0.131, *p* = .083) with bootstrapped 95% LLCI = 0.044 and ULCI = 0.549.

Discussion (analysis two)

The binary logistic regression analysis (path analysis) sheds light on the nature of the relationships between clinically relevant anxiety, illness beliefs, exposure worry, and cognitive impairment. The questions that the regression analysis were concerned with are:

1. Whether clinically relevant anxiety could predict the tendency to agree that their illnesses were caused by ionising radiation exposure, and whether this in turn predicts a greater likelihood of reporting exposure worry, and what is the mediating role of illness beliefs in veterans with a physical health condition.
2. Whether cognitive impairment is a significant predictor of illness beliefs and exposure worry, in the context of the posited mediation model.

Research question 1

The mediation analysis showed that exposure worry is significantly predicted by clinically relevant anxiety and the extent one believes their health condition is caused by ionising radiation exposure. In addition, clinically relevant anxiety significantly predicted the extent one believes their health condition is caused by ionising radiation exposure. While there was a significant direct effect of clinically relevant anxiety on exposure worry, there was a non-significant indirect effect suggesting that the effect of clinically relevant anxiety on exposure worry can occur in the absence of the influence of illness beliefs (applied specifically to veterans with a physical health condition). In other words, there was no significant mediating role of illness beliefs on the effect of clinically relevant anxiety on exposure worry in veterans with at least one physical illness.

The observation of clinically relevant anxiety predicting the extent which one believes their health condition is caused by ionising radiation exposure can be explained using attentional bias and disengagement of threat models. Anxious individuals (trait, clinical, and non-clinical) evidently show heightened attentional bias to threatening stimuli which is thought to maintain worry (Bar-Haim et al., 2007). These individuals are also likely to exhibit ruminative thinking through deficits of disengagement with threatening stimuli (Koster et al., 2006). In the context of British nuclear test veterans, one could speculate that the threatening stimuli perhaps provided by media reports or through other nuclear veterans (as indicated by the qualitative

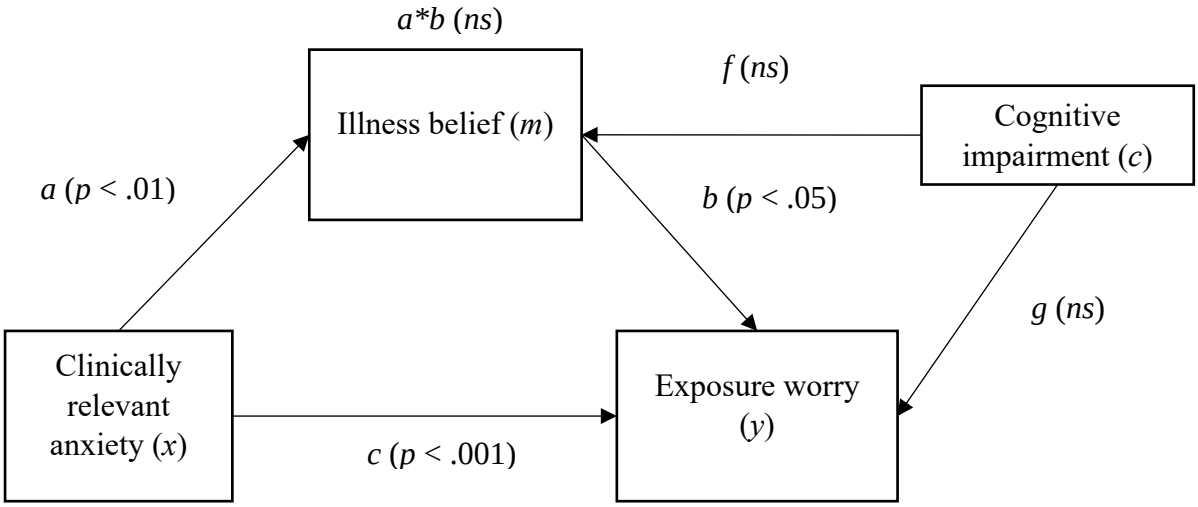
findings of Chapter 6) are attended to at a greater extent in nuclear veterans with clinically relevant anxiety.

To elaborate, media reports associating the nuclear testing programme with adverse health conditions, thus presenting 'threatening' radiation-related information, were available before the emergence of the UK epidemiological studies (Darby et al., 1988, 1993). Moreover, these epidemiological studies primarily focused on cancers (Muirhead et al., 2003, 2004), but the veterans participating in this project reported health conditions not documented by these epidemiological studies (see Table 11 in Chapter 6 for examples of health conditions). Therefore, in the absence of empirical reports, nuclear veterans may rely on schemas formed by media reports and interactions with other veterans when interpreting the causal nature of their physical illnesses. Even following the availability of epidemiological evidence, anxious individuals (clinical and subclinical) have a recall bias for threatening information specifically on free recall tasks and appear to recall fewer positive information compared to low anxiety controls (Herrera et al., 2017; Mitte, 2008). Thus, anxious individuals may recall threatening information more readily than any epidemiological studies relevant to their health condition, when interpreting the causal nature of their physical illness.

Individuals with anxiety disorders also appear to make more threatening interpretations of ambiguous scenarios, compared to non-anxious individuals (Hirsch et al., 2016). Thus, in this context, the ambiguity regarding attributing any causation to their illnesses may be interpreted as threatening (i.e. caused by ionising radiation exposure), compared to more benign perceived causes such as age or genetics. This ambiguity regarding the causal nature of any physical illnesses may play a further role. Since intolerance of uncertainty is inherent in clinically anxious individuals (Carleton, 2012), these individuals may seek explanations for any unexplainable physical health conditions to alleviate any uncertainty and ambiguity. Although there is available epidemiological evidence (Darby et al., 1988, 1993; Muirhead et al., 2003, 2004), this evidence may not be readily accessible to lay-persons but more accessible (in terms of ability to access) information of individual cases may be delivered through media reports. Thus, the more available and accessible information about possible health effects to British nuclear test veterans could be threat-related information (particularly when serving to promote sensationalised content) which are likely to reinforce negative interpretations of health conditions.

Figure 12.

Analysed mediation model



Note. Path *c* is the direct effect on exposure worry and path *a*b* is the indirect effect. The total effect on exposure worry = path *c* + (*ab*).

I observed that the extent one believes their physical health condition is caused by ionising radiation significantly predicted exposure worry. While there is no prior research examining this relationship, believing one's physical illness is caused by ionising radiation exposure (by default) suggests that they believe they have been exposed. This belief may result in the veterans considering the potential for further adverse health effects in themselves or family members, thus contributing to further psychological stress.

Despite this observation, the path analysis indicates that perceived illness causation does not significantly mediate the relationship between clinically relevant anxiety and exposure worry in nuclear veterans with at least one physical illness. One explanation for this is that physical health conditions are varied within this sample. As observed in the qualitative work of Chapter 6, the health conditions perceived to be 'normal' for someone of a certain age and lifestyle are unlikely to be attributed to ionising radiation exposure. Those with clinically relevant anxiety may have had a health condition professionally diagnosed as being caused by a factor besides ionising radiation (e.g. age or lifestyle), but the individual may continue to worry about the potential for future adverse health effect in family members. This is plausible considering that participants rated their exposure worry (7th item) in the context of varying aspects of exposure worry (e.g. their own health *and* their descendants' health).

The uncertainty regarding causal attributions is also relevant to the lack of mediation. One may suspect that exposure worry may be exacerbated in nuclear veterans with clinically relevant anxiety if they are uncertain about the causal role of their health condition.

Research question 2

Although there was a significant inverse correlation between cognitive functioning score and the extent their illnesses are perceived to be caused by ionising radiation exposure, this relationship was not evident in the regression analysis when dichotomizing cognitive functioning into impaired or 'normal'. The reason being that, while there was a significant bivariate correlation between cognitive functioning and illness beliefs, the relationship between these two variables is non-significant relative to clinically relevant anxiety as a strong predictor of illness beliefs. Therefore, this analysis does not support the potential for cognitive impairment impacting on health beliefs. Similar assumptions can be made regarding cognitive impairment and exposure worry, where cognitive impairment did not significantly predict exposure worry likely due to the relative significance of other variables in the model.

Implications

The first key implication of this study (as highlighted earlier in the chapter) is that, by using a screening measure for anxiety validated in older adults (Byrne & Pachana, 2011), it formalises the anxiety issues prevalent in the nuclear test veteran population. Anxiety issues have previously been indicated in other studies (Alexis-Martin et al., 2019; Dockerty et al., 2020; Miles et al., 2011), but there were limits to the validity of previous measures used. Thus, I provide evidence that clinically relevant anxiety is a matter of concern in the nuclear test veteran population, compared with non-veteran older adults elsewhere (Forlani et al., 2014). This study is also the first to demonstrate the role of clinically relevant anxiety influencing attributing one's own physical health condition to ionising radiation exposure and influencing worry about the impact of possible ionising radiation exposure.

As such, this study can inform approaches to promote wellbeing in older adults with perceived ionising radiation or chemical agent exposure. Possible interventions to promote psychological wellbeing in British nuclear test veterans, but also individuals with perceived exposure through other occupations, may benefit from focusing on alleviating general anxiety symptoms. This may reduce the potential for anxious individuals focusing their attention on threatening stimuli

(e.g. media reports depicting adverse health effects), despite the available epidemiological evidence (Darby et al., 1988, 1993; Muirhead et al., 2003, 2004) suggesting that there is no excess risk of cancer incidence in this population. One may speculate that the current available epidemiological evidence and scientific knowledge is perceived as ambiguous given the ongoing scientific debates regarding low-dose health risks of ionising radiation (Kasperson, 2012). Indeed, such debates extend to nuclear test veterans where self-report studies (Busby & de Messieres, 2014) suggest an increased incidence of congenital diseases in test veteran descendants, but such findings must be taken with caution due to methodological concerns. Perceived ambiguous or uncertain health risk information could be especially unhelpful to anxious individuals when interpreting the causal role of their health conditions and may lead to further worry, thus an emphasis on effective scientific communication is required (see Chapter 6 discussion).

Furthermore, there was no convincing evidence in the present study to suggest the role of socioeconomic status to be associated with exposure worry. It is likely that relevant coping resources used to cope with exposure worry are not adequately assessed in this study, nor might any coping resources associated with socioeconomic status be relevant to coping with exposure worry. As such, there may be coping resources unrelated to socioeconomic status. I propose a need to examine the BNTVA and NCCF (and other veteran organisations) as a social-support coping resource, consistent with Thoits (2011). Since socioeconomic factors appear irrelevant to coping with exposure worry, one could rather encourage involvement with a social group of experientially-similar others (i.e. BNTVA) which will provide more effective social-support coping resources and may itself alleviate general anxiety depending on the activities engaged through the BNTVA or NCCF. Moreover, engaging in social groups of experientially-similar others (Gage, 2013; Thoits, 2011, 2020) may have the potential to alleviate broader psychological effects such as guilt, which was highlighted in the qualitative findings (Chapter 6).

Despite these implications and the utility of this analysis, there are several limitations. It is unclear how the perceived cause of ionising radiation exposure is interpreted in the context of multiple health conditions. For example, it is unclear whether participants provide a rating based on their most salient health condition, or if they provide a rating based on multiple perceived causes. The health conditions found in this sample extend beyond those studied in epidemiological studies (Darby et al., 1988, 1993; Muirhead et al., 2003, 2004). Therefore, we

can only speculate anxious veterans' preferences for health risk information. It would be valuable to examine high-anxious and low-anxious veterans' perceptions of the credibility of epidemiological evidence specific to their own health conditions.

Moreover, we must be cautious when interpreting the findings due to the small sample size (and limited power). For example, while a significant inverse correlation was observed between cognitive functioning scores and the extent one believes their health condition is caused by ionising radiation exposure, there may be insufficient power to detect the unique effect of cognitive functioning in a regression model. Separately, an inspection of cross-tabulation (see Appendix P) shows a highly unbalanced number of respondents, particularly in those who screen as probable clinically relevant anxiety but who disagree that they are worried about ionising radiation exposure, for example. In this case, only three participants who screened as probable clinically relevant anxiety fell into the 'disagree' category when exposure worry was dichotomised. It is likely that, in accordance with my expectations, being clinically anxious would result in multifocal worry (including potential health effects from ionising radiation), but the magnitude of the observed relationship must be treated with caution due to the limited number of participants falling in certain outcomes.

Lastly, a further limitation is that the variables and data collected were driven by the initial cognitive functioning hypothesis. While variables such as socioeconomic status and general anxiety were useful to examine in the context of exposure worry, there are other variables relevant to coping such as 'perceived mastery' may have been more suitable. It may have been interesting to examine trait-type factors such as neuroticism, trait anxiety, and constructs related to worry such as intolerance of uncertainty (Koerner & Dugas, 2006, 2008).

Conclusion

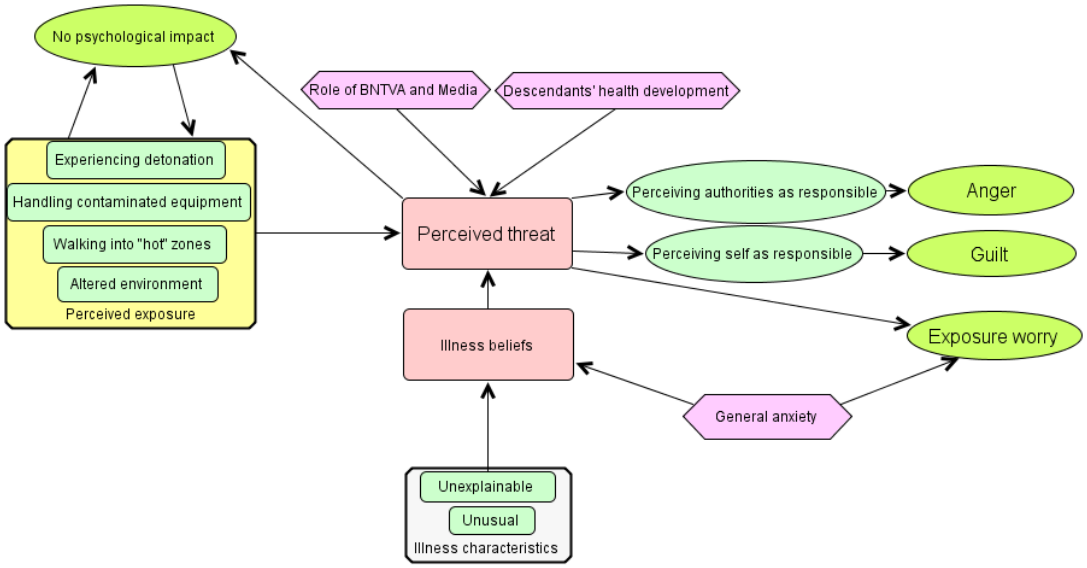
To conclude, this quantitative analysis suggests that socioeconomic status indicators such as principal lifetime occupation do not appear relevant to GAI-SF scores nor exposure worry. It is likely that the proxy measures were poor indicators of socioeconomic status, because if they were indicating socioeconomic status then we would also expect some correlation with anxiety and exposure worry. But if socioeconomic status was accurately measured, we may not observe such a relationship anyway since the psychological impact of ionising radiation exposure is unique and may not be adequately dealt with by personal and social coping resources associated with socioeconomic status (Thoits, 2011). Rather, more effective social coping resources may

be found in experientially-similar social networks (e.g. BNTVA or NCCF). This is interesting because there could be, to some extent, both positive and negative influences of veteran groups on communicating health risk and worry. On one hand, such groups may exacerbate worry about the risk of radiation-related health effects, but they may also play a key role in alleviating worry and the broader psychological impact.

Importantly, this chapter uses a validated anxiety screening measure to extend our understanding of anxiety-specific mental health issues in the British nuclear test veteran population, demonstrating that the prevalence of clinically relevant anxiety in this population appears markedly higher than anticipated. In nuclear veterans with a physical health condition, the mediation analysis revealed that clinically relevant anxiety predicts the extent one believes their physical health condition is caused by ionising radiation exposure, which in turn predicts exposure worry. Therefore, those who are generally anxious are more likely to experience exposure worry, and this relationship occurs in the absence of believing their illness is caused by ionising radiation exposure. Two suggestions for the future arise: a need to reduce general anxiety symptoms in older exposed populations, and to further research the effectiveness of social coping resources in alleviating exposure worry.

Figure 13.

Final conceptual model illustrating the possible psychological impact of perceived ionising radiation exposure in the context of the British nuclear testing programme



The findings of this analysis further inform the conceptual model derived from the qualitative data. We can now incorporate the path analysis into the conceptual model, with the addition of ‘general anxiety’ as a factor influencing ‘illness beliefs’ which also influences ‘exposure worry’. Indeed, a direct arrow from ‘general anxiety’ to ‘exposure worry’ is added to demonstrate that this relationship can occur in the absence of illness beliefs. The hypothesised variables of socioeconomic status and cognitive impairment are now omitted from the final conceptual model (Figure 13).

Chapter 8 – General Discussion and Conclusion

In conclusion to this field of inquiry, I present an overall summary of the research studies that constitute the thesis. As an in-depth discussion of each chapter has already been provided; full details are not required here, but an overall discussion drawing the quantitative and qualitative findings together in the context of investigating exposure worry will be given. This final chapter also reflects on and evaluates the methods used and makes recommendations for future research in the field of psychology and radiation exposure.

To recap, this doctoral thesis presented the history and context of the British nuclear testing programme, and outlined the subsequent events (e.g. legal cases, media reports, epidemiological studies) to demonstrate its societal and political significance. The original aim of this project was to address the hypothesis that psychological stress due to perceived ionising radiation exposure, namely 'exposure worry', is a significant predictor of cognitive functioning in British nuclear test veterans. The Current Exposure Worry Scale (and the disregarded Mid-Life Exposure Worry Scale) were intended to be implemented in a study addressing this hypothesis. But as highlighted in Chapter 5 and elsewhere in the thesis, it soon became evident that exposure worry is a phenomenon too complex and dynamic to be accurately measured using the developed scale. Nonetheless the Current Exposure Worry Scale retained utility in understanding the extent of exposure worry and the specific factors this population are worried about. As such, the analysis examining the relationship between exposure worry and cognitive functioning was not pursued, but rather the thesis set to address the following research questions:

I. What are the levels of exposure worry in a sample of British nuclear test veterans?
    a. What specific aspects of exposure worry do British nuclear test veterans report?
    b. To what extent do British nuclear test veterans report feeling stressed as a result of their worry about ionising radiation exposure?
II. What are the mechanisms and dynamics of exposure worry?
    a. How has it developed over time?
    b. What is the broader psychological impact of involvement in the testing programme, and how is this influenced by time?
III. What factors are associated with exposure worry in British nuclear test veterans?
    a. How does exposure worry relate to the belief that a physical health condition is caused by ionising radiation exposure?

I will now summarise the thesis to address the above research questions. It is also important to reflect on the methods used and evaluate their effectiveness in answering the intended research questions and to make suggestions for future research addressing similar questions.

To begin, while this doctoral thesis was initially concerned with examining exposure worry in relation to cognitive functioning, the broad aim of this thesis was ultimately to investigate the worry about perceived ionising radiation exposure in British nuclear test veterans, and the broader psychological impact of the British nuclear testing programme. The first research chapter of this thesis, Chapter 4, described the development of two 8-point 6-item scales to measure various aspects of exposure worry at present and earlier in life. Both scales included a 7th item designed to reflect the extent that their worry makes them feel stressed and to indicate excessive worry. This scale development involved a single focus group of eight participants (six British nuclear test veterans and two wives), four individual telephone calls, and lastly distributing the proposed scales and analysing a total of 124 responses using quantitative methods. The chapter does not directly address the above research questions which comprise the thesis but was a critical stage in the project, nonetheless. Piloting these scales also provided the first indications about the probable dimensions pertaining to exposure worry: the PCA indicated that items four and five could be related to the perceived role of authorities (a consideration made in the light of the qualitative findings of Chapter 6), while items one, two, three, and six are likely to be related to health and wellbeing of themselves and their family members. Despite this, all six items were retained, and further analysis was required to understand the dimensions constituting exposure worry.

Addressing the above research questions, quantitative data collected using the Current Exposure Worry Scale in Chapter 5 indicated that while the responses were diverse, the average responses from this sample of nuclear test veterans were moderately skewed towards "strongly agree" for each six items. Due to my concern that the Mid-Life Exposure Worry Scale is actually representing current worry, I focus on the findings obtained with the Current Exposure Worry Scale. The findings of Chapter 5 indicate that most of this sample are generally worried about at least one aspect of perceived ionising radiation exposure. Interestingly, the average scores indicated that this sample were generally worried more by the perception that scientists were not explaining the full effects of ionising radiation exposure (item four) and about the lack of protective equipment provided (item five), than their descendants' health (item two and item three) and their own health (item one). In addition, this sample generally appeared more

worried about their descendants' health (item two and item three) and descendants' worry (item six) than their own health (an observation consistent with age-trends of worry content). The responses to the 7th stress/nervous item were more balanced and showed relatively little skew. To provide an indicator of the extent that this sample of British nuclear test veterans exhibit excessive exposure worry, we can examine the percentages of valid responses for the stress item (Table 6). When dichotomised into 'disagree' and 'agree', the data suggests that 53.9% of valid respondents disagreed, while 46.1% of valid respondents agreed that their exposure worry makes them feel stressed or nervous. Thus, a considerable proportion of the sample of British nuclear test veterans exhibit exposure worry.

Similar to the analysis of the pilot data, the PCA in Chapter 5 also raised the prospect that the high average scores regarding item four and item five may be underpinned by anger towards authorities. Indeed, while all items correlated with a common component, it appeared that item four and five also correlated with a second component (presumably relating to the perceived role of authorities) to capture additional variance. We can turn to Böhm and Pfister's (Böhm, 2003; Böhm & Pfister, 2000) development of appraisal theory to support the findings obtained using the PCA. According to Böhm and Pfister (2000), our appraisal of risks/threats involves deontological/ethical evaluations (especially regarding anthropogenic risks) which describes evaluating whether the risk violates ethical principles and evaluates who is responsible for such violations. These deontological/ethical evaluations tend to give rise to emotions such as anger or guilt, distinguished by who is responsible for the violation. Relating to the scale items, item four and item five pertain to the role of others, namely scientists and authorities in charge of safety protocols and protection at the time of the tests, which one would expect to give rise to anger (despite using the term 'worry' in the scale items).

While the Current Exposure Worry Scale was useful in measuring current levels of worry regarding different aspects of perceived ionising radiation exposure and the extent that exposure worry makes one feel stressed, the scale failed to capture the complex nature of exposure worry. For example, it is uncertain using the Current Exposure Worry Scale alone how persistent exposure worry might be in British nuclear test veterans. While the Mid-Life Exposure Worry Scale was developed, consisting of the same content as the Current Exposure Worry Scale but framed in the past (e.g. "At a point in my life, I had been worried…") to capture exposure worry throughout life, it was ultimately discarded from any further analysis. The issue here is that, without a longitudinal design, using the Mid-Life Exposure Worry Scale

to measure exposure worry is relying on retrospection, where the participant must remember how they felt in the past and reduce a lifetime of worry experiences to a number. As we saw in Chapter 5, the two scales were highly correlated which may indicate that veterans rely on how they feel at present to judge their levels of exposure worry in the past. This leads one to consider multicollinearity in any regression models, thus I would also be limited in my ability to robustly examine the extent a lifetime of exposure worry predicts cognitive functioning (the presence of multicollinearity violates a core assumption of regression models) if this hypothesis had been pursued.

As discovered in Chapter 6, exposure worry is dynamic and any psychological stress in veterans may in fact extend beyond worry. In not initially understanding this latter point, I may have been misled by psychological research in other exposure populations where it is unclear what aspects are central to psychological stress. To elaborate, while a core feature of psychological stress in the radiation exposure context is the worry about adverse health effects in oneself or in one's descendants (Abbott et al., 2006; Bromet et al., 1990; Murphy et al., 1990), it is also uncertain to what extent psychological stress could be exacerbated by other stressors. In quantitative studies of individuals affected by nuclear power plant accidents (Cwikel et al., 1997, 2000; Havenaar, Rumyantzeva, Van den Brink, et al., 1997), it is even more uncertain what is driving levels of anxiety (in studies using anxiety measures not specific to ionising radiation exposure). The importance of this is that nuclear power plant accidents are unanticipated and are accompanied by radical economic and social change, and issues relating to evacuation, all of which are likely to be stressful (Barnett, 2007). As highlighted by Dockerty et al. (2020), the psychological stress in nuclear test veterans may not solely relate to perceived ionising radiation exposure either, since the type of service and transitioning from the military to civilian life often contribute to psychological stress in veterans generally. Without unpicking these stressors, one may overestimate the psychological stress caused by perceived exposure itself, and overestimate the extent that worry is central to any psychological stress. This would have been a critical confounder in any regression analysis of exposure worry and cognitive functioning.

Chapter 6 presented a qualitative study involving 20 semi-structured interviews exploring exposure worry, the broader psychological impact of the tests, and perceptions of health in British nuclear test veterans. To some extent, this qualitative work also informed the first research question regarding the levels of exposure worry in the population, but it primarily

addressed the second main research question of this thesis: what are the mechanisms and dynamics of exposure worry?

The qualitative findings demonstrated that exposure worry was generally influenced by the awareness of health risk, which was shared through the media and interactions with other nuclear test veterans at association meetings, for example. Interestingly, any worry also appeared to be strongly influenced by observing descendants' health development as an indicator for concern *or* reassurance that possible health consequences are unlikely to occur. Importantly, the participants in the qualitative study generally reported limited exposure worry at present, and worry was only expressed by a few participants in the context of their grandchildren's health. To an extent, this qualitative finding corroborates with the quantitative scale data suggesting that British nuclear test veterans are generally more worried about their descendants compared to their own health. However, one would not have expected the extent that worry was not relevant to the interview participants. There are two obvious possible explanations for this discrepancy. Firstly, the sample size of the qualitative study is markedly smaller than the quantitative study and I ensured that I had interviewed participants who explicitly stated (anecdotally) that they were not worried about their ionising radiation exposure. Therefore, it could be expected that the findings appeared to contrast between the quantitative and qualitative data, with respect to worry. Secondly, as discussed in Chapter 6, the role of masculinities must be acknowledged given that the participants are older male veterans. I speculate that it is easier for older men to report worry using scale measures compared to articulating experiences of worry in in-depth interviews.

Interestingly, the qualitative findings pertaining to sociopsychological issues such as perceived deception and negligence by authorities which often resulted in anger in the participants, was a key finding and can be used to corroborate the quantitative scale data. As mentioned previously, the quantitative data indicated that respondents were generally more worried about the lack of protective equipment and lack of scientific explanation regarding the full effects of ionising radiation, compared to other aspects of exposure worry (e.g. their own health and the health of their descendants). My view that respondents are reporting worry within the scale framework and language specified by me has already been discussed, and I suspect that item four and item five are measuring anger despite being presented as worry items. The PCA analyses of Chapter 4 and Chapter 5 offers some support for this position. Combining the findings from the PCA of Chapter 4 and Chapter 5, and the qualitative findings of Chapter 6,

if one were to devise a brief scale assessing the most appropriate items regarding exposure worry, I suggest two items: one regarding their own physical health and the second item regarding their family members' wellbeing (encompassing physical and mental health). These two items would adequately capture most of the variance across the six Current Exposure Worry Scale items, according to the PCA.

Regarding the qualitative work of Chapter 6, it is important to comment on the effectiveness in eliciting valuable data relevant to exposure worry and the broader psychological impact. In this study, the interviews were not regular semi-structured interviews but were biographical and (only in the face-to-face interviews) used techniques drawing on object elicitation. This relatively novel style of interviewing was effective in eliciting valuable data: the biographical style allowed participants to discuss freely the topics important to them and to provide context, while the use of objects is likely to have facilitated discussion which may not have been discussed otherwise. To illustrate the benefit of object elicitation, there were numerous instances where participants referred to the objects presented in the interviews. For example, on page 116, Andrew presented a MRI scan photograph which served as a discussion point regarding attributing causality to health conditions in his descendants and describing the extent of any exposure worry. In another example, Dennis discussed the notion of negligence and lack of protective clothing and referred to a safety protocol provided in an AWRE booklet. These are two examples where the use of objects had elicited data relevant to the research questions in this chapter.

The face-to-face interviewees were notably longer than the telephone interviews where object elicitation was not applicable. This could be attributable to the use of objects, but telephone interviews are generally more prompt which I believe may be due to the lack of physical cues. On reflection, objects *could* have been used in the telephone interview but may not have resulted in an organic conversation about the object if I were unable to see it. None the less, telephone interviews had their merit in eliciting (potentially sensitive) data due to the physical barrier between me and the participant (Novick, 2008).

Ultimately, the qualitative analysis of Chapter 6 generated a set of themes describing the possible psychological issues faced by British nuclear test veterans, which was then illustrated as a conceptual model. To further inform the nature of exposure worry and to examine factors associated with exposure worry, and thus addressing the third and final research question of this thesis, Chapter 7 presented a quantitative study (n = 91) utilising the developed Current

Exposure Worry Scale to extend the conceptual model. Specifically, Chapter 7 presented scale, questionnaire, and cognitive test data, analysed using bivariate correlations and a path/mediation analysis.

The analysis suggested that proxy measures of socioeconomic status were unlikely to be associated with exposure worry, and there was no significant relationship between exposure worry and cognitive functioning (albeit a modest correlation between increased exposure worry and poorer cognitive functioning). The path/mediation analysis demonstrated (in those with at least one physical illness; $n = 55$) that the presence of clinically relevant anxiety predicted exposure worry, and the extent participants believed their physical illness was caused by ionising radiation exposure also predicted exposure worry. Interestingly, the relationship between clinically relevant anxiety and exposure worry was not significantly mediated by the extent one believes their physical illness was caused by ionising radiation, despite those with clinically relevant anxiety were also more likely to believe their physical illness was cause by ionising radiation. Moreover, aside from the critical role of clinically relevant anxiety in exposure worry, the screening of clinically relevant anxiety in this sample using a validated measure was a key finding in itself, and extends the previous suggestions for anxiety-related mental health issues in nuclear test veterans (Alexis-Martin et al., 2019; Dockerty et al., 2020; Miles et al., 2011). The analysis also indicated that cognitive functioning was not a significant predictor of exposure worry nor health belief. None the less, there remains the original hypothesis that exposure worry may predict cognitive functioning, but I am unable to robustly test this.

Despite concluding that socioeconomic status is not a predictor of exposure worry in British nuclear test veterans, I had reservations regarding the proxy measures of socioeconomic status, namely educational attainment, occupation, and index of multiple deprivation. An evaluation of these proxy measures was provided in Chapter 7; I hold the view that these may not accurately assess socioeconomic status nor assess the coping resources related to socioeconomic status. For future work, a more appropriate measure would be a subjective item akin to Ingrand et al.'s (2018) measure of financial status, where participants rate their financial status as *fairly well-off*, or *income adequate to meet fundamental needs*, or *difficult financial situation*. This is useful because it would assess the perceived financial coping resources to deal with psychological stress, rather than using proxy measures thought to indicate socioeconomic status (and its related coping resources). While this would not tap into personal

coping resources such as perceived mastery (Pearlin et al., 2007), this could be remediated by directly asking participants to complete a measure directly assessing perceived mastery (Pearlin and Schooler, 1978). Items regarding social support from significant others and experientially-similar others would tap into social coping resources.

Conclusion and future work

Drawing the threads together from each research chapter to answer the three key research questions, I can conclude that exposure worry is a considerable issue in the British nuclear test veteran population, with almost half of the sample reporting that their exposure worry makes them feel nervous or stressed (according to the quantitative data). While the quantitative data also indicated that higher proportions were worried about at least one aspect of exposure worry, in particular items relating to protective clothing and scientists' explanations of health effect, I propose that these particular items generally do not represent worry, specifically, but probably represent anger. This is rather a valuable finding and, when examining the PCA and qualitative findings together, one can conclude that the sociopsychological issues relating to the role of authorities are perhaps more pertinent issues compared to any worry. Moreover, the PCA and qualitative findings also suggest that British nuclear test veterans are more worried about the health of descendants than their own health.

According to this thesis, it appears that any exposure worry in British nuclear test veterans is not related to nuclear test programme-specific factors such as their role in the programme, the location they were stationed, or their national service status. Nor is exposure worry related to factors such as their cognitive functioning or socioeconomic factors such as educational attainment, principal lifetime occupation, or the deprivation index level of their current neighbourhood. However, the awareness of health risk and the health development in themselves and in their descendants, and intrinsic factors such as the presence of clinically relevant anxiety and the belief that one's own health condition is caused by ionising radiation appear to be factors influencing exposure worry in British nuclear test veterans, as indicated by the qualitative and quantitative findings, respectively. Aside from exposure worry, the markedly high presence of clinically relevant anxiety, and sociopsychological issues relating to authorities, we must also be mindful of psychological issues pertaining to guilt specifically in veterans who perceive themselves as responsible for any health conditions in family members. As such, this multiple-methods thesis has provided a comprehensive investigation

into exposure worry, the broader psychological impact of the British nuclear testing programme, and anxiety-related mental health issues in this veteran population.

This thesis initially intended to address the hypothesis that exposure worry predicts cognitive functioning in British nuclear test veterans. A feasible research design for this doctoral thesis aimed at addressing this hypothesis would have yielded unconvincing findings. Given that there were roughly 250 veterans contactable on the GDPR-compliant NCCF mailing list (where participants provided email address or postal address; excluding telephone address), a sample of 91 veterans for this study was not disappointing by any means. But a sample of 91 veterans is limited in terms of power for a regression analysis given the number of covariates required in a model predicting cognitive functioning. In addition to the limited sample size, the proposed research design would have been cross-sectional. Rather, robust studies examining psychological stress as a predictor of cognitive functioning or cognitive decline in older adults tend to be longitudinal (see Aggarwal et al., 2014; Y. Chen et al., 2019; Gulpers et al., 2019; Scott et al., 2015 as examples). A longitudinal design spanning ideally 3 to 5 years minimum with an adequate sample size is not feasible for a PhD project.

The structure of the research process in this thesis was scale development, followed by quantitative data collection and analysis, followed by qualitative data collection and analysis, then further analysis of quantitative data. On reflection, a qualitative study preceding the scale development and quantitative data collection would have been appropriate and might have avoided the focus of exposure worry in the context of cognitive functioning. While limited qualitative work was conducted in Chapter 4 as part of scale development, the purpose was not to explore the nature of exposure worry but to validate the content of presumed relevant scale items. There were indications from the focus group and informal telephone discussions that worry about descendants' health effects was not necessarily persistent but appeared to change with their descendants' health development. As advised by Vogt et al. (2004), the approach to incorporating focus group data into scale item development should be liberal: to be open to new ideas but not overemphasise the findings of the focus group. This latter point was especially pertinent in this thesis, where the data informing the scale development was acquired from a single focus group. On the one hand, it was sensible at the time to avoid letting the single focus group fully dictate the scale items: on the other hand, this resulted in disregarding information which was later evidenced in greater detail in the qualitative study of Chapter 6. In retrospect, the most effective method would have been multiple focus groups or unstructured

individual qualitative interviews (such as those in Chapter 6) where the intention is not to inform the pre-existing scale items, but rather to generate scale items based on themes.

Furthermore, an in-depth, exploratory qualitative study such as that of Chapter 6 would have elucidated the nature of the psychological impact of ionising radiation exposure at the beginning of the project. It was evident that the psychological impact in nuclear test veterans was broader than worry. Therefore, addressing the initial cognitive functioning hypothesis using the Current Exposure Worry Scale would have neglected other forms of psychological stress relevant to British nuclear test veterans (e.g. anger and guilt), and of course would have neglected psychological stress from adversity experienced by veterans generally (e.g. relocation, transitioning to civilian life) and the general population (e.g. financial stress, relationships stress, bereavement etc.). As such, the scale development was undertaken without the knowledge about the psychological impact which was later acquired through qualitative work. These broader psychological issues would contribute to any psychological stress and would have been a considerable limitation if they were unacknowledged in any study examining the relationship between exposure worry and cognitive functioning. A more suitable measure of psychological stress in a project examining the impact on cognitive functioning may be the Kessler Psychological Distress Scale (K-10; Kessler et al., 2002). This is a measure of global psychological distress and ideally would be administered at various time points across a longitudinal design. While this would not capture exposure worry or other specified psychological stress related to the testing programme, this could be supplemented with qualitative work to highlight the sources of their stress.

With these methodological and conceptual issues in mind, the thesis diverted away from the cognitive functioning hypothesis and towards an in-depth investigation of exposure worry. Thus, the thesis is a valuable contribution to understanding the psychological impact of perceived ionising radiation exposure in a relatively unexamined population, namely British nuclear test veterans. This contribution leads to one considering further questions and future research opportunities in this field.

A key output of academic research should be to improve the lives of those studied and to apply the findings to other relevant populations. Now that the possible psychological issues in British nuclear test veterans have been investigated, a natural progression would be to develop an intervention to promote successful ageing in this population. The British nuclear test veteran population are all well into older adulthood with a substantial proportion likely to be in the

upper age categories, venturing into oldest-old. There is insufficient time to gain funding and to develop an intervention to improve the quality of life and promote successful ageing in British nuclear test veterans. Nevertheless, their first-generation descendants are also now older adults. Conducting research with descendants would offer opportunities to study psychological issues across generations and across genders. This has only previously been explored in second-generation descendants of atomic bomb survivors (Kamite, 2017). This is especially important because mothers of young children appear most at risk of psychological effects of IR exposure (Bromet, 2014). Of course, the difference here is that the female descendants of British nuclear test veterans are unlikely to perceive themselves as being exposed to ionising radiation, rather, they may perceive they are at risk of inherited effects. Thus, this presents a further interesting avenue to examine the possible psychological impact of perceiving oneself to be at risk of passing on heritable effects in the absence of ionising radiation exposure.

We can make theoretical applications in future work too. Since uncertainty in terms of possible inherited health effects remains relevant to the descendants, we can apply concepts such as 'intolerance of uncertainty' (Carleton, 2012; Dugas et al., 2004; Koerner & Dugas, 2006) to examine whether individuals high in intolerance of uncertainty are more likely to express excessive worry about future health in themselves and in their descendants.

Of course, worry (and the broader psychological effects relevant to their descendants) could be a critical factor in the quality of life of first-generation descendants, but it is not the only factor. Perceived responsibility and guilt may also be relevant to those (descendants of nuclear veterans) whose descendant is born with a serious health condition (d'Agincourt-Canning, 2006; Hallowell et al., 2006), despite not being involved in the nuclear testing programme. A future project would, similar to the present thesis, be a multiple-methods design (qualitative and quantitative) to identify wellbeing needs and predictors of quality of life in first-generation nuclear test veteran descendants, with a focus on the psychological impact of perceiving oneself to be at increased health risk and how this may impact on quality of life. Using semi-structured interviews to explore the relevant psychological issues and using survey methods to measure predictors of quality of life (e.g. physical health, social engagement, mental health, perceived mastery, perceived financial status) could produce a comprehensive model similar to that of Ingrand et al. (2018) and Bowling and Iliffe (2011). This will set the groundwork to co-produce an intervention to improve quality of life in first-generation nuclear test veteran

descendants. Potential participants for a subsequent intervention study might be those scoring in the lowest tertile on a quality-of-life measure.

We can also make recommendations for research examining the psychological impact of ionising radiation in other contexts. As noted previously, the qualitative work of Chapter 6 highlights that different exposure contexts have their own unique factors contributing to psychological stress. In other words, while perceived ionising radiation exposure is the common factor, the contexts are unique and cannot be generalised to one another. I argue that radiation research should emphasise the different sources of stress (e.g. perceived ionising radiation exposure, evacuation, job loss, financial hardship, wider social change etc.) to avoid the risk of overattributing or underattributing psychological stress to ionising radiation exposure specifically. Such attributions were evident in the present thesis where, based on the extant literature of psychological effects in other contexts, I overestimated the extent that I understood the British nuclear test veterans' possible psychological issues (i.e. the overemphasis on exposure worry). To avoid making similar errors, one should conduct exploratory (qualitative) work first when researching unique populations and pursue the unexpected findings.

Finally, uncovering the broader possible psychological issues (namely sense of responsibility leading to guilt, and perceived deception and negligence leading to frustration) can lead us to make recommendations in the healthcare context. Many nuclear veterans (and other exposed older adult populations) may experience serious physical health conditions due to ageing which can cause suffering. This suffering, consisting of the psychosocial impact as well as the biological diagnosis of a health condition, constitutes an illness (Kleinman, 1988). Drawing on Beck's concept of the risk society (Beck, 1995, as cited in Lupton, 2013), one can speculate that invisible exposures (and thus perceived risks) will increase as technology continues to develop. A recent notable example is the increasing public concern regarding radio waves from 5G networks. Moreover, there is always some level of risk of future nuclear power plant accidents. Exposure may also stem from biological, chemical, or radiological terrorism; current Prime Minister Boris Johnson stated that such an event is likely by the year 2030 (Cabinet Office, 2021). Therefore, the risk of novel exposure contexts is likely to occur. On top of invisible technological risks, we are also in an increasing ageing society. According to the European Commission (European Commission, 2014), it is expected that there will be an increase in the proportion of people aged 65 and over from 17.4% to 25.6% in 2030 and rising

to 29.5% in 2060 in Europe. Thus, perceptions of health at the intersection of ageing and perceived exposure may be a significant issue in future years. As we have seen in the qualitative work in this thesis, it can be difficult for exposed populations (and general populations for that matter) to understand what health conditions are caused by genetics (e.g. the ageing process, heredity), lifestyle, or their exposure. As such, it is important for authorities such as the IAEA to emphasise transparency and establish trust with the public to avoid amplifying the perceived risk of adverse health effects in oneself and in one's descendants. Furthermore, in clinical consultations, acknowledging the context in which a health condition occurs and the patient's beliefs, emotions, and attitudes relating to the context which contribute towards suffering (i.e. narrative-based medicine; Greenhalgh & Hurwitz, 1999) could greatly improve radiologically exposed patients' healthcare experiences.

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Appendices

Appendix A.

Chapter 4: Ethics Approval (Stage I)

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

14 May 2018

LETTER OF APPROVAL

Applicant: Mr George Collett

Project Title: Measuring Radiation Exposure Worry: A Pilot Study

Reference: 11270-MHR-May/2018- 12714-2

Dear Mr George Collett

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The poster needs to say College of Health and Life Sciences Research Ethics Committee. Please change

The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

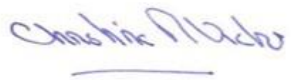
Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor

(where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.

Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.

The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the studyYou may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.



Professor Christina Victor

Chair

College of Health and Life Sciences
Research Ethics Committee (DCS) Brunel
University London

College of Health and Life Sciences

Department of Clinical Sciences

Consent Form

Measuring Radiation Exposure Worry: A Pilot Study

The participant should complete the whole of this sheet

Please tick the appropriate box

	YES	NO
Have you read the Research Participant Information Sheet?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Have you received satisfactory answers to all your questions?	☐	☐
Do you understand that you will not be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study:		
• **At any time?**	☐	☐
• **Without having to give a reason for withdrawing?**	☐	☐
• **Without any consequence?**	☐	☐
I agree to the focus group being recorded.	☐	☐
I agree to the use of non-attributable direct quotes when the study is written up or published.	☐	☐
Do you agree to take part in this study?	☐	☐

Signature of Research Participant:
Date:
Name in capitals:

Researcher name:	**Signature:**
Supervisor name:	**Signature:**

College of Health and Life Sciences

Department of Clinical Sciences

PARTICIPANT INFORMATION SHEET

Measuring Radiation Exposure Worry: A Pilot Study

You are being invited to take part in a research study. Before you decide, 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. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part

What is the purpose of the study?

The overall aim of the project in which this small study is part of is to see what contributes to healthy brain functioning in older adults, that is, your memory, problem solving, and reasoning skills. A special feature of this study is to look at 'radiation exposure worry' and brain functioning. We would like to find out whether British Nuclear Test Veterans feel that our 'exposure worry' measure is appropriate. This will be done in a group discussion.

Why have I been invited to participate?

You have been invited to take part because you are a British Nuclear Test Veteran Association (BNTVA) member and have witnessed at least one nuclear test. There will be between 5 and 8 BNTVA members taking part in the discussion.

Do I have to take part?

As taking part is entirely voluntary, 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 will happen to me if I take part?

You will take part in a group discussion lasting 45 minutes. This will take place in the conference room in this building. You will be shown the proposed 'exposure worry' scale, and asked as a group whether or not the measure is appropriate and the reasons why. You

will also be asked how you think it can be improved. Your voices will be recorded and notes will be taken by Prof. Mary Gilhooly during the discussion. You will not be filmed.

What do I have to do?

There will not be any restrictions or changes to your lifestyle when taking part in the study. Your lifestyle will remain unaffected as a result of taking part. You may, however, become aware of your worry towards radiation exposure as this is what our proposed measure will be addressing.

What are the possible disadvantages and risks of taking part?

While we do not anticipate that the discussion will cause you to be upset, the topic of exposure to radiation and the worry relating to this may be upsetting. The members of the Centre for Health Effects of Radiological and Chemical Agents are aware of the sensitivities of this issue. However, the discussion is aimed solely at understanding views about the exposure worry scale.

What if something goes wrong?

If you are unhappy with your experience taking part and would like to make a complaint, you can contact the University Research Ethics Committee via res-ethics@brunel.ac.uk

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Any information about you which leaves the premises will have your name and address removed so that you cannot be identified from it. Names and addresses will be replaced with “dummy” names. We will ask participants to keep information discussed confidential during and after the focus group, however full confidentiality may not be guaranteed.

What will happen to the results of the research study?

As this is only a small stage of our research project, there will be no 'results' which could be published. After all the stages of piloting are complete it might be possible to publish a paper on the development of the scale. If you would like a copy of the published paper you can receive it by contacting myself or Prof. Mary Gilhooly using the email addresses listed at the bottom of this document.

Who is organising and funding the research?

This research is being funded by the Nuclear Community Charity Fund (NCCF).

Who has reviewed the study?

This study has been reviewed by the College of Health and Life Sciences Research Ethics Committee.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints

George Collett (PhD Researcher) – exposureworrystudy@gmail.com

Professor Mary Gilhooly (Primary Supervisor) – mary.gilhooly@brunel.ac.uk

For complaints and questions about the conduct of the research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee Christina.victor@brunel.ac.uk

Should you seek further support, please contact:

thenccf.org or https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Thank you very much for your time.

College of Health and Life Sciences
Department of Life Sciences

Debrief

We would like to take this opportunity to say **Thank You** for taking the time to take part in our focus group.

Please be assured, all data collected will be treated in the strictest confidence. You are free to withdraw your data from the research at any time by contacting George Collett exposureworrystudy@gmail.com or Prof. Mary Gilhooly mary.gilhooly@brunel.ac.uk

This focus group will help to gain an understanding of what factors need to be taken into account when creating a scale to measure radiation exposure worry. This focus group is part of the larger project examining exposure worry and the relationship with cognitive functioning in older adults. You were chosen to take part in the study because of your experience of witnessing a nuclear test and your involvement with the BNTVA.

If you were unduly or unexpectedly affected by taking part in the study please feel free to feed it back to the researcher. If you feel unable for whatever reason what-so-ever to talk with the researcher then please either contact Prof. Mary Gilhooly or the research ethics committee res-ethics@brunel.ac.uk

Should you seek further support, please contact:

Nuclear Community Charity Fund thenccf.org

Or British Nuclear Test Veterans Association https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

26 July 2018

LETTER OF APPROVAL

Applicant: Mr George Collett

Project Title: Measuring Radiation Exposure Worry: A Pilot Study STAGE 2A

Reference: 11755-MHR-Jul/2018- 13549-2

Dear Mr George Collett

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

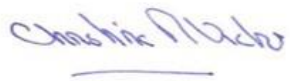
- Research Participant Information Sheets and (where relevant) flyers, posters, and consent
- forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries
- should be directed, in the first instance, to the Supervisor

(where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.

Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.

The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study. You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake

research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.



Professor Christina Victor

Chair

College of Health and Life Sciences
Research Ethics Committee (DCS) Brunel
University London

College of Health and Life Sciences
Department of Life Sciences

Consent Form

MEASURING RADIATION EXPOSURE WORRY: A PILOT STUDY

The participant should tick answers to all the questions below before signing and dating the form

	Yes	No
Have you read the Research Participant Information Sheet?	☐	☐
Do you understand that you will not be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study…		
at any time?	☐	☐
without having to give a reason for withdrawing?	☐	☐
Do you agree to take part in the telephone discussion?	☐	☐

Participant

First Name	
Signature	Date _ _ / _ _ / _ _ _ _
Telephone number:	
When is an appropriate time and day to hold the telephone discussion:	

Researcher (to be completed by the researcher)

Name	
Signature	Date _ _ / _ _ / _ _ _ _

This study has been reviewed by the Brunel University London College of Health & Life Sciences Research Ethics Committee.

College of Health and Life Sciences,

Department of Clinical Sciences

PARTICIPANT INFORMATION SHEET

Measuring Radiation Exposure Worry: A Pilot Study

You are being invited to take part in a research study. Before you decide, 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. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The overall aim of the project in which this small study is part of is to see what contributes to healthy brain functioning in older adults, that is, your memory, problem solving, and reasoning skills. A special feature of this study is to look at 'radiation exposure worry' and brain functioning. We would like to begin "testing" our proposed measure. We would also like to find out whether British Nuclear Test Veterans feel that our 'exposure worry' measure is appropriate. This will be done through a short telephone discussion lasting 20-minutes.

Why have I been invited to participate?

You have been invited to take part because you are a British nuclear test-veteran and have witnessed at least one nuclear test.

Do I have to take part?

As taking part is entirely voluntary, it is up to you to decide whether or not to take part. If you do decide to take part in the telephone discussion, you will tick the relevant box on the consent form, and to leave your telephone number and to provide an appropriate time to receive the phone call. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will find two ‘exposure worry’ scales inside the envelope, another envelope with our address and a postage stamp attached. If you agree to the telephone discussion, you will provide your first name, telephone number, and write down an appropriate time and day to receive the telephone call on the consent form. You will use the stamped envelope to return your consent form.

The telephone discussion will focus on whether or not the measure is appropriate and the reasons why. You will also be asked how you think it can be improved. You will not be audio-recorded but hand-written notes may be taken during the telephone call. You will need to keep hold of your questionnaires so that you can refer to them during the telephone discussion.

What do I have to do?

There will not be any restrictions or changes to your lifestyle when taking part in the study. Your lifestyle will remain unaffected as a result of taking part. You may, however, become aware of your worry towards radiation exposure as this is what our proposed measure will be addressing.

What are the possible disadvantages and risks of taking part?

While we do not anticipate that reviewing our ‘exposure worry’ measure or the telephone discussion will cause you to be upset, the topic of exposure to radiation and the worry relating to this may be upsetting. The members of the Centre for Health Effects of Radiological and Chemical Agents are aware of the sensitivities of this issue. However, the discussion is aimed solely at understanding views about the exposure worry scale.

What if something goes wrong?

If you are unhappy with your experience taking part and would like to make a complaint, you can contact the University Research Ethics Committee via res-ethics@brunel.ac.uk

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. We will ask participants to receive their phone call in an environment where they are given privacy and will not be disturbed.

What will happen to the results of the research study?

As this is only a small stage of our research project, there will be no 'results' which could be published. After all the stages of piloting are complete it might be possible to publish a paper on the development of the scale. If you would like a copy of the published paper you

can receive it by contacting myself or Prof. Mary Gilhooly using the email address listed below.

Who is organising and funding the research?

This research is being funded by the Nuclear Community Charity Fund (NCCF).

Who has reviewed the study?

This study has been reviewed by the College of Health and Life Sciences Research Ethics Committee.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints

chrc@brunel.ac.uk

For complaints and questions about the conduct of the research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee Christina.victor@brunel.ac.uk

Should you seek further support, please contact:

thenccf.org or https://bntva.com or The Armed Forces Charity: https://www.ssafa.org.uk/

Thank you very much for your time.

College of Health and Life Sciences
Department of Life Sciences

Debrief

We would like to take this opportunity to say **Thank You** for taking the time to take part in our study.

Please be assured, all data collected will be treated in the strictest confidence. You are free to withdraw your data from the research at any time by contacting George Collett or Prof. Mary Gilhooly using chrc@brunel.ac.uk

Your thoughts regarding our 'exposure worry' measure will help us gain an understanding of whether or not our proposed scale is appropriate to use in research. The telephone discussion will also help us understand in-depth whether our proposed scale is sensible and worded appropriately. This is called 'piloting' and it is part of the larger project examining exposure worry and the relationship with cognitive functioning in older adults. You were chosen to take part in the study because of your experience of witnessing a nuclear test and your involvement with the BNTVA. If you agreed to take part in the telephone discussion, you will also receive a verbal debrief at the end of the telephone call.

If you were unduly or unexpectedly affected by taking part in the study please feel free to feed it back to the researcher. If you feel unable for whatever reason what-so-ever to talk with the researcher then please either contact Prof. Mary Gilhooly or the research ethics committee res-ethics@brunel.ac.uk

Should you seek further support, please contact:

Nuclear Community Charity Fund thenccf.org

Or British Nuclear Test Veterans Association https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Appendix B.

Chapter 4: Telephone Discussion Notes (Stage II)

Telephone discussion notes: scale piloting

Findings:

1) P1
    a. Concerned that test-veterans should have been warned prior to weapons tests.
    b. Concerned about lack of information.
    c. Concerned that only recently research is being conducted. Why should this be and why did it take so long? What are the intentions of the research institution?
    d. Item about concealing information may influence participant into thinking that the government is actually concealing information.
    e. Wish for disseminated findings to be put into lay-terms.
    f. Scales were formatted well and language was appropriate
2) P2
    a. 'concerned' could be a better term to use than 'worried'. According to this participant, 'worried' is a term used to describe a thought that is constantly on your mind. Concerned is a bit less intrusive?
3) P3
    a. 'worry' is dynamic. It may increase in relation to children or grandchildren.
    b. 'child meta-worry' item was less relevant to this participant
    c. Also worried about exposure to chemical agents such as DDT. Perhaps allow scale to include for chem agent exposure?
    d. Concerned that the GP does not want to take responsibility for treating perceived radiation-related health damage.
    e. 1958 dirty bomb was a particularly worrisome event for this participant. Many test-veterans that this participant knew had been exposed to this particular test was apparently died relatively young.
    f. No particular concerns with the formatting or language of the scale.
4) P4
    a. No particular concerns with the formatting or language of the scale
    b. Believed all items were relevant in assessing exposure-worry
    c. Felt that item 5 (protective clothing) and item 6 (child meta-worry) is less relevant to him, but acknowledged that these items may be relevant to other test-veterans.
    d. First few BNTVA meetings were a particular trigger of his worry i.e. speaking with other test-veterans who had become ill.
5) P5 (not interviewed)
    a. Returned completed mid-life scale
    b. No consent form returned therefore no telephone discussion conducted.
    c. Indicates that mid-life scale instructions were understandable and that it was relatively easy to read.

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

9 July 2018

LETTER OF APPROVAL

Applicant: Mr George Collett

Project Title: Measuring Radiation Exposure Worry: A Pilot Study STAGE 2B (Testing for normality, skewness, and kurtosis)

Reference: 11923-MHR-Jun/2018- 13161-1

Dear Mr George Collett

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- C15 - are participants aware of the potential for future publication?
  D16 - Please use a generic email address rather than personal one

  best practice to use generic response email eg research@ rather than names especially for phd students

  D23 - Mention that data might be used in publications/PhD thesis
- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

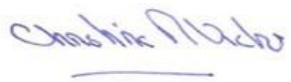
Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor

(where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.

Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.

The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study. You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.



Professor Christina Victor

Chair

College of Health and Life Sciences
Research Ethics Committee (DCS) Brunel
University London

Chapter 4: Consent Form (Stage III)

College of Health and Life Sciences
Department of Life Sciences

Consent Form

MEASURING RADIATION EXPOSURE WORRY: A PILOT STUDY

The participant should tick answers to all the questions below before signing and dating the form

	Yes	No
Have you read the Research Participant Information Sheet?	☐	☐
Do you understand that you will not be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study…		
at any time?	☐	☐
without having to give a reason for withdrawing?	☐	☐
Do you agree to have your 'exposure worry' responses used for analysis?	☐	☐

Participant

Signature

Researcher

Name	Date _ _ / _ _ / _ _
Signature	

This study has been reviewed by the Brunel University London College of Health & Life Sciences Research Ethics Committee.

College of Health and Life Sciences

Department of Clinical Sciences

PARTICIPANT INFORMATION SHEET

Measuring Radiation Exposure Worry: A Pilot Study

You are being invited to take part in a research study. Before you decide, 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. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The overall aim of the project in which this small study is part of is to see what contributes to healthy brain functioning in older adults, that is, your memory, problem solving, and reasoning skills. A special feature of this study is to look at 'radiation exposure worry' and brain functioning. We would like to begin "testing" our proposed measures- two short questionnaires measuring current 'exposure worry' and mid-life 'exposure worry'. Once these questionnaires are developed, they will be a useful tool to examine radiation-worry in the test-veteran community and will also indicate the severity of this worry in the community. This may indicate that extra support must be put in place for test-veterans to help overcome their worry.

Why have I been invited to participate?

You are chosen to take part in the study because of your experience of witnessing a nuclear test or because you were involved in the programme in some other form (e.g. clean-up operation). You have also been contacted by us because of your presence on the Nuclear Community Charity Fund opt-in mailing list.

Do I have to take part?

As taking part is entirely voluntary, it is up to you to decide whether or not to take part. If you wish to take part in our study, you will tick the relevant box on the consent form, and return your consent form and your two completed 'exposure worry' questionnaires using the spare envelope provided. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will find the two 'exposure worry' scales inside the envelope, another envelope with our address and a postage stamp attached. You will be asked to complete the 'exposure worry' questionnaires, circling the numbers corresponding to your response. You will use the envelope with our address and postage stamp to return your completed questionnaires and consent form.

What do I have to do?

There will not be any restrictions or changes to your lifestyle when taking part in the study. Your lifestyle will remain unaffected as a result of taking part. You may, however, become aware of your worry towards radiation exposure as this is what our proposed measure will be addressing.

What are the possible disadvantages and risks of taking part?

While we do not anticipate that filling out our 'exposure worry' measure will cause you to be upset, the topic of exposure to radiation and the worry relating to this may be upsetting. The members of the CHRC are aware of the sensitivities of this issue.

What if something goes wrong?

If you are unhappy with your experience taking part and would like to make a complaint, you can contact the University Research Ethics Committee via res-ethics@brunel.ac.uk

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential.

What will happen to the results of the research study?

As this is only a small stage of our research project, there will be no 'results' which could be published. After all the stages of piloting are complete it might be possible to publish a paper on the development of the scale. If you would like a copy of the published paper you can receive it by contacting myself or Prof. Mary Gilhooly using the email addresses listed at the bottom of this document.

Who is organising and funding the research?

This research is being funded by the Nuclear Community Charity Fund (NCCF).

Who has reviewed the study?

This study has been reviewed by the Brunel University London College of Health and Life Sciences Research Ethics Committee.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints

George Collett (PhD Researcher) –chrc@brunel.ac.uk

Professor Mary Gilhooly (Primary Supervisor) – mary.gilhooly@brunel.ac.uk

For complaints and questions about the conduct of the research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee Christina.victor@brunel.ac.uk

Should you seek further support, please contact:

The Nuclear Community Charity Fund - thenccf.org

The British Nuclear Test Veteran Association - https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Thank you very much for your time.

Appendix C.

Chapter 4: Online version of the proposed Current Exposure Worry Scale and the Mid-Life Exposure Worry Scale (Stage III)

5. Current Exposure Worry

Please don't select more than 1 answer(s) per row.

	Strongly Disagree	- 2 -	- 3 -	Neutral	- 5 -	- 6 -	Strongly Agree
1) Whenever I am ill, I am worried that it may be a result of exposure to ionising radiation and/or exposure to chemical agents.	☐	☐	☐	☐	☐	☐	☐
2) I am worried that my exposure to ionising radiation and/or chemical agents may have affected my children.	☐	☐	☐	☐	☐	☐	☐
3) I am worried that my exposure to ionising radiation and/or chemical agents may have affected my grandchildren.	☐	☐	☐	☐	☐	☐	☐
4) I am worried that scientists are not explaining fully the effects of exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐
5) I am worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites.	☐	☐	☐	☐	☐	☐	☐
6) I am worried that my children are worried about my exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐

6. Mid-life Exposure Worry

Please don't select more than 1 answer(s) per row.

	Strongly Disagree	- 2 -	- 3 -	Neutral	- 5 -	- 6 -	Strongly Agree
1) At a point in my life, I had been worried that my illness had been caused by my exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐
2) At a point in my life, I had been worried that my children may have been affected by my exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐
3) At a point in my life, I had been worried that my grandchildren may have been affected by my exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐
4) At a point in my life, I had been worried that scientists were not fully explaining the effects of ionising radiation exposure and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐
5) At a point in my life, I had been worried that I should have been given protective clothing at the nuclear and/or chemical agent testing sites.	☐	☐	☐	☐	☐	☐	☐
6) At a point in my life, I had been worried that my children were worried about my exposure to ionising radiation and/or chemical agents.	☐	☐	☐	☐	☐	☐	☐

Appendix D.

Chapter 4: Frequencies and percentages of pilot Current Exposure Worry Scale responses (*n* = 120) and pilot Mid-Life Exposure Worry Scale responses (*n* = 124; Stage III).

Frequency of responses for each item on the pilot Current Exposure Worry Scale.

	1	2	3	4	5	6	7
Item 1	6 (5.0%)	1 (0.8%)	4 (3.4%)	28 (23.5%)	22 (18.5%)	20 (16.8%)	38 (31.9%)
Item 2	7 (6.2%)	2 (1.8%)	2 (1.8%)	10 (8.8%)	20 (17.7%)	21 (18.6%)	51 (45.1%)
Item 3	6 (5.5%)	2 (1.8%)	6 (5.5%)	13 (11.9%)	17 (15.6%)	14 (12.8%)	51 (46.8%)
Item 4	1 (0.8%)	3 (2.5%)	0 (0.0%)	14 (11.7%)	14 (11.7%)	19 (15.8%)	69 (57.5%)
Item 5	2 (1.7%)	0 (0.0%)	2 (1.7%)	16 (13.3%)	10 (8.3%)	17 (14.2%)	73 (60.8%)
Item 6	5 (4.3%)	0 (0.0%)	7 (6.1%)	37 (32.2%)	12 (10.4%)	19 (16.5%)	35 (30.4%)

Note. Percentages exclude missing values. Responses 1, 4, and 7 are anchored with 'strongly disagree', 'neutral', and 'strongly agree', respectively.

Frequency of responses for each item on the pilot Mid-Life Exposure Worry Scale.

	1	2	3	4	5	6	7
Item 1	4 (3.3%)	3 (2.5%)	3 (2.5%)	23 (18.9%)	12 (9.8%)	26 (21.3%)	51 (41.8%)
Item 2	5 (4.2%)	1 (0.8%)	3 (2.5%)	17 (14.3%)	18 (15.1%)	21 (17.6%)	54 (45.4%)
Item 3	5 (4.4%)	1 (0.9%)	5 (4.4%)	15 (13.2%)	15 (13.2%)	22 (19.3%)	51 (44.7%)
Item 4	2 (1.6%)	3 (2.4%)	0 (0.0%)	13 (10.6%)	17 (13.8%)	18 (14.6%)	70 (56.9%)
Item 5	2 (1.7%)	1 (0.8%)	1 (0.8%)	15 (12.4%)	10 (8.3%)	19 (15.7%)	73 (60.3%)
Item 6	5 (4.2%)	1 (0.8%)	8 (6.7%)	33 (27.5%)	18 (15.0%)	18 (15.0%)	37 (30.8%)

Note. Percentages exclude missing values. Responses 1, 4, and 7 are anchored with 'strongly disagree', 'neutral', and 'strongly agree', respectively.

Appendix E.

Chapter 4: Spearman's Rho Correlation Matrix for pilot Current Exposure Worry Scale (n = 120) and pilot Mid-Life Exposure Worry Scale (n = 124) data (Stage III).

Inter-Item Correlation Matrix for Current Exposure Worry pilot data.

			Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
Spearman's rho	Item 1	Correlation Coefficient	1.000	-	-	-	-	-
		Sig. (1-tailed)	.	-	-	-	-	-
		N	119	-	-	-	-	-
	Item 2	Correlation Coefficient	.517	1.000	-	-	-	-
		Sig. (1-tailed)	.000	.	-	-	-	-
		N	112	113	-	-	-	-
	Item 3	Correlation Coefficient	.468	.805	1.000	-	-	-
		Sig. (1-tailed)	.000	.000	.	-	-	-
		N	108	107	109	-	-	-
	Item 4	Correlation Coefficient	.477	.497	.509	1.000	-	-
		Sig. (1-tailed)	.000	.000	.000	.	-	-
		N	119	113	109	120	-	-
	Item 5	Correlation Coefficient	.527	.624	.505	.619	1.000	-
		Sig. (1-tailed)	.000	.000	.000	.000	.	-
		N	118	113	108	119	120	-
	Item 6	Correlation Coefficient	.572	.545	.584	.481	.461	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	115	111	107	115	114	115

Inter-Item Correlation Matrix for Mid-Life Exposure Worry pilot data.

			Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
Spearman's rho	Item 1	Correlation Coefficient	1.000	-	-	-	-	-
		Sig. (1-tailed)	.	-	-	-	-	-
		N	122	-	-	-	-	-
	Item 2	Correlation Coefficient	.610	1.000	-	-	-	-
		Sig. (1-tailed)	.000	.	-	-	-	-
		N	119	119	-	-	-	-
	Item 3	Correlation Coefficient	.563	.857	1.000	-	-	-
		Sig. (1-tailed)	.000	.000	.	-	-	-
		N	114	113	114	-	-	-
	Item 4	Correlation Coefficient	.509	.377	.348	1.000	-	-
		Sig. (1-tailed)	.000	.000	.000	.	-	-
		N	122	119	114	123	-	-
	Item 5	Correlation Coefficient	.500	.475	.469	.724	1.000	-
		Sig. (1-tailed)	.000	.000	.000	.000	.	-
		N	120	118	112	121	121	-
	Item 6	Correlation Coefficient	.565	.637	.710	.401	.449	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	120	118	113	120	118	120

Appendix F.

Chapter 5: Ethics Approval.

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

7 February 2019

LETTER OF APPROVAL

Applicant: Mr George Collett

Project Title: Exposure Worry, Ageing, and Cognitive Functioning: Telephone Cognitive Testing

Reference: 12528-A-Jan/2019- 17350-1

Dear Mr George Collett

The Research Ethics Committee has considered the above amendment application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the studyYou may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Christina Victor

Chair

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London

Chapter 5: Consent Form

College of Health and Life Sciences
Department of Life Sciences

Exposure Worry, Ageing, and Cognitive Functioning: Telephone Cognitive Testing

Consent Form

The participant should tick answers to all the questions below before signing and dating the form

	Yes	No
Have you read the Research Participant Information Sheet?	☐	☐
Do you understand that you will <u>not</u> be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study…		
at any time?	☐	☐
without having to give a reason for withdrawing?	☐	☐
Do you agree to have your responses used for analysis?	☐	☐

Participant

First Name

Signature Date _ _ / _ _ / _ _ _ _

Telephone number:

When is an appropriate time and day to hold the telephone cognitive test:

Researcher (to be completed by the researcher)

Name

Signature Date _ _ / _ _ / _ _ _ _

This study has been reviewed by the Brunel University London College of Health & Life Sciences Research Ethics Committee.

College of Health and Life Sciences

Department of Clinical Sciences

PARTICIPANT INFORMATION SHEET

Exposure Worry and Cognitive Functioning

You are being invited to take part in a research study. Before you decide, 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. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The overall aim of the project in which this small study is part of is to see what contributes to healthy brain functioning in older adults, that is, your memory, problem solving, and reasoning skills. A special feature of this study is to look at 'radiation exposure worry' and brain functioning.

Why have I been invited to participate?

You have been invited to take part because you are a British nuclear test veteran having witnessed at least one nuclear test, or because you were involved in the clean-up operation. You may have been contacted by the Centre for Health Effects of Radiological and Chemical Agents (CHRC) through the Nuclear Community Charity Fund opt-in mailing list. You may have also contacted CHRC at Brunel University to show your interest in taking part in our study.

Do I have to take part?

As taking part is entirely voluntary, it is up to you to decide whether or not to take part. If you wish to take part in our study, you will tick the relevant box on the consent form, and return your consent form, your two completed 'exposure worry' questionnaires, anxiety questionnaire, and sociodemographic questionnaire using the spare envelope provided. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will find the two 'exposure worry' scales inside the envelope, another envelope with our address and a postage stamp attached. You will also find another anxiety questionnaire, and a general questionnaire asking about your age, postcode, lifestyle, and your involvement in the

testing programme. Information about your postcode is used to see if certain areas of Britain are associated with brain functioning.

You will be asked to complete the questionnaires, circling the numbers corresponding to your response. You will use the envelope with our address and postage stamp to return your completed questionnaires and consent form.

You will need to state on the consent form when you would be able to have a 20-minute phone call. During this phone call a short test of brain functioning will be given.

What do I have to do?

There will not be any restrictions or changes to your lifestyle when taking part in the study. Your lifestyle will remain unaffected as a result of taking part. You may, however, become aware of your worry towards radiation exposure as this is what our proposed measure will be addressing. If you agree to take part you will take part in a short test of brain functioning which will be conducted over the telephone.

What are the possible disadvantages and risks of taking part?

While we do not anticipate that filling out our 'exposure worry' measure will cause you to be upset, the topic of exposure to radiation and the worry relating to this may be upsetting. The members of the CHRC are aware of the sensitivities of this issue. However, the discussion is aimed solely at understanding views about the exposure worry scale.

You may also find the brain functioning test upsetting if you become aware of any difficulties that you have with your memory or other functioning. You must know that the test is not used for providing a diagnosis, but it is used to see the test score is related to your worry scores.

What if something goes wrong?

If you are unhappy with your experience taking part and would like to make a complaint, you can contact the University Research Ethics Committee via res-ethics@brunel.ac.uk

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential.

What will happen to the results of the research study?

It might be possible to publish a paper on the results at the end of the study. If you would like a copy of the published paper you can receive it by contacting myself or Prof. Mary Gilhooly using the email addresses listed at the bottom of this document. It may also be possible to present these findings at research conferences.

Who is organising and funding the research?

This research is being funded by the Nuclear Community Charity Fund (NCCF).

Who has reviewed the study?

This study has been reviewed by the Brunel University London College of Health and Life Sciences Research Ethics Committee.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints

George Collett (PhD Researcher) –chrc@brunel.ac.uk

Professor Mary Gilhooly (Primary Supervisor) – mary.gilhooly@brunel.ac.uk

For complaints and questions about the conduct of the research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee
Christina.victor@brunel.ac.uk

Should you seek further support, please contact:

The Nuclear Community Charity Fund - thenccf.org

The British Nuclear Test Veteran Association - https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Thank you very much for your time.

Chapter 5: Debrief Form

College of Health and Life Sciences

Department of Life Sciences

Debrief

We would like to take this opportunity to say **Thank You** for taking the time to take part in our study.

Please be assured, all data collected will be treated in the strictest confidence. You are free to withdraw your data from the research at any time by contacting George Collett chrc@brunel.ac.uk or Prof. Mary Gilhooly mary.gilhooly@brunel.ac.uk

Your responses on our 'exposure worry', general anxiety, and sociodemographic questionnaires, as well as your participation in the telephone cognitive test will help us understand the relationship between persistent 'exposure worry' and cognitive functioning (i.e. memory and other brain processes).

You were chosen to take part in the study because of your experience of witnessing a nuclear test and/or involvement in the clean-up operations. You had come forward offering to take part as a result of witnessing our advertisements, or you were contacted by us as a result of being on the NCCF opt-in mailing list.

If you were unduly or unexpectedly affected by taking part in the study please feel free to feed it back to the researcher. If you feel unable for whatever reason what-so-ever to talk with the researcher then please either contact Prof. Mary Gilhooly or the research ethics committee res-ethics@brunel.ac.uk

Should you seek support, please contact:

Nuclear Community Charity Fund thenccf.org

British Nuclear Test Veterans Association https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Appendix G.

Chapter 5: Research Pack Materials for Data Collection

Socio-demographic Information and Assessing Exposure Questionnaire

This questionnaire aims to gather information regarding social characteristics and information regarding the nuclear weapons testing (or clean-up operations). The reason for gathering information on social characteristics is because factors such as your age, occupation, education, and the area that you live in are known to be associated with brain functioning (i.e. memory skills, thinking skills etc.). The information you provide is completely voluntary and anonymous.

Basic Information

1. What is your date of birth? _____
2. How old were you when you finished full-time education? _____
    a. What was your highest qualification? _____
3. What was your lifetime principal occupation? _____
4. What is your postcode? _____

Lifestyle Factors

5. At the time of the testing programme:
    a. Did you smoke? Yes ☐ No ☐
        i. If yes how many cigarettes did you smoke per day? _____
        ii. How many do you smoke per day now? (if any) _____
        iii. If you did smoke but do not smoke anymore, at what age did you stop smoking? _____
    b. Did you consume alcohol? Yes ☐ No ☐
        i. If yes how many units per week? _____
        ii. How many units do you consume per day now? (if any) _____

3 units = a pint of beer or a large glass of wine 1 unit = a single measure of whisky, gin, rum or other spirit

Assessing Exposure

We are interested in the details of your involvement in the nuclear testing programme because it could be that different types of involvement or the number of tests witnessed are associated with different levels of exposure worry.

1. What was your role in the nuclear testing programme?

_____

   a. Was this part of national service? Yes ☐ No ☐

   b. Where were you stationed?

      _____

   c. How many tests (if any) did you witness? (please specify a number)

      _____

   d. What were the names of the tests that you witnessed (if any)?

      _____

2. Were you exposed to chemical agents? Yes ☐ No ☐ Unsure ☐

   a. If yes, which chemical agents were you exposed to?

      _____

Finally, we are interested in how test-veterans perceive their illnesses.

1. Do you have any physical illnesses? (please tick) Yes ☐ No ☐

    a. If yes, please specify:

    _____

    b. If yes, please indicate how much you agree or disagree with the following statement (please check a box below):

"My exposure to ionising radiation and/or chemical agents caused my illness."

Strongly disagree	**Disagree**	**Agree**	**Strongly agree**

Thank you for taking the time to complete this questionnaire. We value the information you have provided, and your responses will contribute to our understanding of healthy cognitive ageing and exposure worry.

We will also be conducting in-depth interviews with test-veterans about exposure worry.

Would you be interested in being selected to take part? Yes ☐ No ☐

Please provide an email or postal address to receive information regarding the above-mentioned interviews or in-depth cognitive assessments, should you wish to be selected.

Appendix H.

Table showing maximum scores across the six items on the Current Exposure Worry Scale (*n* = 91) and the Mid-Life Exposure Worry Scale (*n* = 90).

Maximum scores across items on the Current Exposure Worry Scale and Mid-Life Exposure Worry Scale (excluding stress item).

	1	2	3	4	5	6	7	8
Maximum Current Worry (*n* = 91)	2 (2.2%)	3 (3.3%)	0 (0.0%)	3 (3.3%)	6 (6.6%)	5 (5.5%)	11 (12.1%)	61 (67.0%)
Maximum Mid-Life Worry (*n* = 90)	2 (2.2%)	2 (2.2%)	0 (0.0%)	3 (3.3%)	5 (5.6%)	7 (7.8%)	11 (12.2%)	60 (66.7%)

Appendix I.

Table showing Spearman's rho correlation coefficients between the Current Exposure Worry items and the Mid-Life Exposure Worry items.

Spearman's rho bivariate correlation coefficients.

	M1	M2	M3	M4	M5	M6	MStress
C1	.56***	-	-	-	-	-	-
C2	-	.74***	-	-	-	-	-
C3	-	-	.81***	-	-	-	-
C4	-	-	-	.82***	-	-	-
C5	-	-	-	-	.86***	-	-
C6	-	-	-	-	-	.89***	-
CStress	-	-	-	-	-	-	.86***

Note. *** Correlation is significant at the .001 level (1-tailed). Missing data handled using pairwise deletion.

Appendix J.

Table showing response types to the exposure worry duration item (item 8) included with the Mid-Life Exposure Worry Scale (n = 65) aiming to understand the duration of exposure worry throughout life.

Response types for exploratory item (item 8) on Mid-Life Exposure Worry Scale (n = 65).

	N	%
Answer type		
Qualitative	27	41.5
Quantitative	38	58.5
Occurrence		
Sporadic	12	18.5
Other	53	81.5

Note. % excludes missing data. 'Other' includes any answer not interpreted as 'sporadic'.

Appendix K.

Chapter 6: Ethics Approval

College of Health and Life Sciences Research Ethics Committee (DCS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.u

k 13 June 2019

LETTER OF APPROVAL

Applicant: Mr George Collett

Project Title: Exposure Worry, Ageing, and Cognitive Functioning: Exploring Exposure Worry

Reference: 12920-MHR-May/2019- 19132-2

Dear Mr George Collett

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor
  (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant
- Research Ethics Committee.
  Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear
- above, in addition to any subsequent changes to the protocol.

The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the studyYou may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Christina Victor

Chair of the College of Health and Life Sciences Research Ethics Committee (DCS)

Brunel University London

College of Health and Life Sciences
Department of Life Sciences

A Qualitative Study Exploring Exposure Worry

Consent Form

The participant should tick answers to all the questions below before signing and dating the form

Participant

First Name	
Signature	Date _ _ / _ _ / _ _ _ _
Telephone number/email address (this is to arrange a time and date for the interview):	

For completion on date of interview	Yes	No
Have you read the Research Participant Information Sheet?	☐	☐
Do you understand that you will <u>not</u> be referred to by name in any report concerning the study?	☐	☐
Do you understand that you are free to withdraw from the study…		
at any time?	☐	☐
without having to give a reason for withdrawing?	☐	☐
Do you agree to have your interview audio-recorded and used for analysis?	☐	☐

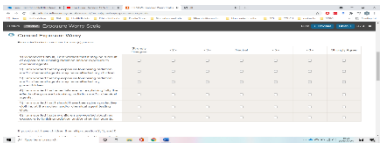
Researcher (to be completed by the researcher)

Name	
Signature	Date _ _ / _ _ / _ _ _ _

This study has been reviewed by the Brunel University London College of Health & Life Sciences Research Ethics Committee.

College of Health and Life Sciences

Department of Clinical Sciences



PARTICIPANT INFORMATION SHEET

In-depth exploration of exposure-worry

You are being invited to take part in a research study. Before you decide, 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. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The overall aim of the project is to examine worry about exposure to ionising radiation in British nuclear test veterans. You will recall that we have previously been examining the possible link between exposure worry and brain functioning. Now we will be exploring the nature and development of exposure worry over the lifetime of a test-veteran.

Why have I been invited to participate?

You have been invited to take part because you are a British nuclear test veteran having witnessed at least one nuclear test, or because you were involved in the clean-up operation. You had previously participated in the previous telephone cognitive functioning study and declared interest in participating in this in-depth interview study.

Do I have to take part?

As taking part is entirely voluntary, it is up to you to decide whether or not to take part. If you wish to take part in our study, you will tick the relevant box on the consent form, and return your consent form using the spare envelope provided. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will find the consent form with this information sheet, a spare envelope with our address, and a postage stamp attached. You will be required to sign the consent form and return it to us using the spare envelope. You will need to state on the consent form your telephone number or your email address so that we can arrange a time and date to hold a face-to-face interview.

What do I have to do?

There will not be any restrictions or changes to your lifestyle when taking part in the study. Your lifestyle will remain unaffected as a result of taking part. If you agree to take part you will take part in an interview at a neutral location or at your home. Throughout the interview I will sit with you and draw a timeline which will aid the discussion and may help with recollection of certain events. You can place photographs relating to your worry along the timeline if you believe that it will help. The interviews will last about an hour and will be audio-recorded.

What are the possible disadvantages and risks of taking part?

While we do not anticipate that the interviews will cause you to be upset, the topic of exposure to radiation and the worry relating to this may be upsetting. The members of the CHRC are aware of the sensitivities of this issue. If you find the interview upsetting then the interview will be paused and you will be asked if you wish to stop or carry on.

What if something goes wrong?

If you are unhappy with your experience taking part and would like to make a complaint, you can contact the University Research Ethics Committee via res-ethics@brunel.ac.uk

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential.

What will happen to the results of the research study?

It might be possible to publish a paper on the results at the end of the study. If you would like a copy of the published paper you can receive it by contacting myself or Dr. Wendy Martin using the email addresses listed at the bottom of this document. It may also be possible to present these findings at research conferences.

Who is organising and funding the research?

This research is being funded by the Nuclear Community Charity Fund (NCCF).

Who has reviewed the study?

This study has been reviewed by the Brunel University London College of Health and Life Sciences Research Ethics Committee.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints

George Collett (PhD Researcher) – chrc@brunel.ac.uk

Dr Wendy Martin (Primary Supervisor) – wendy.martin@brunel.ac.uk

For complaints and questions about the conduct of the research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee Christina.victor@brunel.ac.uk

Should you seek further support, please contact:

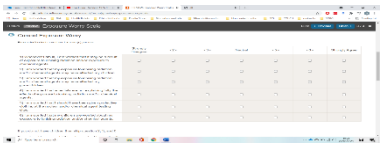
The Nuclear Community Charity Fund - thenccf.org

The British Nuclear Test Veteran Association - https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Thank you very much for your time.

College of Health and Life Sciences
Department of Life Sciences



Debrief

We would like to take this opportunity to say **Thank You** for taking the time to take part in our study.

Please be assured, all data collected will be treated in the strictest confidence. You are free to withdraw your data from the research at any time by contacting George Collett (chrc@brunel.ac.uk) or Dr. Wendy Martin (wendy.martin@brunel.ac.uk).

Your participation in the face-to-face interview will help us understand the in-depth nature of exposure worry and the course of exposure worry over a lifetime since your involvement in the nuclear testing programme. We believe that exposure worry is not constant throughout life, and these interviews will help us understand how specific events and experiences may impact your exposure worry.

You were chosen to take part in the study because of your experience of witnessing a nuclear test or because of your involvement in the clean-up operations. You had come forward offering to take part after declaring your interest following participation in the previous study (telephone cognitive testing).

If you were unduly or unexpectedly affected by taking part in the study please feel free to feed it back to the researcher. If you feel unable for whatever reason what-so-ever to talk with the researcher then please either contact the research ethics committee res-ethics@brunel.ac.uk

Please note that you are able to withdraw your interview recording from analysis without any adverse effect. If you wish to do this then please contact us using the email addresses above.

Should you seek support, please contact:

Nuclear Community Charity Fund thenccf.org

British Nuclear Test Veterans Association https://bntva.com

SSAFA; The Armed Forces Charity: https://www.ssafa.org.uk/

Appendix L.

Chapter 6: Qualitative Interview Schedule

Interview schedule

"Thank you very much for agreeing to participate in this interview. The purpose of the interview is to explore the perceived impact of witnessing nuclear tests. Shall we begin with you telling me about yourself?"

Identity

- What does it mean to be a nuclear test-veteran? **(STANDARDIZED)**
    - What feelings does this bring?
    - How so?
    - Is there some psychological impact of this?

Uncertainty

- Can you describe your thoughts when you think back to the testing programme? **(STANDARDIZED)**
- Has something else contributed to this feeling?
    - Trust in authorities? Why/why not?
    - Experience with test-veteran groups? Why/why not
    - Any media reports? Why was that?

Risk perception

- Do you think that there were any risks to witnessing a test? **(STANDARDIZED)**
    - If yes, how do these risks make you feel?

Health attribution

- Do you have any health conditions? What do you think caused these?

Biographical disruption

- Were there any significant life events which followed on from the tests? **(STANDARDISED)**
    - How did it feel? What was the impact of this?

Cognitive function

- Do you ever think about your memory? **(STANDARDIZED)**
    - Why/why not?

Appendix M.

Chapter 6: Reflexive diary notes

DIARY FOR QUALITATIVE PHASE

- For some, testing programme was just a 'chapter' in their life. E.g. in terms of identity they are as much identifying as a veteran as they are as a postman, for example. It could be that poor health in themselves or descendents is a driving factor for why some feel strongly re their test-veteran identity. Is their poor health a result of their efforts in preventing another world war (i.e. development of nuclear weapons as deterrant for war) which they fail to be recognised for? This is similar to observations by Vyner (1983) for identity conflicts. E.g. work to helping the nation yet not receiving recognition for it.
- Guinea pig seems to be related to feelings of frustration, shame (e.g. being used as a pawn), being lied to,
- Health conditions being attributed to nuclear testing tend to be unusual conditions which may not be age related. E.g. stroke may not be attributed because many people get stroke. However an illness at the age of 40 may be treated with suspicion because it is unusual. Similarly genetic diseases in descendants are also more likely to be attributed. They are unusual. The veteran may ask "why my children/grandchildren and not someone else's?" and then look for what makes themselves unique which is witnessing nuclear tests and perceived exposure to ionising radiation. Process of eliminating other possible causes, e.g. no history was such illness in family tree makes them to believe that the damage began with the veteran.
- For worry re childrens health, most concerns appeared to arise during and after 1980s when newspapers began reporting nuclear tests and formation of BNTVA. Before this

- people were generally unaware of dangers of radiation and had no reason to worry. Particularly if they had a child who grew healthy before this period.
- Maralinga veterans perhaps more worried and frustrated? Higher levels of ill health (anecdotal) perhaps because of environment e.g. lots of dust, types of bomb tests
- Generally no worry or risks perceived to radiation at time of testing nor shortly after. Participants were mostly in late teens at time of testing, topic of naivety was discussed. Combination of being naïve, military culture (e.g. if you're asked to do a task then you do it without questioning authority), little information was given regarding tests. Only previous event relating to nuclear weapons and radiation was Japanese A-bombs.
- 15/11/2019- participant 10 attributed own illnesses (osteoporosis and cancer) and granddaughters encephalopathy to Christmas island tests. You would presume that worry or generally stress is the normal reaction to this. Said that he did think about it every now and then but that's just the extent of it. Not worried. Maybe it is just his personality?
- 18/11/2019 – newspaper cuttings collection? If some participants are keeping newspaper cuttings from 80s etc, what does this signify? Why were they keeping the cuttings? Is this normal?
- 18/11/2019 – why don't many veterans attribute health conditions to DDT? Where it is clear they were sprayed? Yet it is chosen to attribute to radiation? (interview 4)
- 18/11/2019 – misinterpretation of Geiger counter? Depends on sensitivity set by Geiger counter i.e. just because it is clicking a lot does not mean there is a large dose?

Reflecting on methods

- Asking why someone is <u>not</u> worried is difficult to elicit answers. For example, although asking why someone is not happy may equate to asking why someone is feeling unhappy. However is asking why someone is <u>not</u> worried similar to asking why someone feels neutral/indifferent? Or is a better way of wording it: "do you feel calm?"
- Similarly asking why someone feels a certain way felt difficult especially when the participant was noticeably distressed. E.g. it could be obvious why a certain topic makes them feel angry, therefore feels daft to ask "why does this make you angry". Consider other ways of framing it e.g. "can you explain a bit more about why this makes you feel angry?".
- Not all participants used photographs (in fact only 1 so far, as of 9 total), although did not relate specifically to worry they may be useful for recollection and bring up other topics. E.g. photo of aborigines reminded participant about frustration and sadness for aborigines relocated from homes due to weapons testing (did not understand what was going on).

Some participants had family members present which may or may not be useful (?). During one interview, moment when wife and granddaughter left the room and participant told me that he was "ashamed". Was it a coincidence that he decided to talk about shame when family members were out of the room? Wife and granddaughter did indicate that the veteran didn't usually like to talk about his role in the testing. "bottling up" concerns may make worry/shame worse (also suggested by wife). Discussion

- between veteran and family members mid-interview may prompt interesting discussion and add a level of informality to the interview.
- In participants where they were clearly not worried (considered themselves as a control sample), the interview did not have a logical flow. Questions were difficult to ask and follow on maybe because there wasn't much information to lead on to? Need to work on following all answers logically rather than forcing questions into the flow.

- 03/12/2019- interview with OMITTED failed to record. Recorder was on the wrong setting and did not record through microphone. Extremely frustrating, and I am considering re-interviewing him after the new year. This felt like a good idea but it would mean that the interview would technically not be standardised as the rest of them. I am also of the view that a lot of information is produced in the time and space of an interview, whether or not it is accurate to how to participant actually feels. Could I then be building on inaccurate information? I don't think qualitative research should be done this way where I am reinterviewing participants. It could also mean that what is discussed in the interview will be built on by a prior experience of an interview (this would make him unique to the other participants). I will use this one as a 'pilot' in a sense and try to recall his feelings about exposure worry. Although I cannot use code or theme this interview, it will serve as anecdotal evidence and I will see if it is in concordance with the other interviews.

- 03/12/2019 – discussion from OMITTED interview

    - OMITTED was of ill-health and had a long list of conditions and endless medication. Key current illnesses were two cancers and arthritis. Also had a
    - He was in the Navy and witnessed two tests at the Monte Bello Islands in 1956. Although never came ashore on Monte Bello, the ship that he was on (HMS Diana) stayed near the islands. Both bombs were detonated from a tower. The tests were called G1 and G2 and were part of Operation Mosaic.
    - Responding to questions asking to state an emotion was difficult. Is this again due to generational 'keep calm carry on' mentality. Perhaps worse for men and veterans?
    - Feelings of fear at initial blast and sailing through the cloud. "Oh god what have we let ourselves and other
    - "Whats round the corner?" – relating to what health issues may arise
    - Fear and worry came following Australias refusal to take the navy seamen ashore because they were "contaminated". This led to worry about being contaminated.
    - In the first 10-15 years following the tests there wasn't really much talk about the programme. Involvement in the battle of the Suez was just as significant as witnessing the tests. Witnessing the tests was always "in the back of my mind", indicating some level of concern. Difficult to understand the extent of this?

- Following interview wife asked if he found it helpful to talk about the testing programme. Perhaps indicating that it is something significant that had been on his mind.
- Reading articles in BNTVA magazine was significant to him. In response to the emotion question regarding this, he said he felt sadness for the descendents. Wife agreed that for the descendents was the key issue. Perhaps less important for older adults because they may have lived majority of their lives without ill health? OMITTED also stated that, although it was a harsh thing to say, he is glad that they never had children (indicating some worry for passing on disease to descendents)
- Testing was justified? "keeping up with the jones'" i.e. if everyone else is developing weapons then so do we. And they have to test them with someone and it was unfortunately him. However, he would not change his past.
- Health attribution- He is pretty certain that his illnesses had something to do with Montebello island. On the other hand, there is an element of uncertainty due to being of old age and having been a smoker. Can never be sure what the cause is. When asking his wife how she feels in relation to old age and illnesses, she also searches for answers in relation to her health but generally concludes that majority are age related.
- Very, very difficult to gain a good understanding of the reality of the psychological impact in this interview. OMITTED was not very forward with talking about emotions. Whether answers were intentional to avoid topic or whether it was simply the way the questions was interpreted is something I am curious about. Perhaps questions relating to emotions and mental health are interpreted in certain ways for older adults?

Is anxiety about one's health following exposure to radiation only occurring if there is media exposure or actual knowledge that the exposure **could** be harmful? For example, generally veterans reporting no concern or thoughts until the 1980s. 1980s because this is when media reports and BNTVA formed.

Understand the issue of naming feelings. What would I do in the future? More creative visual methods? Although some participants presented photographs, medical documents, and other documents relating to their testing programme, for some this still was not enough to draw out emotion/affect. It did however encourage further depth to the discussions. I think this is where the telephone interview lacks, on the other hand, depending on the interviewee the telephone interview does have to benefit of keeping a 'safety' barrier for the interviewee and may be more likely to give their emotions. Difficulty here is you can't read body language.

Also acknowledge time and space; i.e. what about my role as a male interviewer?; the role of wives present in interviews also shed light on difficulties of acquiring details of affect in older male veterans.

I plan to listen back to the transcripts and review the codes that I have written and amend accordingly, with a particular focus on those pertaining to affect/emotion

My steps to analysis:

Transcribe and jot down possible theme ideas

Coding

Listen back to recordings to pick up emotional detail

Amend codes accordingly

Themes

Revise themes.

Initial thoughts on themes after coding (continuous process)

- Role of social interaction (via interpersonal and via BNTVA/media) on risk perception and perceived exposure
    - Prior to 80s media surge, no awareness/knowledge meant no worry unless serious unusual illness in themselves or descendents.
    - Significant role of media and BNTVA on our perceptions of harm caused by radiation. Ignorance is bliss idiom.

- Distance from bomb = less perceived risk at time of test? However awareness of contamination and environment becomes contaminated etc. uncertainty as to where radiation actually is.

- General experience was particularly enjoyable for some, however negative consequences overrides this.

- How do we attribute conditions?
    - Comparative process and role in health condition attribution. Why me?
    - Examining hereditary conditions, is it in my genes? If not then could be radiation?
    - Which conditions are unusual?
    - At what age do we realise condition? (old age = more normal and therefore unlikely to be perceived to radiation)
    - Hence why declining memory in this population tended to be attributed to old age and is not uncommon for non-NTVs to have declining memory.
    - Conditions perceived as incurable
    - Medical uncertainty/lack of explanation for conditions draws concern to radiation
    - Persistent conditions are rad. related

- Guilt and perceived responsibility for family health consequences (relating to health attribution) following narrowing down to veteran as cause of problems.

- Feeling sorry for other veterans. Moral obligation to support others through research participation and BNTVA membership/magazine subscription

- Distrust in medical staff, distrust in government, distrust in scientists (particularly those at time of testing)

    - wanting 'truthful' answers
    - notion of admittance similar to government

- Us vs. them power dynamic
    - Guinea pig, perception of being experimented on
    - Age at time of testing; naivety; enjoyable experience masked consequences?
    - Some appreciation for fact that scientists had little understanding as well
    - Politicians ones really held accountable
    - Battle of getting government to admit consequences

- key emotions: anger (is this masculinity??), frustration, guilt, sadness, worry
    - What leads to these?

- lack of choice in armed forces;
- Luck in old age particular when thinking about mortality rates or illnesses. Locus of control after radiation exposure?

- Timing of certain events and anxiety. E.g. having children before awareness of media reports then no reason for concern, whereas considering having children/grandchildren after media reports then would have different impact.

    - also perception that effects may dilute along generation line?
    - After certain amount of time you perceive yourself to be 'in the clear', that is any serious consequences would've occurred long ago. If you reach certain age then you stop worrying re: your own health.
    - Perhaps the concerns regarding children and grandchildrens health are normal of general individual, and not something specific to nuclear test veterans? Or maybe it's heightened in NTVs?
    - BNTVA magazine and articles may fuel the anxiety or distrust from government. How accurate are the articles? Is there an element of chinese whispers going on? After all a significant number of BNTVA members are descendents who weren't actually present at the tests.
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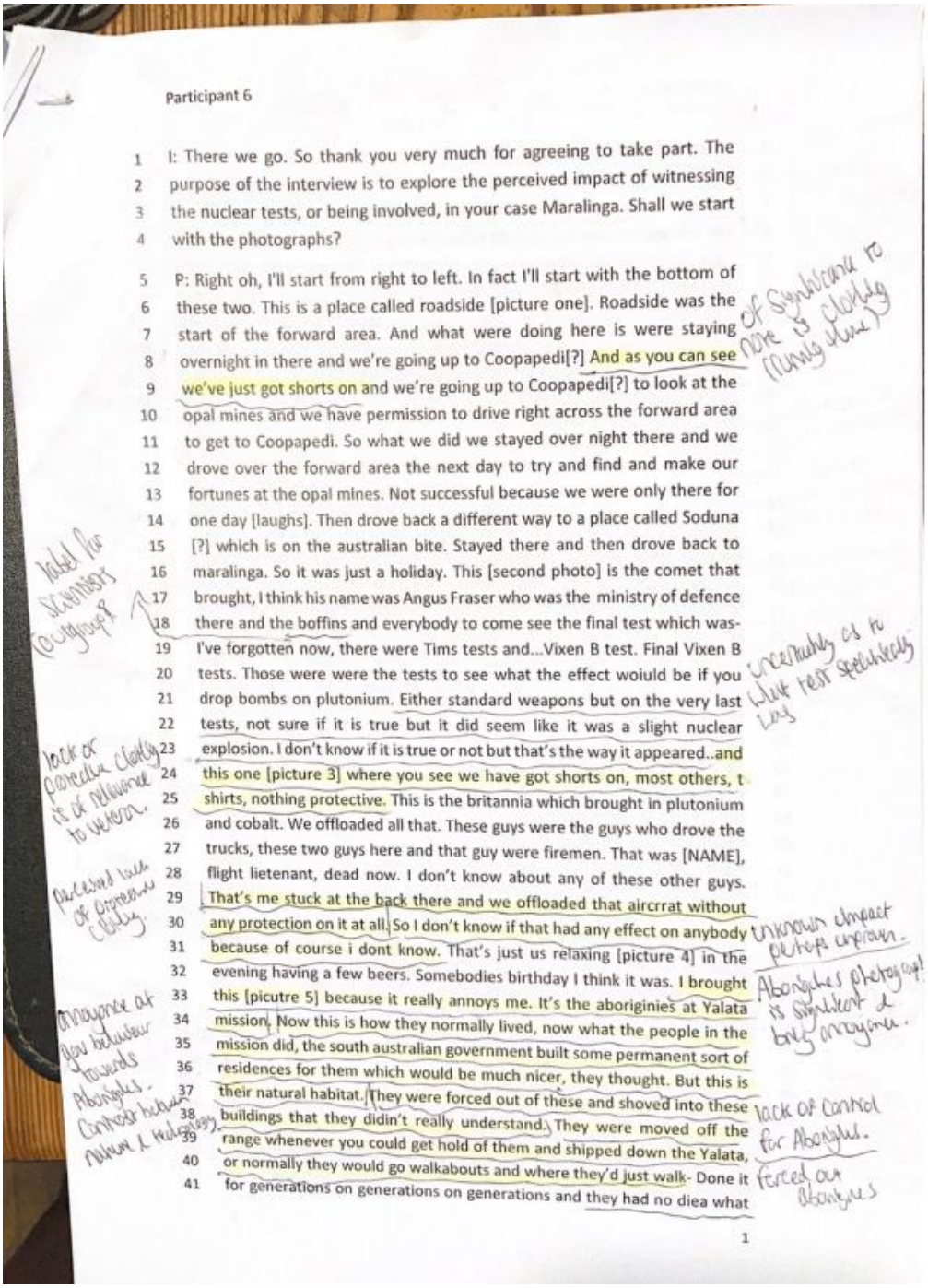
Appendix N.

Chapter 6: Interview transcript



Participant 6

I: There we go. So thank you very much for agreeing to take part. The purpose of the interview is to explore the perceived impact of witnessing the nuclear tests, or being involved, in your case Maralinga. Shall we start with the photographs?

P: Right oh, I'll start from right to left. In fact I'll start with the bottom of these two. This is a place called roadside [picture one]. Roadside was the start of the forward area. And what were doing here is were staying overnight in there and we're going up to Coopapedi[?] And as you can see we've just got shorts on and we're going up to Coopapedi[?] to look at the opal mines and we have permission to drive right across the forward area to get to Coopapedi. So what we did we stayed over night there and we drove over the forward area the next day to try and find and make our fortunes at the opal mines. Not successful because we were only there for one day [laughs]. Then drove back a different way to a place called Soduna [?] which is on the australian bite. Stayed there and then drove back to maralinga. So it was just a holiday. This [second photo] is the comet that brought, I think his name was Angus Fraser who was the ministry of defence there and the boffins and everybody to come see the final test which was- I've forgotten now, there were Tims tests and...Vixen B test. Final Vixen B tests. Those were were the tests to see what the effect woiuld be if you drop bombs on plutonium. Either standard weapons but on the very last tests, not sure if it is true but it did seem like it was a slight nuclear explosion. I don't know if it is true or not but that's the way it appeared..and this one [picture 3] where you see we have got shorts on, most others, t shirts, nothing protective. This is the britannia which brought in plutonium and cobalt. We offloaded all that. These guys were the guys who drove the trucks, these two guys here and that guy were firemen. That was [NAME], flight lietenant, dead now. I don't know about any of these other guys. That's me stuck at the back there and we offloaded that aircrrat without any protection on it at all. So I don't know if that had any effect on anybody because of course i dont know. That's just us relaxing [picture 4] in the evening having a few beers. Somebodies birthday I think it was. I brought this [picutre 5] because it really annoys me. It's the aboriginies at Yalata mission. Now this is how they normally lived, now what the people in the mission did, the south australian government built some permanent sort of residences for them which would be much nicer, they thought. But this is their natural habitat. They were forced out of these and shoved into these buildings that they didin't really understand. They were moved off the range whenever you could get hold of them and shipped down the Yalata, or normally they would go walkabouts and where they'd just walk- Done it for generations on generations on generations and they had no diea what

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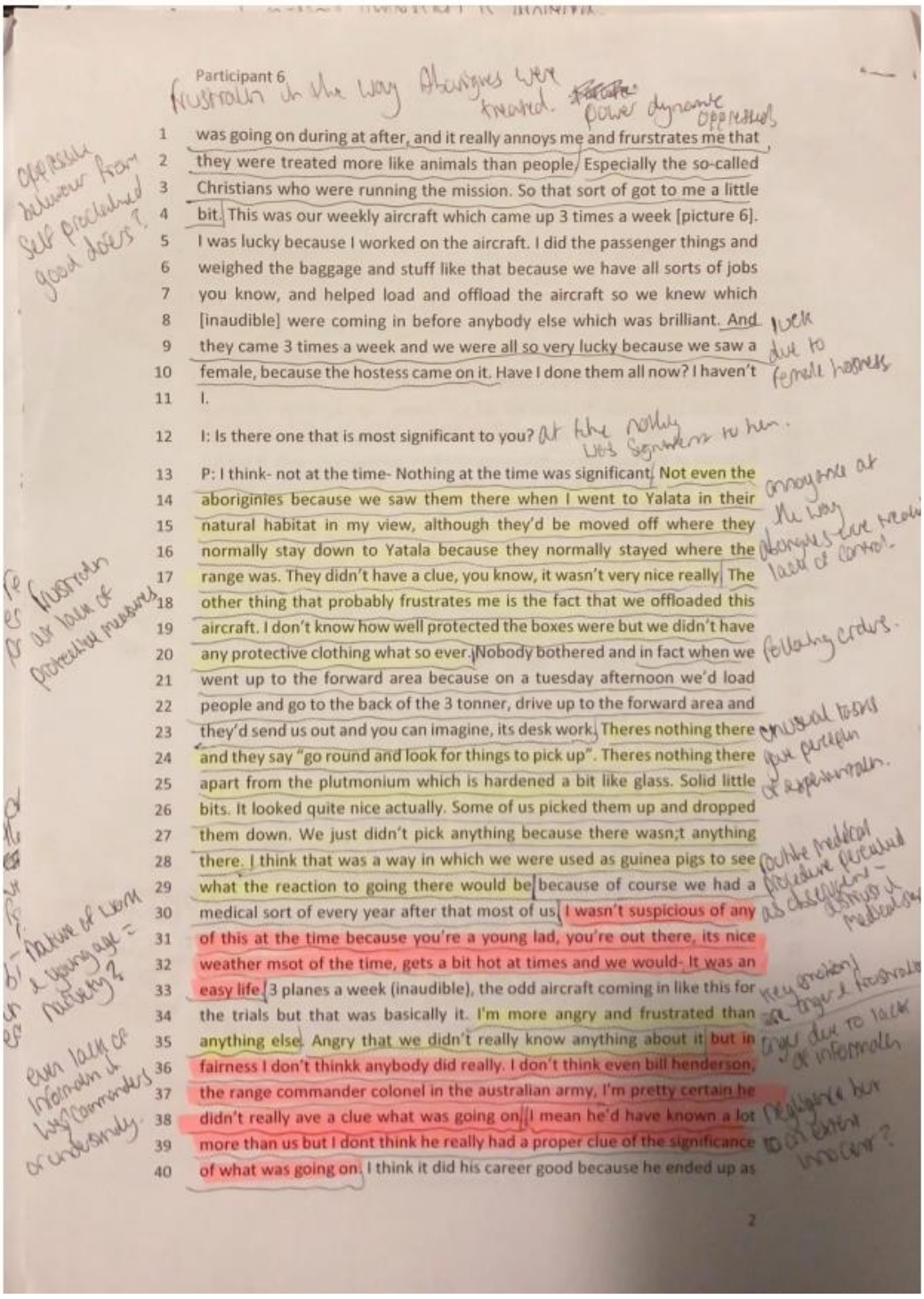
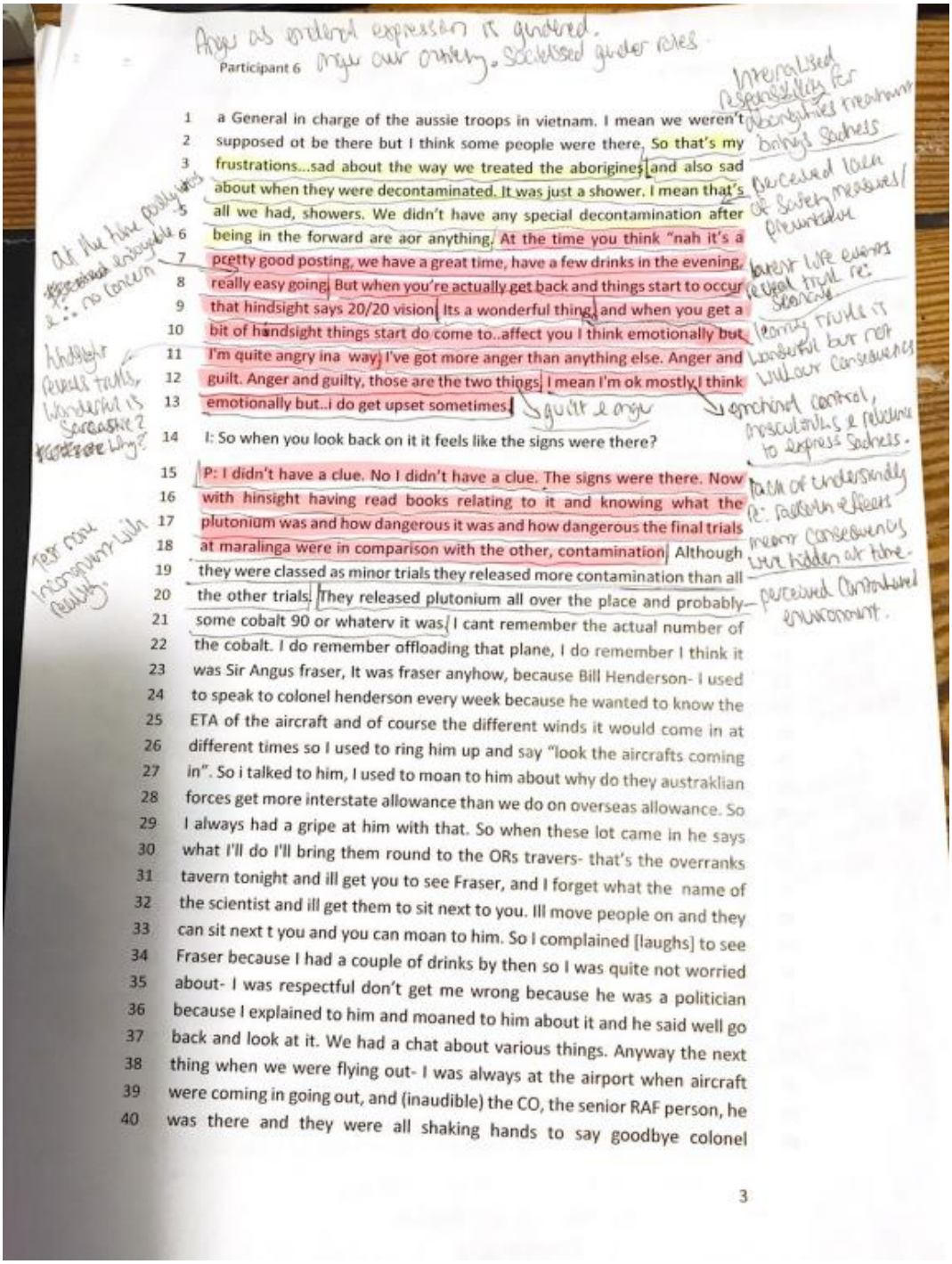


Participant 6

P: I think- not at the time- Nothing at the time was significant. Not even the aboriginies because we saw them there when I went to Yalata in their natural habitat in my view, although they'd be moved off where they normally stay down to Yatala because they normally stayed where the range was. They didn't have a clue, you know, it wasn't very nice really. The other thing that probably frustrates me is the fact that we offloaded this aircraft. I don't know how well protected the boxes were but we didn't have any protective clothing what so ever. Nobody bothered and in fact when we went up to the forward area because on a tuesday afternoon we'd load people and go to the back of the 3 tonner, drive up to the forward area and they'd send us out and you can imagine, its desk work. Theres nothing there and they say "go round and look for things to pick up". Theres nothing there apart from the plutmonium which is hardened a bit like glass. Solid little bits. It looked quite nice actually. Some of us picked them up and dropped them down. We just didn't pick anything because there wasn;t anything there. I think that was a way in which we were used as guinea pigs to see what the reaction to going there would be because of course we had a medical sort of every year after that most of us. I wasn't suspicious of any of this at the time because you're a young lad, you're out there, its nice weather msot of the time, gets a bit hot at times and we would- It was an easy life. 3 planes a week (inaudible), the odd aircraft coming in like this for the trials but that was basically it. I'm more angry and frustrated than anything else. Angry that we didn't really know anything about it but in fairness I don't thinkk anybody did really. I don't think even bill henderson, the range commander colonel in the australian army, I'm pretty certain he didn't really ave a clue what was going on. I mean he'd have known a lot more than us but I dont think he really had a proper clue of the significance of what was going on. I think it did his career good because he ended up as



Participant 6

a General in charge of the aussie troops in vietnam. I mean we weren't supposed ot be there but I think some people were there. So that's my frustrations...sad about the way we treated the aborigines and also sad about when they were decontaminated. It was just a shower. I mean that's all we had, showers. We didn't have any special decontamination after being in the forward are aor anything. At the time you think "nah it's a pretty good posting, we have a great time, have a few drinks in the evening, really easy going. But when you're actually get back and things start to occur that hindsight says 20/20 vision. Its a wonderful thing, and when you get a bit of hindsight things start do come to..affect you I think emotionally but I'm quite angry ina way. I've got more anger than anything else. Anger and guilt. Anger and guilty, those are the two things. I mean I'm ok mostly I think emotionally but..i do get upset sometimes.

I: So when you look back on it it feels like the signs were there?

P: I didn't have a clue. No I didn't have a clue. The signs were there. Now with hinsight having read books relating to it and knowing what the plutonium was and how dangerous it was and how dangerous the final trials at maralinga were in comparison with the other, contamination. Although they were classed as minor trials they released more contamination than all the other trials. They released plutonium all over the place and probably some cobalt 90 or whaterv it was. I cant remember the actual number of the cobalt. I do remember offloading that plane, I do remember I think it was Sir Angus fraser, It was fraser anyhow, because Bill Henderson- I used to speak to colonel henderson every week because he wanted to know the ETA of the aircraft and of course the different winds it would come in at different times so I used to ring him up and say "look the aircrafts coming in". So i talked to him, I used to moan to him about why do they austraklian forces get more interstate allowance than we do on overseas allowance. So I always had a gripe at him with that. So when these lot came in he says what I'll do I'll bring them round to the ORs travers- that's the overranks tavern tonight and ill get you to see Fraser, and I forget what the name of the scientist and ill get them to sit next to you. Ill move people on and they can sit next t you and you can moan to him. So I complained [laughs] to see Fraser because I had a couple of drinks by then so I was quite not worried about- I was respectful don't get me wrong because he was a politician because I explained to him and moaned to him about it and he said well go back and look at it. We had a chat about various things. Anyway the next thing when we were flying out- I was always at the airport when aircraft were coming in going out, and (inaudible) the CO, the senior RAF person, he was there and they were all shaking hands to say goodbye colonel

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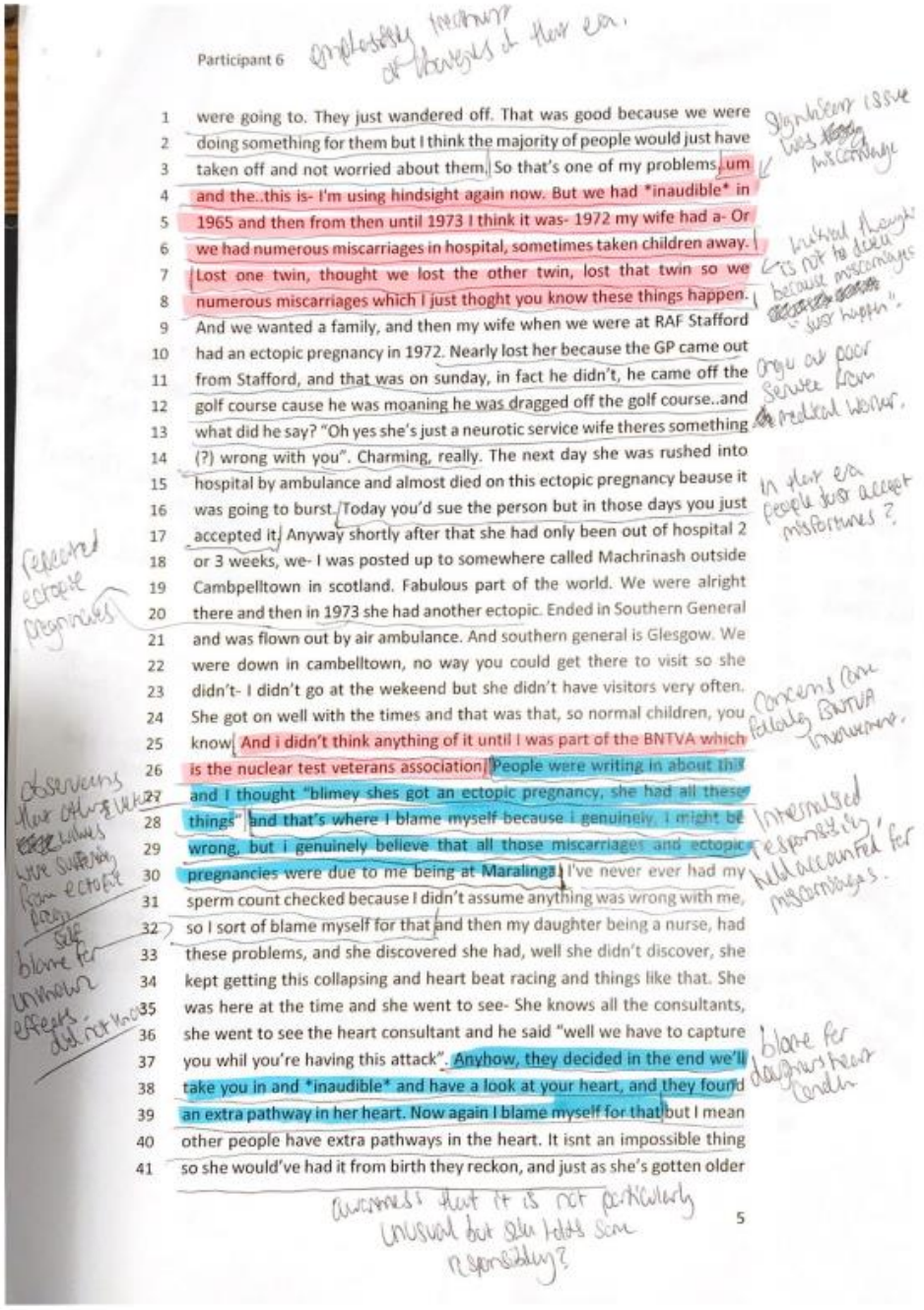
henderson, all the senior navy guys, al the senior officers were there shaking hands, and angus fraser saw me in the background and walked over to say goodbye to me. I said "cheers!" and he went off. I was called into my bosses office and said you do not say cheers to a member of parliament. So there you go, there a little anecdote for you. Right ill go sit over there for now, will that be ok for your recording? And you can ask me some questions and ill try to tell you no lies. Can I just explain, I've got three books down here that i've read, not quite a lot fo that one and..this one Maralinga's Long Shadow gives the aboriginal storyu. Fantastic book, quite disturbing, this one Frank Walker, great reporter. He wrote this Maralinga, all about it. Brought it all up. I read this backt o front and I emailed Frank because I found some of the information here wasn't accurate. So in the next edition he said if he could publish what I said and I said "yes of course you can". This one is an australian biased one called Atomic Thunder. Explains everything this. Really really good. This for example, *showing map of Maralinga in book*. I mean it's a terrible thing. The australian people didnt know anything about it. Dorpping bombs on their country. Its unbelieveable.

I: And this frustration relating to the aboriginies is this a significant part of your overall-

P: well it is now because I think the way they were treating, well the way they were treating anyhow because you've got the remember in 1962 '63 when I was there australia still had the white australian policy you know whereonly white people are allowed to go to australia. Which when you look back on where we are today, you couldn't believe it could you. You couldn't believe there was something like that. So the aboriginies weren't really seen as people by the australoians. And they were the only australians. True australians. So that's why- I mean I've got another photograph whch shows when we met some australians out in bush one day. we always went on what we call them Swans when you go away for a weekend, go ahead of the bite(?) or something like. You just get out the place and you take all your food and all your fuel with you, oil drums and you go off in a few landrovers, a group of you, make sure you got a chef with you and have a good weekend really. Just doing nothing, eating, perhaps if you could find a pub in the outback. Theres very few and far between. And one day we were driving across and this group of aboriginies were just wondering around. Wrong to say, they were obviously on walkabout as they call it. And we stopped and uh..we had ice cream there so we gave them some ice cream. And we had more tinned food then we needed and we gave them some tins and off they went to wherever they



Participant 6

were going to. They just wandered off. That was good because we were doing something for them but I think the majority of people would just have taken off and not worried about them. So that's one of my problems, um and the..this is- I'm using hindsight again now. But we had *inaudible* in 1965 and then from then until 1973 I think it was- 1972 my wife had a- Or we had numerous miscarriages in hospital, sometimes taken children away. Lost one twin, thought we lost the other twin, lost that twin so we numerous miscarriages which I just thoght you know these things happen. And we wanted a family, and then my wife when we were at RAF Stafford had an ectopic pregnancy in 1972. Nearly lost her because the GP came out from Stafford, and that was on sunday, in fact he didn't, he came off the golf course cause he was moaning he was dragged off the golf course..and what did he say? "Oh yes she's just a neurotic service wife theres something (?) wrong with you". Charming, really. The next day she was rushed into hospital by ambulance and almost died on this ectopic pregnancy beause it was going to burst. Today you'd sue the person but in those days you just accepted it. Anyway shortly after that she had only been out of hospital 2 or 3 weeks, we- I was posted up to somewhere called Machrinash outside Cambpelltown in scotland. Fabulous part of the world. We were alright there and then in 1973 she had another ectopic. Ended in Southern General and was flown out by air ambulance. And southern general is Glesgow. We were down in cambelltown, no way you could get there to visit so she didn't- I didn't go at the wekeend but she didn't have visitors very often. She got on well with the times and that was that, so normal children, you know. And i didn't think anything of it until I was part of the BNTVA which is the nuclear test veterans association. People were writing in about this and I thought "blimey shes got an ectopic pregnancy, she had all these things" and that's where I blame myself because i genuinely, I might be wrong, but i genuinely believe that all those miscarriages and ectopic pregnancies were due to me being at Maralinga. I've never ever had my sperm count checked because I didn't assume anything was wrong with me, so I sort of blame myself for that and then my daughter being a nurse, had these problems, and she discovered she had, well she didn't discover, she kept getting this collapsing and heart beat racing and things like that. She was here at the time and she went to see- She knows all the consultants, she went to see the heart consultant and he said "well we have to capture you whil you're having this attack". Anyhow, they decided in the end we'll take you in and *inaudible* and have a look at your heart, and they found an extra pathway in her heart. Now again I blame myself for that but I mean other people have extra pathways in the heart. It isnt an impossible thing so she would've had it from birth they reckon, and just as she's gotten older

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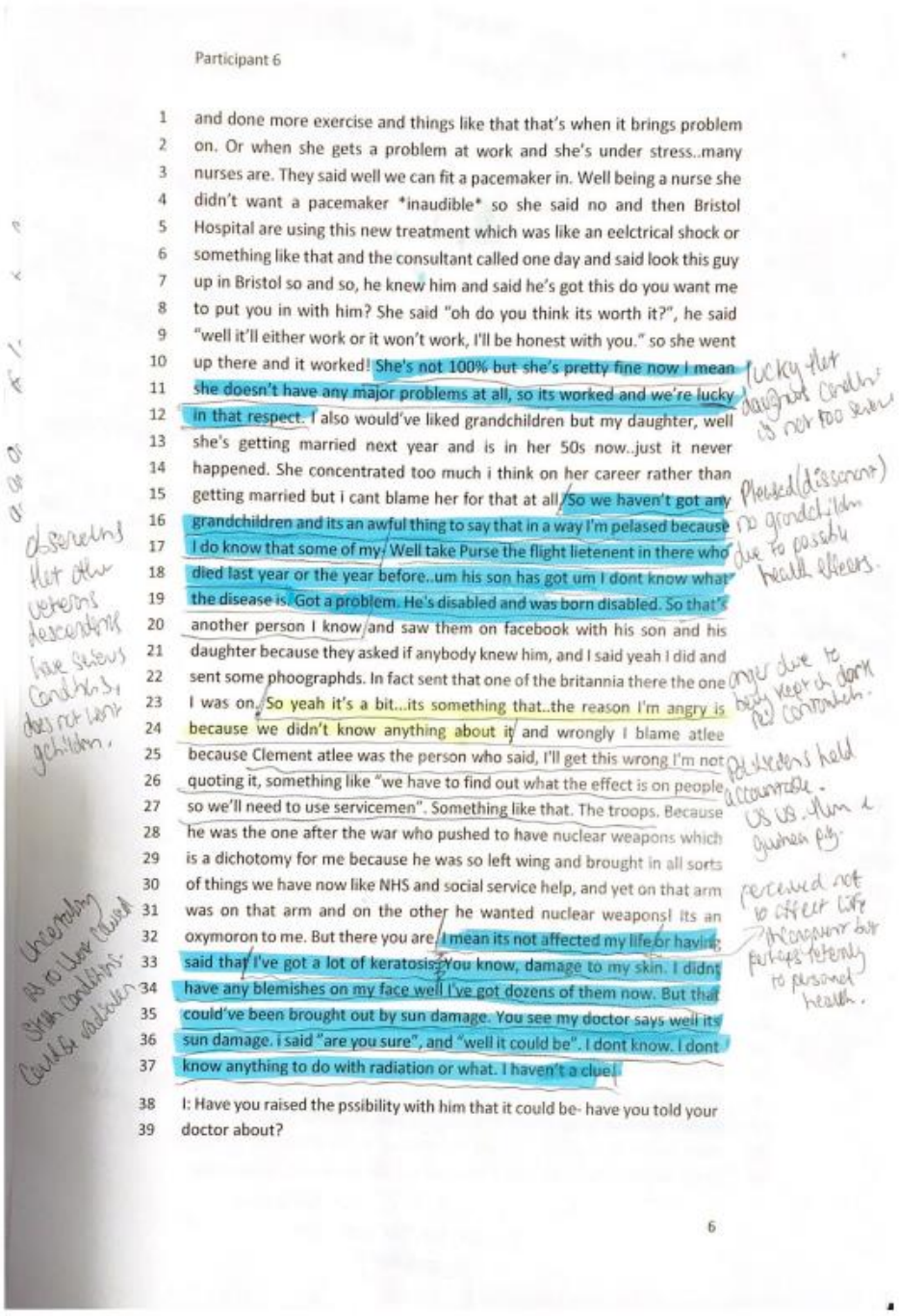

Participant 6

and done more exercise and things like that that's when it brings problem on. Or when she gets a problem at work and she's under stress..many nurses are. They said well we can fit a pacemaker in. Well being a nurse she didn't want a pacemaker *inaudible* so she said no and then Bristol Hospital are using this new treatment which was like an eelctrical shock or something like that and the consultant called one day and said look this guy up in Bristol so and so, he knew him and said he's got this do you want me to put you in with him? She said "oh do you think its worth it?", he said "well it'll either work or it won't work, I'll be honest with you." so she went up there and it worked! She's not 100% but she's pretty fine now I mean she doesn't have any major problems at all, so its worked and we're lucky in that respect. I also would've liked grandchildren but my daughter, well she's getting married next year and is in her 50s now..just it never happened. She concentrated too much i think on her career rather than getting married but i cant blame her for that at all. So we haven't got any grandchildren and its an awful thing to say that in a way I'm pelased because I do know that some of my/ Well take Purse the flight lietenent in there who died last year or the year before..um his son has got um I dont know what the disease is. Got a problem. He's disabled and was born disabled. So that's another person I know and saw them on facebook with his son and his daughter because they asked if anybody knew him, and I said yeah I did and sent some phoographds. In fact sent that one of the britannia there the one I was on. So yeah it's a bit...its something that..the reason I'm angry is because we didn't know anything about it and wrongly I blame atlee because Clement atlee was the person who said, I'll get this wrong I'm not quoting it, something like "we have to find out what the effect is on people so we'll need to use servicemen". Something like that. The troops. Because he was the one after the war who pushed to have nuclear weapons which is a dichotomy for me because he was so left wing and brought in all sorts of things we have now like NHS and social service help, and yet on that arm was on that arm and on the other he wanted nuclear weapons! Its an oxymoron to me. But there you are. I mean its not affected my life or having said that I've got a lot of keratosis. You know, damage to my skin. I didnt have any blemishes on my face well I've got dozens of them now. But that could've been brought out by sun damage. You see my doctor says well its sun damage. i said "are you sure", and "well it could be". I dont know. I dont know anything to do with radiation or what. I haven't a clue.

I: Have you raised the pssibility with him that it could be- have you told your doctor about?

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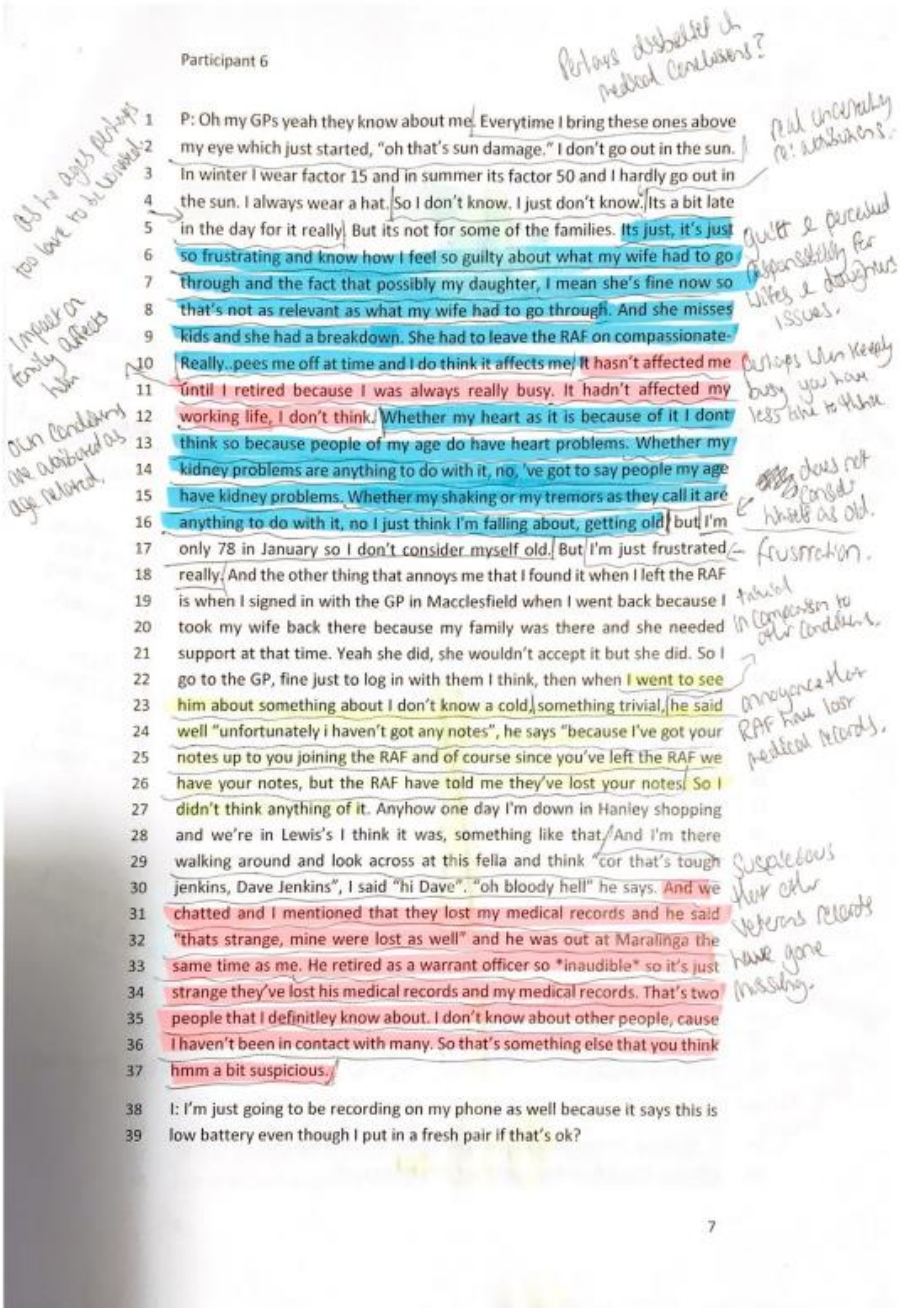

Participant 6

P: Oh my GPs yeah they know about me. Everytime I bring these ones above my eye which just started, "oh that's sun damage." I don't go out in the sun. In winter I wear factor 15 and in summer its factor 50 and I hardly go out in the sun. I always wear a hat. So I don't know. I just don't know. Its a bit late in the day for it really. But its not for some of the families. Its just, it's just so frustrating and know how I feel so guilty about what my wife had to go through and the fact that possibly my daughter, I mean she's fine now so that's not as relevant as what my wife had to go through. And she misses kids and she had a breakdown. She had to leave the RAF on compassionate- Really..pees me off at time and I do think it affects me. It hasn't affected me until I retired because I was always really busy. It hadn't affected my working life, I don't think. Whether my heart as it is because of it I dont think so because people of my age do have heart problems. Whether my kidney problems are anything to do with it, no, 've got to say people my age have kidney problems. Whether my shaking or my tremors as they call it are anything to do with it, no I just think I'm falling about, getting old but I'm only 78 in January so I don't consider myself old. But I'm just frustrated really. And the other thing that annoys me that I found it when I left the RAF is when I signed in with the GP in Macclesfield when I went back because I took my wife back there because my family was there and she needed support at that time. Yeah she did, she wouldn't accept it but she did. So I go to the GP, fine just to log in with them I think, then when I went to see him about something about I don't know a cold, something trivial, he said well "unfortunately i haven't got any notes", he says "because I've got your notes up to you joining the RAF and of course since you've left the RAF we have your notes, but the RAF have told me they've lost your notes. So I didn't think anything of it. Anyhow one day I'm down in Hanley shopping and we're in Lewis's I think it was, something like that. And I'm there walking around and look across at this fella and think "cor that's tough jenkins, Dave Jenkins", I said "hi Dave". "oh bloody hell" he says. And we chatted and I mentioned that they lost my medical records and he said "thats strange, mine were lost as well" and he was out at Maralinga the same time as me. He retired as a warrant officer so *inaudible* so it's just strange they've lost his medical records and my medical records. That's two people that I definitley know about. I don't know about other people, cause I haven't been in contact with many. So that's something else that you think hmm a bit suspicious.

I: I'm just going to be recording on my phone as well because it says this is low battery even though I put in a fresh pair if that's ok?

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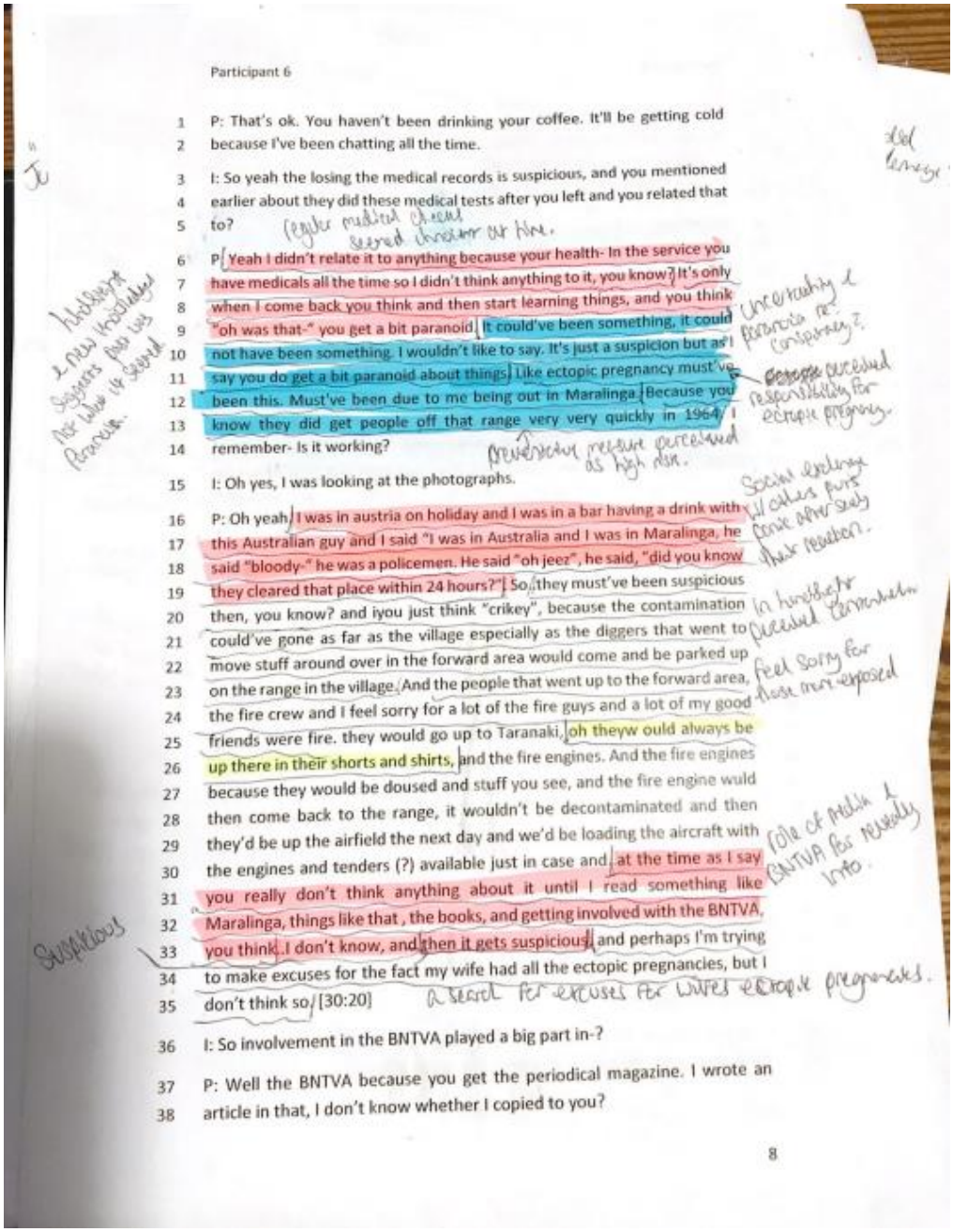

Participant 6

P: That's ok. You haven't been drinking your coffee. It'll be getting cold because I've been chatting all the time.

I: So yeah the losing the medical records is suspicious, and you mentioned earlier about they did these medical tests after you left and you related that to?

P: Yeah I didn't relate it to anything because your health- In the service you have medicals all the time so I didn't think anything to it, you know? It's only when I come back you think and then start learning things, and you think "oh was that-" you get a bit paranoid. It could've been something, it could not have been something. I wouldn't like to say. It's just a suspicion but as I say you do get a bit paranoid about things. Like ectopic pregnancy must've been this. Must've been due to me being out in Maralinga. Because you know they did get people off that range very very quickly in 1964, I remember- Is it working?

I: Oh yes, I was looking at the photographs.

P: Oh yeah. I was in austria on holiday and I was in a bar having a drink with this Australian guy and I said "I was in Australia and I was in Maralinga, he said "bloody-" he was a policemen. He said "oh jeez", he said, "did you know they cleared that place within 24 hours?" So, they must've been suspicious then, you know? and iyou just think "crikey", because the contamination could've gone as far as the village especially as the diggers that went to move stuff around over in the forward area would come and be parked up on the range in the village. And the people that went up to the forward area, the fire crew and I feel sorry for a lot of the fire guys and a lot of my good friends were fire. they would go up to Taranaki, oh theyw ould always be up there in their shorts and shirts, and the fire engines. And the fire engines because they would be doused and stuff you see, and the fire engine wuld then come back to the range, it wouldn't be decontaminated and then they'd be up the airfield the next day and we'd be loading the aircraft with the engines and tenders (?) available just in case and at the time as I say you really don't think anything about it until I read something like Maralinga, things like that , the books, and getting involved with the BNTVA, you think. I don't know, and then it gets suspicious, and perhaps I'm trying to make excuses for the fact my wife had all the ectopic pregnancies, but I don't think so. [30:20]

I: So involvement in the BNTVA played a big part in-?

P: Well the BNTVA because you get the periodical magazine. I wrote an article in that, I don't know whether I copied to you?

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I: Um....maybe back in March time I think I did?

P: Yeah so that sort of thing, my views of it as well. I think that did more damage to me emotionally with reading, not atomic thunder as much because that seems to be an Australian..australian version trying to put all the blame on Britain which I don't blame them because I don't think they were involved but I do think that politicians knew. They tried saying some of them didn't but I don't think they knew as much as ours did, anyhow. But this one by Frank Walker reading through it, it's..it's...mindblowing but i do know some of the facts in there are wrong which as I say I put him right on it.

I: And he's selling a revised version is he?

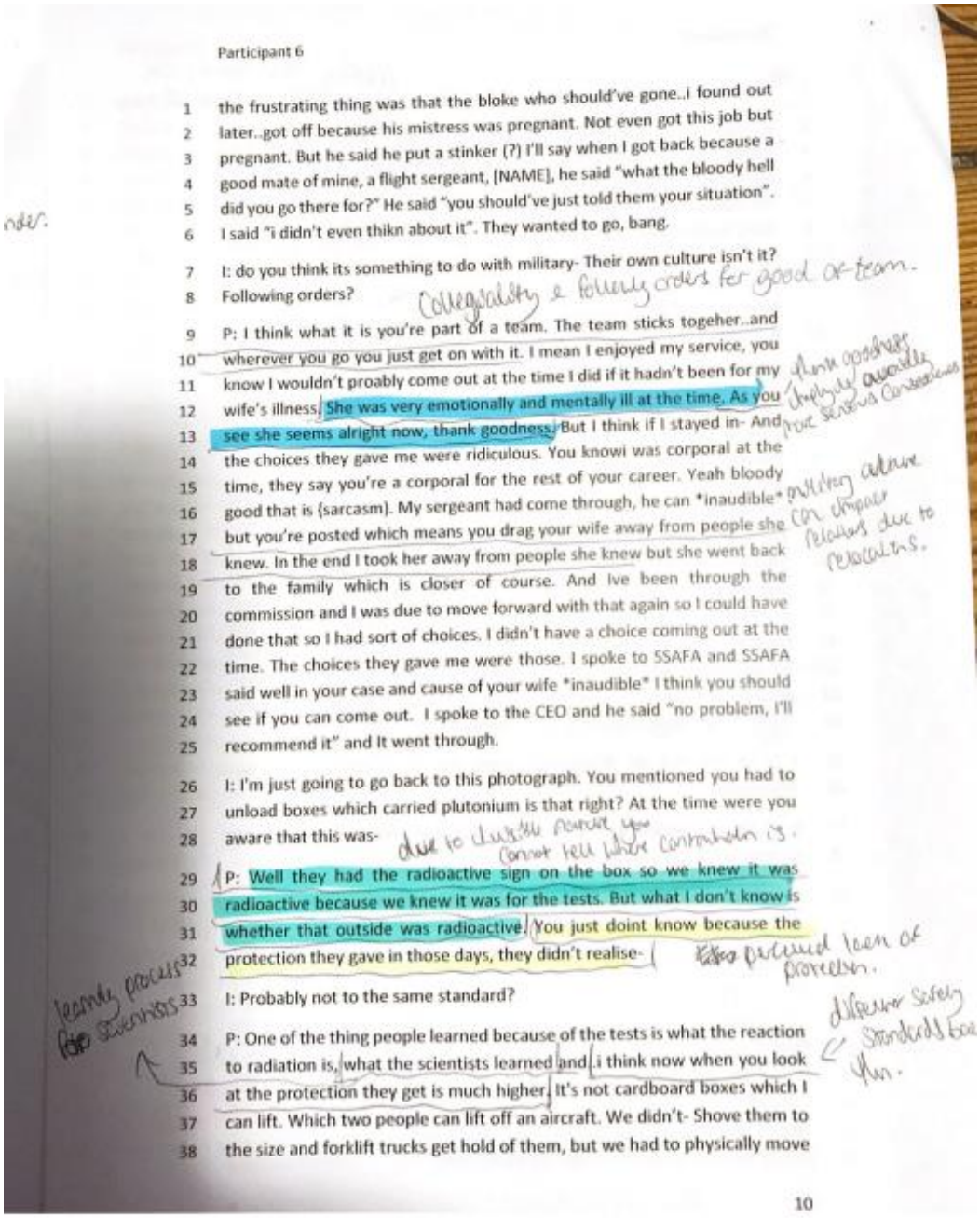
P: *inaudible* revised version if he gets his dates and his facts right. Because he had a bloke discovering something in 1960 who I knew wasn't there in 1960 because he was there with me in 1962 and '63 and he only did one tour there so i had to point that out to him and there were a couple of other instances that weren't correct. Only trivial. A friend of mine across the road is an ex-pilot, he was in the RAF but wasn't flying, he became a pilot after the RAF, and he's got a book on the V bombers that went there and there's a chapter there on Maralinga and he asked if I'd read through it. I read through it and there were a couple of mistakes in that as well [laughter]. Especially a photograph of an airman calling him private because we didn't have privates in the royal airforce. Leading aircraftsmen, senior aircraftsmen, corporal, sergeant, whatever you know. Flying pilot officer, flying officer, flight lieutenant, squadron leader, so yeah...so-

I: So at the time you didn't think much about it or weren't given any information-

P: no those photographs that were what I took or what other people took to remind me of the good times

I: And any other reason you take a photograph, I see what you're saying.

P: yeah wasn't a specific reason to say oh this is to do with the nuclear side because, I don't know, it was just something that you did. When you're in the services you tend to, I say do as you told but I didn't very often..yeah you get posted abroad nd whatever that theatre is you did that theatre. You know I was posted out to Zambia where Ian Smith declared his UDI just a few weeks after my daughter was born. And I went...which using hindsight I should've refused to go because I didn't have to go, I was on whats called 24 hour standby for anywhere in the world. Was on standby so that means I could be sent anywhere within 24 hours notice but *inaudible* because



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the frustrating thing was that the bloke who should've gone..i found out later..got off because his mistress was pregnant. Not even got this job but pregnant. But he said he put a stinker (?) I'll say when I got back because a good mate of mine, a flight sergeant, [NAME], he said "what the bloody hell did you go there for?" He said "you should've just told them your situation". I said "i didn't even thikn about it". They wanted to go, bang.

I: do you think its something to do with military- Their own culture isn't it? Following orders?

P: I think what it is you're part of a team. The team sticks togeher..and wherever you go you just get on with it. I mean I enjoyed my service, you know I wouldn't proably come out at the time I did if it hadn't been for my wife's illness. She was very emotionally and mentally ill at the time. As you see she seems alright now, thank goodness. But I think if I stayed in- And the choices they gave me were ridiculous. You knowi was corporal at the time, they say you're a corporal for the rest of your career. Yeah bloody good that is (sarcasm). My sergeant had come through, he can *inaudible* but you're posted which means you drag your wife away from people she knew. In the end I took her away from people she knew but she went back to the family which is closer of course. And Ive been through the commission and I was due to move forward with that again so I could have done that so I had sort of choices. I didn't have a choice coming out at the time. The choices they gave me were those. I spoke to SSAFA and SSAFA said well in your case and cause of your wife *inaudible* I think you should see if you can come out. I spoke to the CEO and he said "no problem, I'll recommend it" and it went through.

I: I'm just going to go back to this photograph. You mentioned you had to unload boxes which carried plutonium is that right? At the time were you aware that this was-

P: Well they had the radioactive sign on the box so we knew it was radioactive because we knew it was for the tests. But what I don't know is whether that outside was radioactive. You just doint know because the protection they gave in those days, they didn't realise-

I: Probably not to the same standard?

P: One of the thing people learned because of the tests is what the reaction to radiation is, what the scientists learned and i think now when you look at the protection they get is much higher. It's not cardboard boxes which I can lift. Which two people can lift off an aircraft. We didn't- Shove them to the size and forklift trucks get hold of them, but we had to physically move

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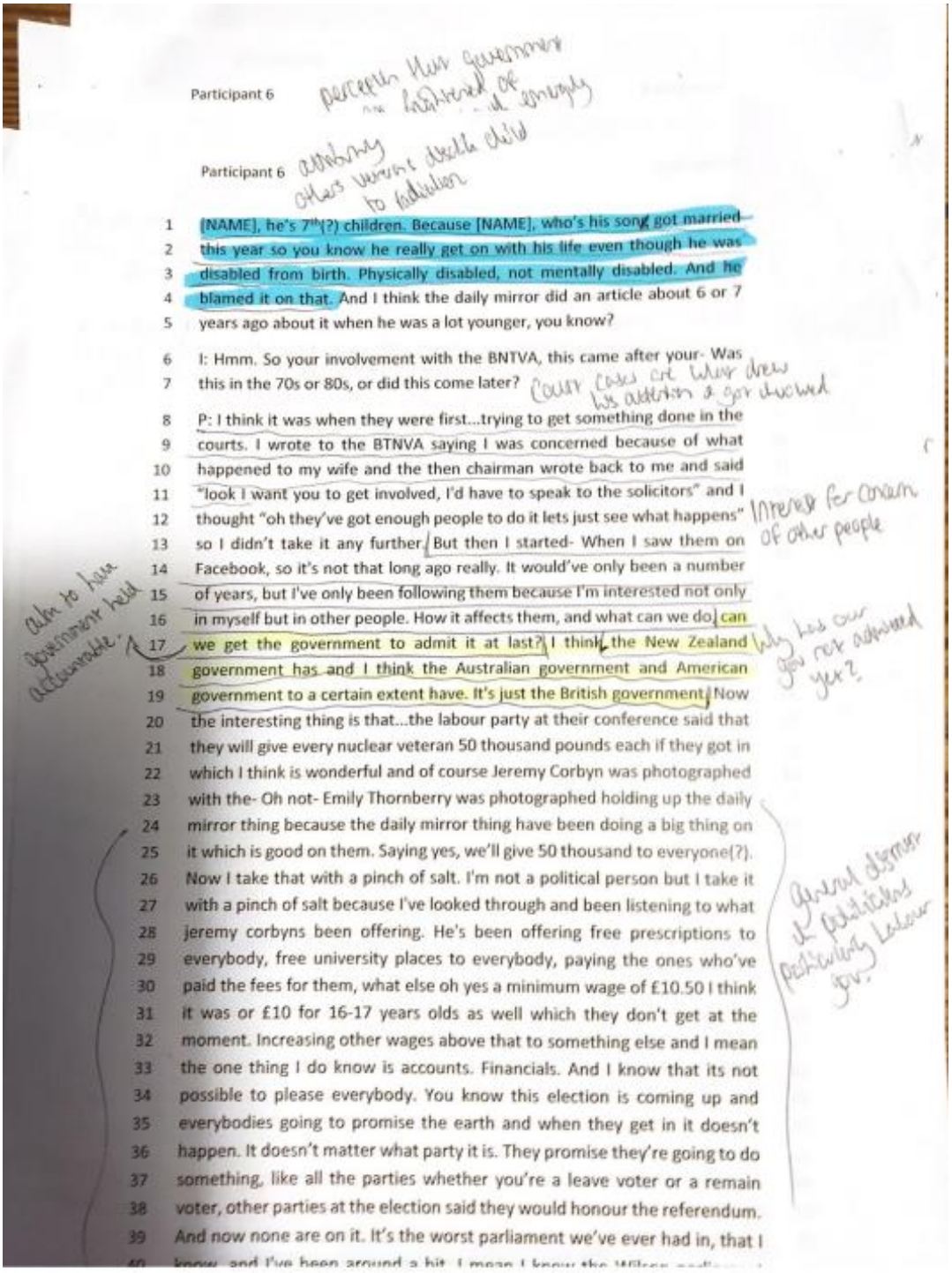
them. So I don't know. But I also- Moving on from that, one of the things we had to load a lot of times were fossils in big boxes. Fossils- loads and loads of these fossils. And again it might just be me jumping to the wrong conclusion but I thought about that on a number of occasions over the last few years but I just wonder..because they were going down to Adelaide museum or something like that. I just wonder if they were articles from the range which were sent down to check about the radiation levels. I just wonder because I didn't know anybody who really went fossil hunting. You know nobody seemed to go fossil hunting except one army major. Australian army major. *inaudible* I just thought- Well now I think he was always up on the range so if it was *inaudible* and he would never left the range then how did he get there? So I don't know. As I say maybe I'm cracking up. I don't know. [laughs]

I: But then it does seem reasonable?

P: Well I think so because we never ever by rail- because I also used to do the Watson which was a train that came by a place called Watson which was about 30 miles down the road from us. Again, we used to be able to the train. The big train that went from Adelaide to Perth which is one of the greatest train rides in the world apparently. And you used to be able to wave to passengers because you've got the think all these men cooped up together with the same people day after the day, month after month, you did get rotation of course but it did get frustrating so it was lovely just to see other people. Used to see the station master and his wife. So that was good but it's no longer there. They knocked that down as well. So yeah, we used to load everything, and we never ever loaded anything that had a radioactive sign on it. So how did they get the samples down to be checked. And they did check them because they said they did. There you go.

I: Have you spoken to anyone else who was at Maralinga about your suspicions?

P: Yes, I think we're all suspicious. I got one of the firemen, who was a good friend of mine- Because I wrote that article in the BNTVA magazine and a couple of guys got in touch with me- Asked to get in touch with me and I said yes, they can. This guy said we he just got a low sperm count. Both of them said they had low sperm counts so why the bloody hell didn't I get mine tested? But never mind. But they were alright. Well they were last year. Haven't spoken to them for 12 months. But they're suspicious because obviously they contacted me because of BNTVA they'd been reading all the information about it. So, they were suspicious as well. [14:38 RECORDING B] so I don't know. The only one I definitely know that had a problem was



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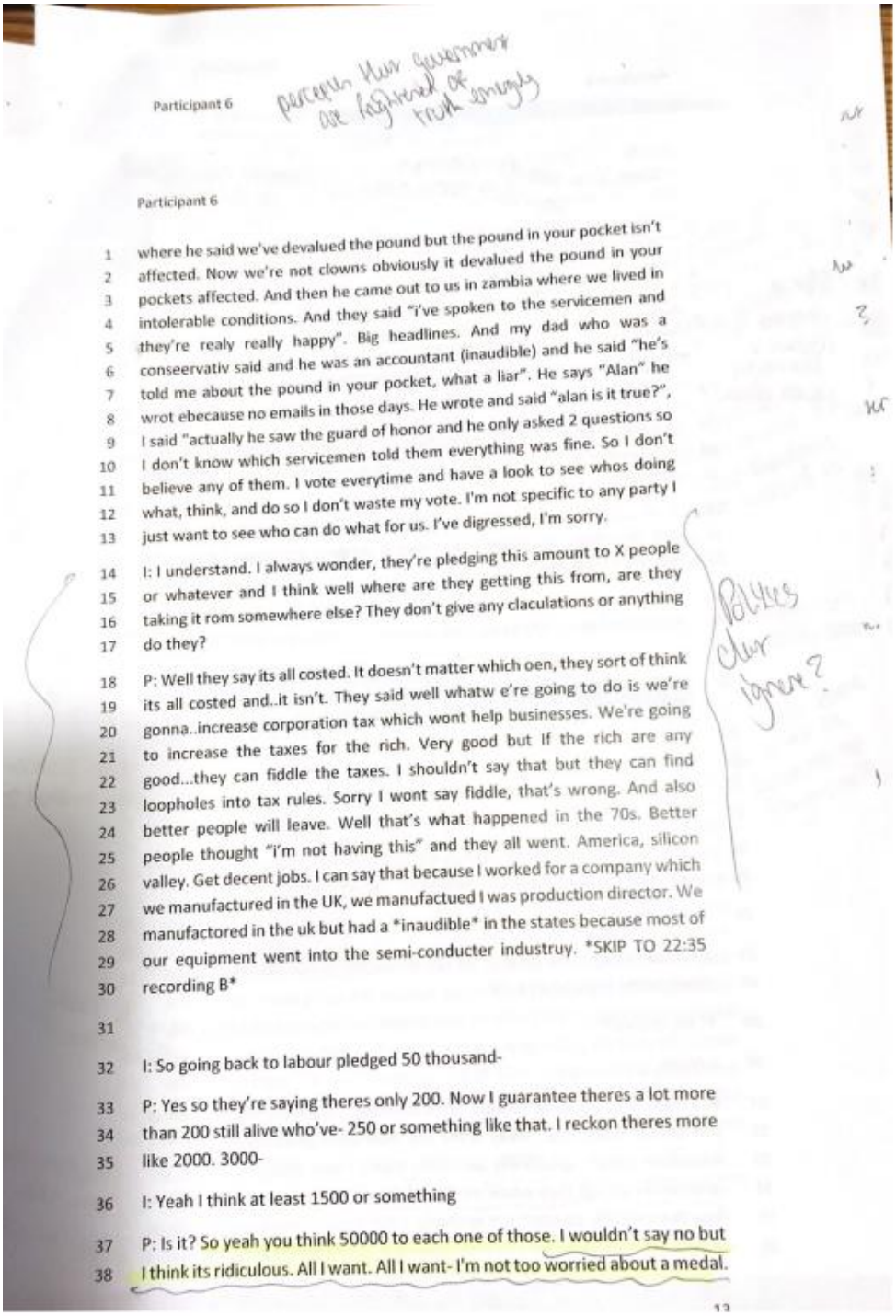
1 [NAME], he's 7th(?) children. Because [NAME], who's his son got married
2 this year so you know he really get on with his life even though he was
3 disabled from birth. Physically disabled, not mentally disabled. And he
4 blamed it on that. And I think the daily mirror did an article about 6 or 7
5 years ago about it when he was a lot younger, you know?

6 I: Hmm. So your involvement with the BNTVA, this came after your- Was
7 this in the 70s or 80s, or did this come later?

8 P: I think it was when they were first...trying to get something done in the
9 courts. I wrote to the BTNVA saying I was concerned because of what
10 happened to my wife and the then chairman wrote back to me and said
11 "look I want you to get involved, I'd have to speak to the solicitors" and I
12 thought "oh they've got enough people to do it lets just see what happens"
13 so I didn't take it any further. But then I started- When I saw them on
14 Facebook, so it's not that long ago really. It would've only been a number
15 of years, but I've only been following them because I'm interested not only
16 in myself but in other people. How it affects them, and what can we do, can
17 we get the government to admit it at last? I think the New Zealand
18 government has and I think the Australian government and American
19 government to a certain extent have. It's just the British government. Now
20 the interesting thing is that...the labour party at their conference said that
21 they will give every nuclear veteran 50 thousand pounds each if they got in
22 which I think is wonderful and of course Jeremy Corbyn was photographed
23 with the- Oh not- Emily Thornberry was photographed holding up the daily
24 mirror thing because the daily mirror thing have been doing a big thing on
25 it which is good on them. Saying yes, we'll give 50 thousand to everyone(?).
26 Now I take that with a pinch of salt. I'm not a political person but I take it
27 with a pinch of salt because I've looked through and been listening to what
28 jeremy corbyns been offering. He's been offering free prescriptions to
29 everybody, free university places to everybody, paying the ones who've
30 paid the fees for them, what else oh yes a minimum wage of £10.50 I think
31 it was or £10 for 16-17 years olds as well which they don't get at the
32 moment. Increasing other wages above that to something else and I mean
33 the one thing I do know is accounts. Financials. And I know that its not
34 possible to please everybody. You know this election is coming up and
35 everybodies going to promise the earth and when they get in it doesn't
36 happen. It doesn't matter what party it is. They promise they're going to do
37 something, like all the parties whether you're a leave voter or a remain
38 voter, other parties at the election said they would honour the referendum.
39 And now none are on it. It's the worst parliament we've ever had in, that I
40 know, and I've been around a bit. I mean I know the Wilson [illegible]



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where he said we've devalued the pound but the pound in your pocket isn't affected. Now we're not clowns obviously it devalued the pound in your pockets affected. And then he came out to us in zambia where we lived in intolerable conditions. And they said "i've spoken to the servicemen and they're realy really happy". Big headlines. And my dad who was a conseervativ said and he was an accountant (inaudible) and he said "he's told me about the pound in your pocket, what a liar". He says "Alan" he wrot ebecause no emails in those days. He wrote and said "alan is it true?", I said "actually he saw the guard of honor and he only asked 2 questions so I don't know which servicemen told them everything was fine. So I don't believe any of them. I vote everytime and have a look to see whos doing what, think, and do so I don't waste my vote. I'm not specific to any party I just want to see who can do what for us. I've digressed, I'm sorry.

I: I understand. I always wonder, they're pledging this amount to X people or whatever and I think well where are they getting this from, are they taking it rom somewhere else? They don't give any claculations or anything do they?

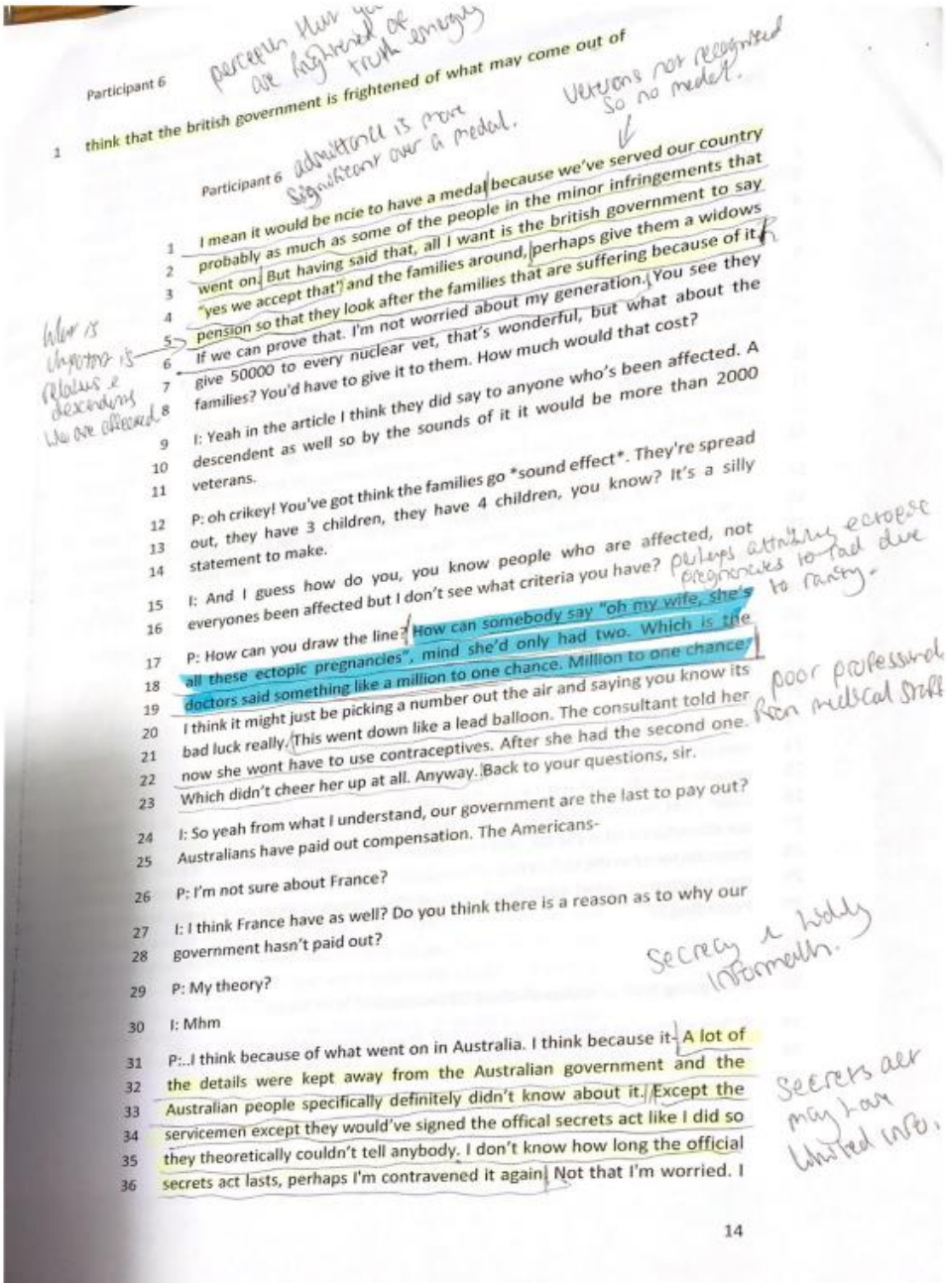
P: Well they say its all costed. It doesn't matter which oen, they sort of think its all costed and..it isn't. They said well whatw e're going to do is we're gonna..increase corporation tax which wont help businesses. We're going to increase the taxes for the rich. Very good but If the rich are any good...they can fiddle the taxes. I shouldn't say that but they can find loopholes into tax rules. Sorry I wont say fiddle, that's wrong. And also better people will leave. Well that's what happened in the 70s. Better people thought "i'm not having this" and they all went. America, silicon valley. Get decent jobs. I can say that because I worked for a company which we manufactured in the UK, we manufactued I was production director. We manufactored in the uk but had a *inaudible* in the states because most of our equipment went into the semi-conducter industruy. *SKIP TO 22:35 recording B*

I: So going back to labour pledged 50 thousand-

P: Yes so they're saying theres only 200. Now I guarantee theres a lot more than 200 still alive who've- 250 or something like that. I reckon theres more like 2000. 3000-

I: Yeah I think at least 1500 or something

P: Is it? So yeah you think 50000 to each one of those. I wouldn't say no but I think its ridiculous. All I want. All I want- I'm not too worried about a medal.



Participant 6 think that the british government is frightened of what may come out of

Participant 6 I mean it would be ncie to have a medal because we've served our country probably as much as some of the people in the minor infringements that went on. But having said that, all I want is the british government to say "yes we accept that" and the families around, perhaps give them a widows pension so that they look after the families that are suffering because of it. If we can prove that. I'm not worried about my generation. You see they give 50000 to every nuclear vet, that's wonderful, but what about the families? You'd have to give it to them. How much would that cost?

I: Yeah in the article I think they did say to anyone who's been affected. A descendent as well so by the sounds of it it would be more than 2000 veterans.

P: oh crikey! You've got think the families go *sound effect*. They're spread out, they have 3 children, they have 4 children, you know? It's a silly statement to make.

I: And I guess how do you, you know people who are affected, not everyones been affected but I don't see what criteria you have?

P: How can you draw the line? How can somebody say "oh my wife, she's all these ectopic pregnancies", mind she'd only had two. Which is the doctors said something like a million to one chance. Million to one chance, I think it might just be picking a number out the air and saying you know its bad luck really. This went down like a lead balloon. The consultant told her now she wont have to use contraceptives. After she had the second one. Which didn't cheer her up at all. Anyway. Back to your questions, sir.

I: So yeah from what I understand, our government are the last to pay out? Australians have paid out compensation. The Americans-

P: I'm not sure about France?

I: I think France have as well? Do you think there is a reason as to why our government hasn't paid out?

P: My theory?

I: Mhm

P:..I think because of what went on in Australia. I think because it- A lot of the details were kept away from the Australian government and the Australian people specifically definitely didn't know about it. Except the servicemen except they would've signed the offical secrets act like I did so they theoretically couldn't tell anybody. I don't know how long the official secrets act lasts, perhaps I'm contravened it again. Not that I'm worried. I

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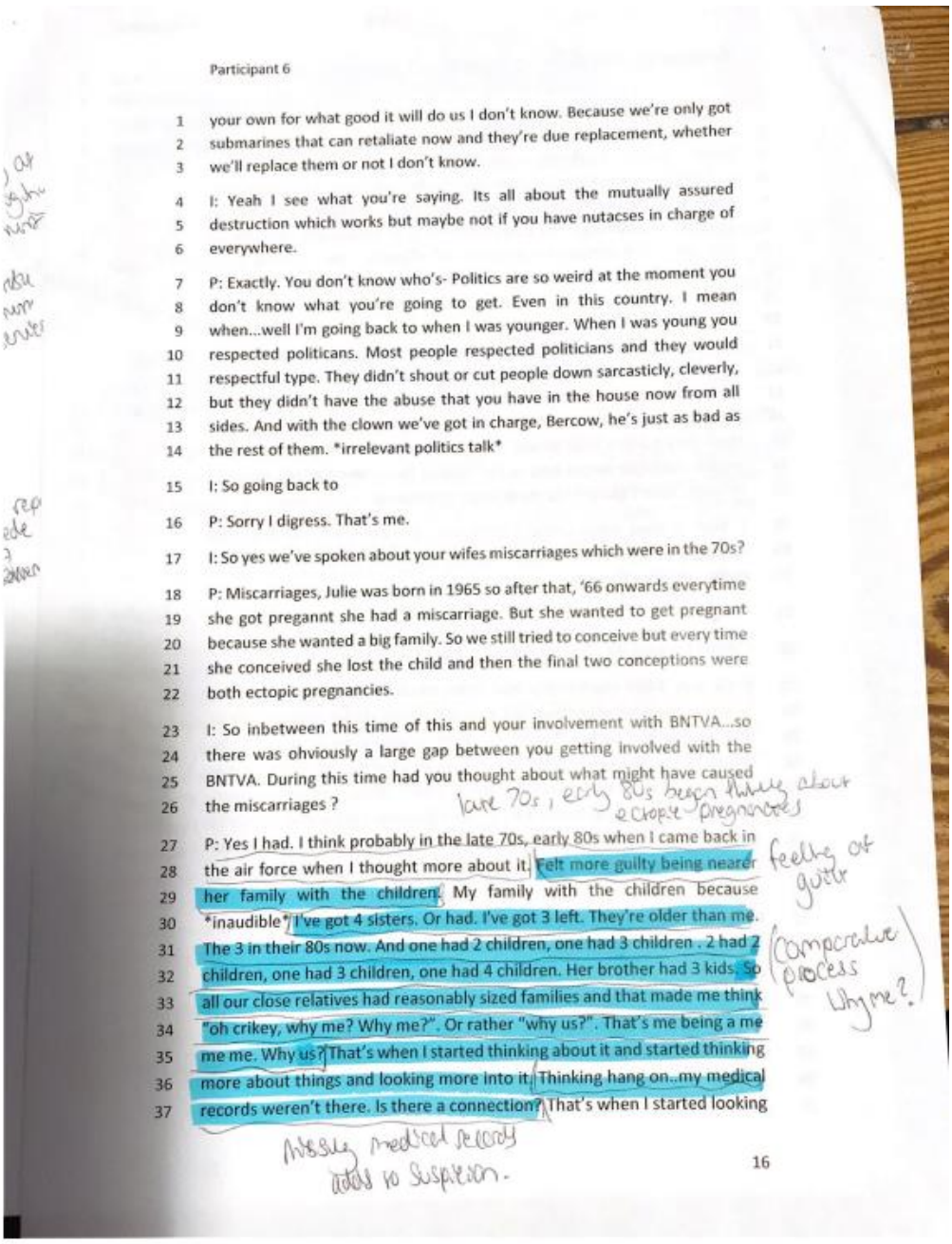
think that the british government is frightened of what may come out of what really havppened in australia especially..with the fact this atomic thunder books out and they're doing a film about it.i was asked if I wanted to take part in it and I read the specifics and they said they could edit it. The editorial license was in their (inaudible) and they could have the edotiral in question. So anything I said they could change it theoretically, so I said no they can stick that. And having read atomic thunder, I think its going to be a film that really does highlight the lack of information that the british government gave the Australian government. And um I still think even though when they comes out something might occur. Austrlaian people might get up in arms, not physically but you know might start complaining but I think that maybe the reason why the british government have been so tardy about this is that they worry the australian government might take them buildings (?). I know they paid a lot. They have paid. But they might think they haven't paid enough. I know they paid the aboriginies some money and a pat on the back but its nothing to my mind what they went through. I don't know what the average is that died.

I: Yeah it does make sense. I think the Australians will put the brits responsible, and think in the past the austrlaians have ordered the british to decontamina the area-

P: Again.

I: Again because they first lot in the 70s wasn't done properly.

P: OH they didn't do anything. That shows you how little they knew about radiation and nuclear contamination. Its just stupid. I know perhaps the fact that people got nuclear bombs has..kept relatively peaceful in all this (inaudible) but especially in europe. Its kept peace in europe I think. I know people could argue that it's the european union that's kept peace in europe, but I still think us and france having the bomb has kept peace in europe because nobody wants to start any real shenanigans and of course the european union joining in union together has probably contributed to that since the 90s. But I think prior to that, since the 60s to the european union it was the threat of the bomb..but I think theres so many idiots around the world now in charge that some clown could quite easily press that button at any time. I was all for the nuclear bomb for us to have it so I'm perhaps wrong to complain now but myself and my wife (?) but I just wish they get rid of it before it happens. But I cant see it happening because of people who've got them. Israel will never get rid of theirs because of the precarious position that they are. Korea I cant see him getting rid of his cause of the person he is. America wont, russia wont, so you've just got the hang onto



your own for what good it will do us I don't know. Because we're only got submarines that can retaliate now and they're due replacement, whether we'll replace them or not I don't know.

I: Yeah I see what you're saying. Its all about the mutually assured destruction which works but maybe not if you have nutacses in charge of everywhere.

P: Exactly. You don't know who's- Politics are so weird at the moment you don't know what you're going to get. Even in this country. I mean when...well I'm going back to when I was younger. When I was young you respected politicans. Most people respected politicians and they would respectful type. They didn't shout or cut people down sarcasticly, cleverly, but they didn't have the abuse that you have in the house now from all sides. And with the clown we've got in charge, Bercow, he's just as bad as the rest of them. *irrelevant politics talk*

I: So going back to

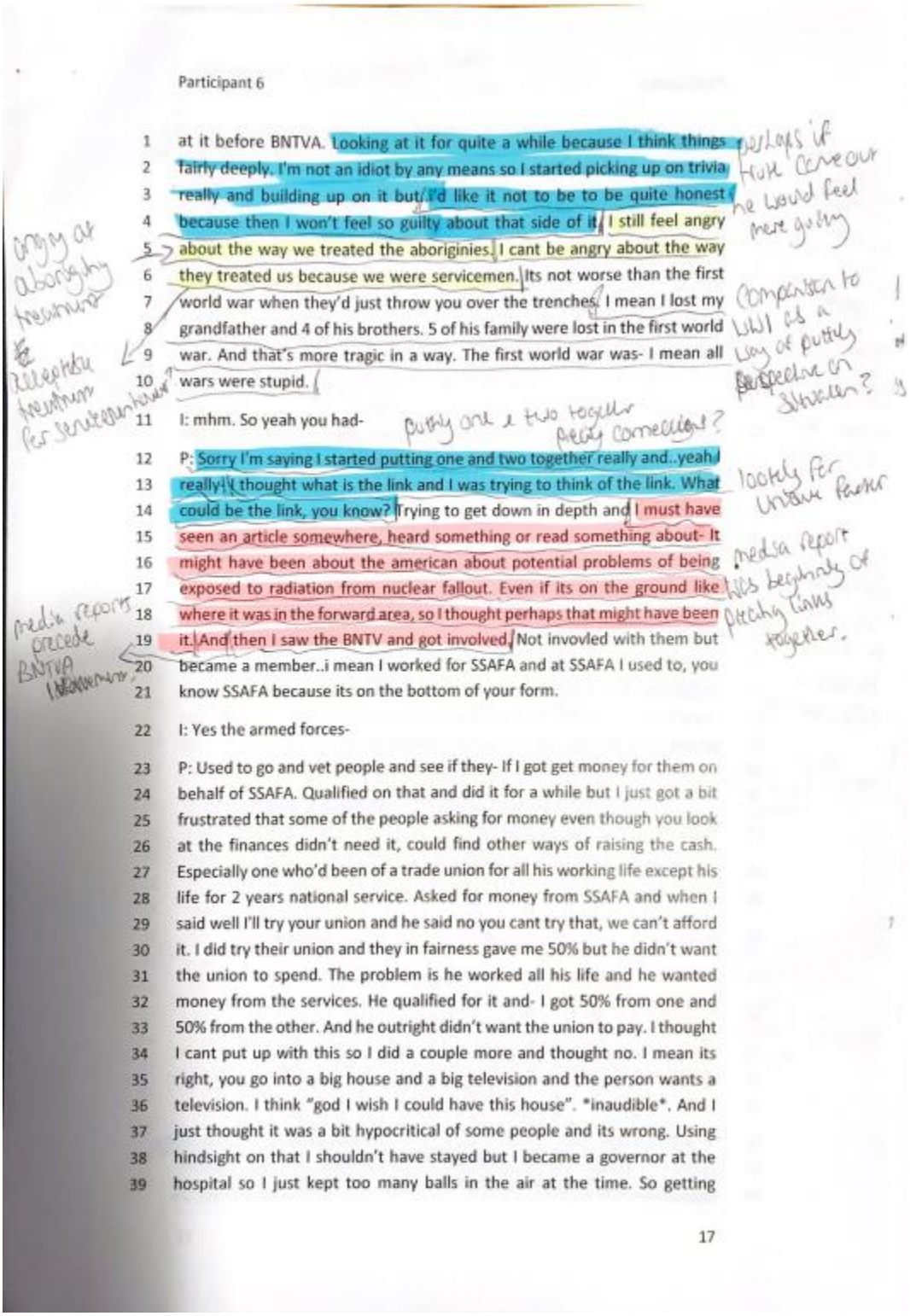
P: Sorry I digress. That's me.

I: So yes we've spoken about your wifes miscarriages which were in the 70s?

P: Miscarriages, Julie was born in 1965 so after that, '66 onwards everytime she got pregannt she had a miscarriage. But she wanted to get pregnant because she wanted a big family. So we still tried to conceive but every time she conceived she lost the child and then the final two conceptions were both ectopic pregnancies.

I: So inbetween this time of this and your involvement with BNTVA...so there was ohviously a large gap between you getting involved with the BNTVA. During this time had you thought about what might have caused the miscarriages ?

P: Yes I had. I think probably in the late 70s, early 80s when I came back in the air force when I thought more about it. Felt more guilty being nearer her family with the children. My family with the children because *inaudible* I've got 4 sisters. Or had. I've got 3 left. They're older than me. The 3 in their 80s now. And one had 2 children, one had 3 children . 2 had 2 children, one had 3 children, one had 4 children. Her brother had 3 kids. So all our close relatives had reasonably sized families and that made me think "oh crikey, why me? Why me?". Or rather "why us?". That's me being a me me me. Why us? That's when I started thinking about it and started thinking more about things and looking more into it. Thinking hang on..my medical records weren't there. Is there a connection? That's when I started looking



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at it before BNTVA. Looking at it for quite a while because I think things fairly deeply. I'm not an idiot by any means so I started picking up on trivia really and building up on it but I'd like it not to be to be quite honest because then I won't feel so guilty about that side of it. I still feel angry about the way we treated the aboriginies. I cant be angry about the way they treated us because we were servicemen. Its not worse than the first world war when they'd just throw you over the trenches. I mean I lost my grandfather and 4 of his brothers. 5 of his family were lost in the first world war. And that's more tragic in a way. The first world war was- I mean all wars were stupid.

I: mhm. So yeah you had-

P: Sorry I'm saying I started putting one and two together really and..yeah I really I thought what is the link and I was trying to think of the link. What could be the link, you know? Trying to get down in depth and I must have seen an article somewhere, heard something or read something about- It might have been about the american about potential problems of being exposed to radiation from nuclear fallout. Even if its on the ground like where it was in the forward area, so I thought perhaps that might have been it. And then I saw the BNTV and got involved. Not invovled with them but became a member..i mean I worked for SSAFA and at SSAFA I used to, you know SSAFA because its on the bottom of your form.

I: Yes the armed forces-

P: Used to go and vet people and see if they- If I got get money for them on behalf of SSAFA. Qualified on that and did it for a while but I just got a bit frustrated that some of the people asking for money even though you look at the finances didn't need it, could find other ways of raising the cash. Especially one who'd been of a trade union for all his working life except his life for 2 years national service. Asked for money from SSAFA and when I said well I'll try your union and he said no you cant try that, we can't afford it. I did try their union and they in fairness gave me 50% but he didn't want the union to spend. The problem is he worked all his life and he wanted money from the services. He qualified for it and- I got 50% from one and 50% from the other. And he outright didn't want the union to pay. I thought I cant put up with this so I did a couple more and thought no. I mean its right, you go into a big house and a big television and the person wants a television. I think "god I wish I could have this house". *inaudible*. And I just thought it was a bit hypocritical of some people and its wrong. Using hindsight on that I shouldn't have stayed but I became a governor at the hospital so I just kept too many balls in the air at the time. So getting

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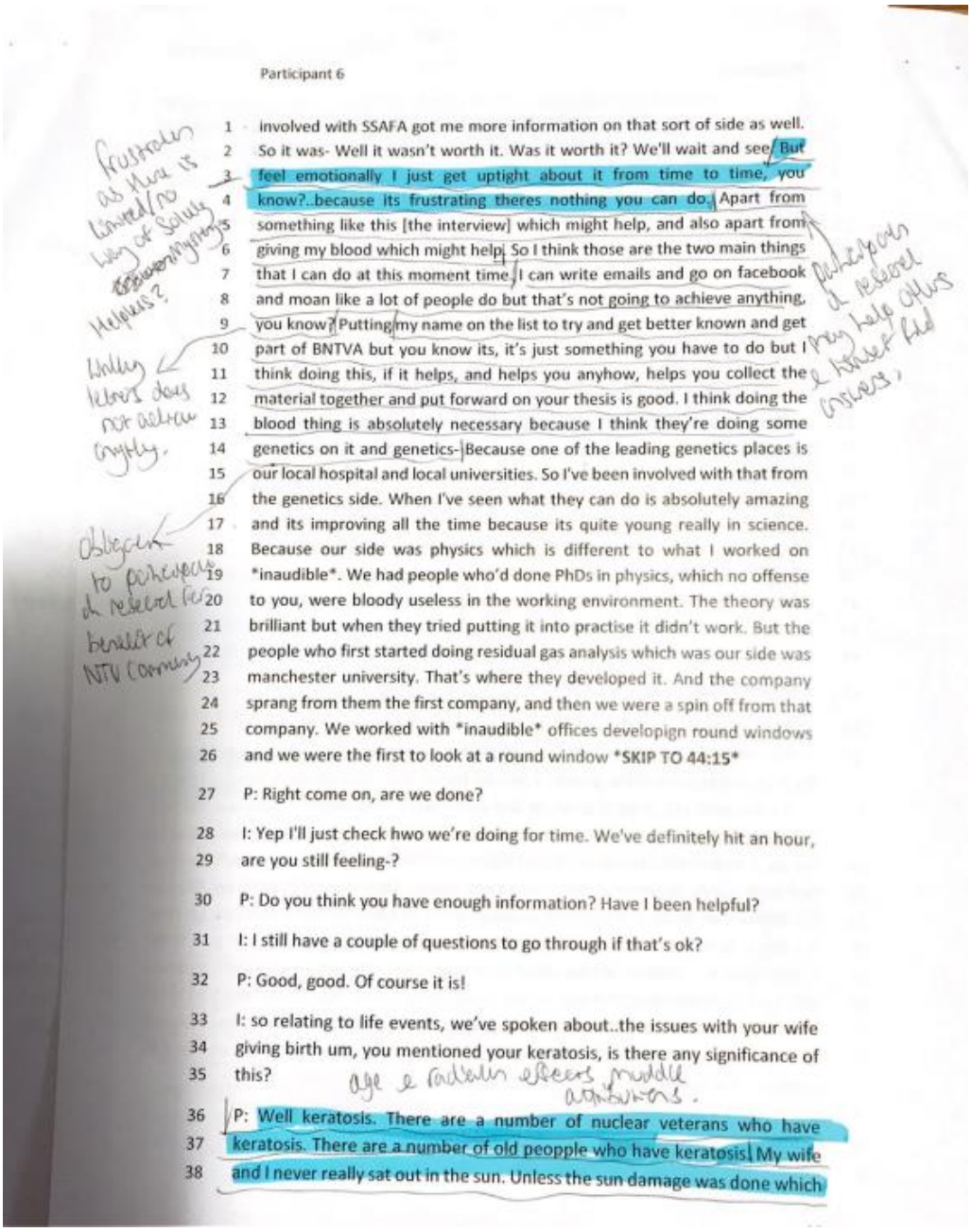

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involved with SSAFA got me more information on that sort of side as well. So it was- Well it wasn't worth it. Was it worth it? We'll wait and see. But feel emotionally I just get uptight about it from time to time, you know?..because its frustrating theres nothing you can do. Apart from something like this [the interview] which might help, and also apart from giving my blood which might help. So I think those are the two main things that I can do at this moment time. I can write emails and go on facebook and moan like a lot of people do but that's not going to achieve anything, you know? Putting my name on the list to try and get better known and get part of BNTVA but you know its, it's just something you have to do but I think doing this, if it helps, and helps you anyhow, helps you collect the material together and put forward on your thesis is good. I think doing the blood thing is absolutely necessary because I think they're doing some genetics on it and genetics- Because one of the leading genetics places is our local hospital and local universities. So I've been involved with that from the genetics side. When I've seen what they can do is absolutely amazing and its improving all the time because its quite young really in science. Because our side was physics which is different to what I worked on *inaudible*. We had people who'd done PhDs in physics, which no offense to you, were bloody useless in the working environment. The theory was brilliant but when they tried putting it into practise it didn't work. But the people who first started doing residual gas analysis which was our side was manchester university. That's where they developed it. And the company sprang from them the first company, and then we were a spin off from that company. We worked with *inaudible* offices developign round windows and we were the first to look at a round window *SKIP TO 44:15*

P: Right come on, are we done?

I: Yep I'll just check hwo we're doing for time. We've definitely hit an hour, are you still feeling-?

P: Do you think you have enough information? Have I been helpful?

I: I still have a couple of questions to go through if that's ok?

P: Good, good. Of course it is!

I: so relating to life events, we've spoken about..the issues with your wife giving birth um, you mentioned your keratosis, is there any significance of this?

P: Well keratosis. There are a number of nuclear veterans who have keratosis. There are a number of old peopple who have keratosis. My wife and I never really sat out in the sun. Unless the sun damage was done which

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is can be when I was younger, like the 12 months I was in australia, although we're all out in the sun r eally, its inevtibable were in the sun when we're loading the aircraft and offloading because you're outside. So yes I was out in the sun but I didn't sunbathe like some of them do. i didn't put the vinegar one and oil would you believe, to get a tan [laugh]. I can understand if they get keratosis. And where else have I been that's warm? The thing is I've served in singapore, africa, australia, all are quite sunny so mine could quite easily be sun damage. I fully understand that. But you always have the- I suppose because I'm a nuclear veteran I have a feeling it might be nuclear reactant (?). I don't think my heart is because my hardening arteries is what people get, or veins or whatever.

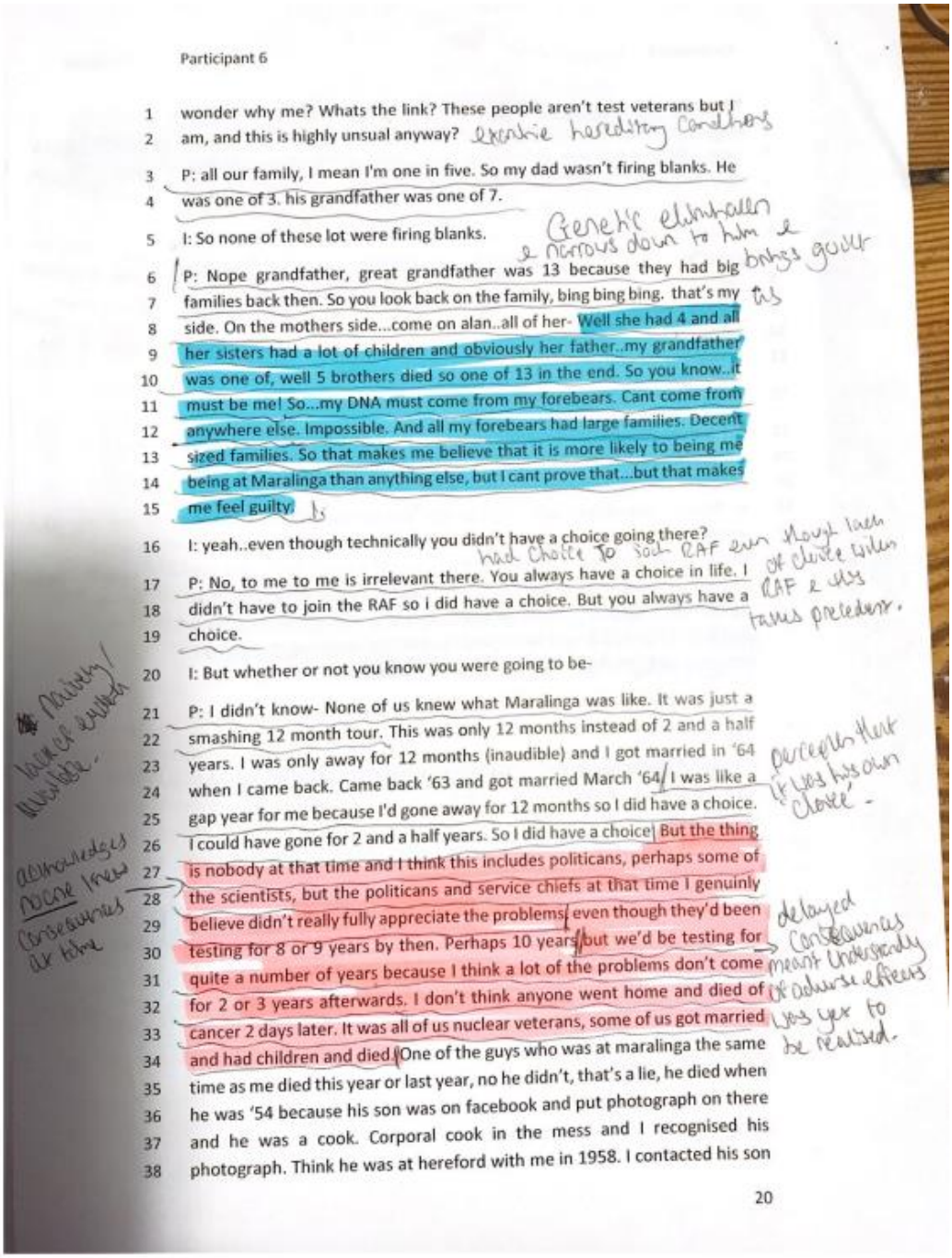
I: You don't think the heart is-?

P: For mine I don't think it is. I don't think the problem I might have because I'm going into hospital next week, a week on friday on the 8th to have a couple of procedures in the afternoon there which I'm not looking forward to. Because one of them when they have to look at your bladder will bring water to your eyes to see where they stick the little tube so I'm not looking forward to that but its no different from havign a catheter. Had a ctaheter when i was in hospital a couple of years ago. Because the other thing ive got which I don't think- I don't know whether its related, I've got osmething called Barrett's oesophagus which is scarring of the oesaophagus which can turn to cancer. Whether that's related to it I don't know.

I: How do you sort- Not sure how to word this. How would you decide on which conditions might be or how do you rule out conditions?

P: I don't know how you can. i just don't know how you can rule them out. I can say Barrett's oseaphagus scarring of the oesaophagus which I've got and the reason when they did my (inaudible) which is where they geta bit of your stomach to wrap it round to close your oesaphuags cause I had a hernia. When I have that they said it will only be 70% so in other words I can still get it because..of the scarring of the oesophagus. So because the scarring was that bad they couldn't fully close it. So if that was caused by- What was that caused by? Acid coming up? I mean that's what usually causes it. Could it be related to, I don't know? I'd say not, all of my problems could be natural but I don't know and until we do the- And I still wont know because unfortuantely the blood tests we have we wont know the results of it so how would we know whether it could(?)..

I: yeah i think its interesting how people attribute certain conditions. I think going back to...the issues with your wifes birth, and how you mentioned the other sides of your family all had big families, lots of kids, and then you



Participant 6

wonder why me? Whats the link? These people aren't test veterans but I am, and this is highly unusual anyway?

P: all our family, I mean I'm one in five. So my dad wasn't firing blanks. He was one of 3. his grandfather was one of 7.

I: So none of these lot were firing blanks.

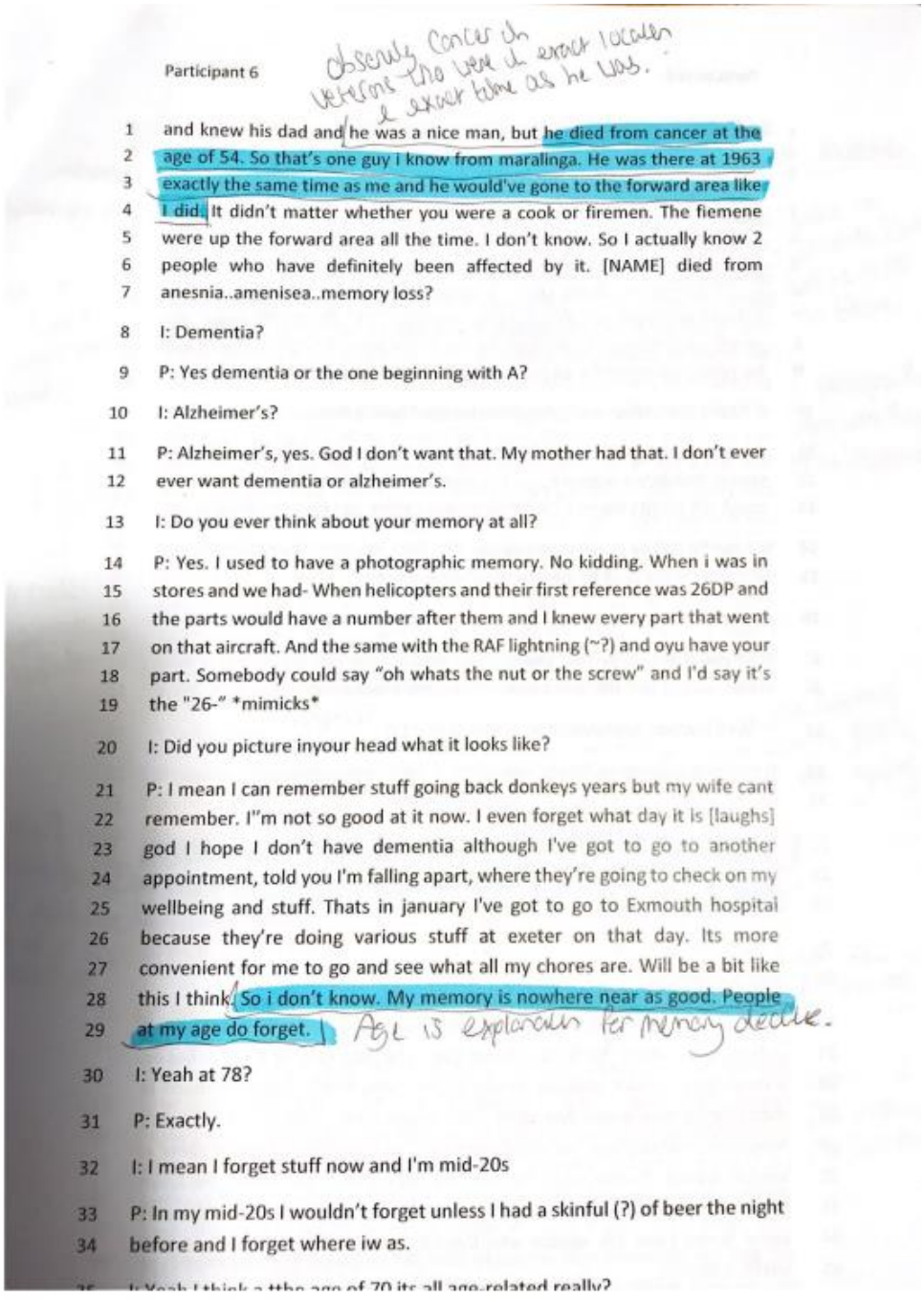
P: Nope grandfather, great grandfather was 13 because they had big families back then. So you look back on the family, bing bing bing. that's my side. On the mothers side...come on alan..all of her- Well she had 4 and all her sisters had a lot of children and obviously her father..my grandfather was one of, well 5 brothers died so one of 13 in the end. So you know..it must be me! So...my DNA must come from my forebears. Cant come from anywhere else. Impossible. And all my forebears had large families. Decent sized families. So that makes me believe that it is more likely to being me being at Maralinga than anything else, but I cant prove that...but that makes me feel guilty.

I: yeah..even though technically you didn't have a choice going there?

P: No, to me to me is irrelevant there. You always have a choice in life. I didn't have to join the RAF so i did have a choice. But you always have a choice.

I: But whether or not you know you were going to be-

P: I didn't know- None of us knew what Maralinga was like. It was just a smashing 12 month tour. This was only 12 months instead of 2 and a half years. I was only away for 12 months (inaudible) and I got married in '64 when I came back. Came back '63 and got married March '64. I was like a gap year for me because I'd gone away for 12 months so I did have a choice. I could have gone for 2 and a half years. So I did have a choice. But the thing is nobody at that time and I think this includes politicans, perhaps some of the scientists, but the politicans and service chiefs at that time I genuinly believe didn't really fully appreciate the problems, even though they'd been testing for 8 or 9 years by then. Perhaps 10 years, but we'd be testing for quite a number of years because I think a lot of the problems don't come for 2 or 3 years afterwards. I don't think anyone went home and died of cancer 2 days later. It was all of us nuclear veterans, some of us got married and had children and died. One of the guys who was at maralinga the same time as me died this year or last year, no he didn't, that's a lie, he died when he was '54 because his son was on facebook and put photograph on there and he was a cook. Corporal cook in the mess and I recognised his photograph. Think he was at hereford with me in 1958. I contacted his son



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Observes Cancer in veterans who were in exact location & exact time as he was.

and knew his dad and he was a nice man, but he died from cancer at the age of 54. So that's one guy I know from maralinga. He was there at 1963 exactly the same time as me and he would've gone to the forward area like I did. It didn't matter whether you were a cook or firemen. The fiemene were up the forward area all the time. I don't know. So I actually know 2 people who have definitely been affected by it. [NAME] died from anesnia..amenisea..memory loss?

I: Dementia?

P: Yes dementia or the one beginning with A?

I: Alzheimer's?

P: Alzheimer's, yes. God I don't want that. My mother had that. I don't ever ever want dementia or alzheimer's.

I: Do you ever think about your memory at all?

P: Yes. I used to have a photographic memory. No kidding. When i was in stores and we had- When helicopters and their first reference was 26DP and the parts would have a number after them and I knew every part that went on that aircraft. And the same with the RAF lightning (~?) and oyu have your part. Somebody could say "oh whats the nut or the screw" and I'd say it's the "26-" *mimicks*

I: Did you picture inyour head what it looks like?

P: I mean I can remember stuff going back donkeys years but my wife cant remember. I"m not so good at it now. I even forget what day it is [laughs] god I hope I don't have dementia although I've got to go to another appointment, told you I'm falling apart, where they're going to check on my wellbeing and stuff. Thats in january I've got to go to Exmouth hospital because they're doing various stuff at exeter on that day. Its more convenient for me to go and see what all my chores are. Will be a bit like this I think. So i don't know. My memory is nowhere near as good. People at my age do forget. Age is explanation for memory decline.

I: Yeah at 78?

P: Exactly.

I: I mean I forget stuff now and I'm mid-20s

P: In my mid-20s I wouldn't forget unless I had a skinful (?) of beer the night before and I forget where iw as.

I: Yeah I think a tthe age of 70 its all age-related really?

Participant 6

P: I think parts of your brain keep dying off once youre born [laughs].

I: Yeah. You don't relate this to your involvement in maralinga at all?

P: No. I don't think most people- Actually I've got a sister who's getting a bit that way now. I mean she's in her 80s, and my mother, she had dementia so, and that was terrible. She didn't know anybody for 10 years. 10 years. I had to put her dog down. I know it's a horrible thing to say about your own parents but it the life was nothing. Just filled and filled with drugs. She ended up in hospital in the end. I went to see her every week. God it was horrible. Talk to her for an hour, she wasn't registering anything.

I: Yeah I don't think a lot people understand how difficult it gets-

P: Yeah well I spoke to her just in case she could understand what I was saying. She didn't appear to, just in case there was something in there that could still could take on board things I was saying, so I kept speaking to her.

I: Yeah I'd do the same. Well you don't know if you don't try and at the end of the day they're still a person so why would you-

P: Exactly. Quite right.

I: So you don't relate the- you said you don't think- The memory you think is age related and this is because other sides of your family had it.

P: Well mother, grandmother, anybody else (?)

I: So the things you relate to maralinga are the things which are unique to you?

P: Yes. Exactly. They have to be. If I know somebody else in the family has got something similar then I would, I wouldn't think it is mainly..what I can't find another answer for, if you like? Is there another reason, I don't know.

I: Yeah and I guess besides Maralinga there arent any other explanations to your knowledge?

P: no, no. When we were out in zambia we were only patrolling to stop fuel getting to southern rhodesia in those days. The pilot said we'd never fire on a rhodesian aircraft anyhow. It was quite funny really. I had relations in rhodesia at the time. My aunt and uncle lived over there. He was headmaster at salsibury university or school or something, then he came at london school of economics because he fell out with Ian Smith. He knew him and he fell out with Ian smith. He didn't think he should do UDIs so he came home then. My cousin who lived in london [talk re Rhodesia SKIP UNTIL 1:00:00].

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to be would have to know what the reaction to nuclear fallout would be.

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I: so in addition to- So your health conditions, the wife, where there any other life events which have you related to maralinga at all?

P: Apart from my anger and frustration, no? Deep down I'm very angry. Anger and guilt rather than frustration. Guilt. Because, I know you say it isn't my fault and yes I understand it isn't my fault but I can't convince myself it isn't my fault. Can you understand that? It sounds totally illogical but I can't. Still feel guilty and so angry not only the way we were treated using hinsight, I know, but the way the aboriginies were treated. I just think- We should have realised- Well a terrible thing happened when we were playing football one day. One of our players- Not our player, playing on the other time (inaudible). Msut've been in his 30s, collapsed and while we were giving mouth to mouth and everything, and by the time the defribbilator came he was dead. We had to dress up in full blues and because we worked on the aircraft we formed a guard of honor and carried the coffin up. This coffin was heavy. Really really heavy. We carried it on, put it down, took the seats off. The air hostess refused to fly back in the aircraft with a dead body because its bad luck so she had to stay up in the officers mess of course so we couldn't get hold of her [laughs]. And I found out when I went into the stores, "this bloody coffin was heavy, he wasn't that heavy"...and they said "well its lead lined". So all the coffins up there were lead lined. Why would they have lead lined coffins?

I: radioactive-

P Exactly. Exactly. And again then I didn't think anything of it. So naive when you're out there because most of the time you're having a good time. In the bar playing snooker, playing darts in the evening. No heavy work, you know down to the train do that, up to the airfield, get people on and off, wave to the air hostess, go tell them what she was like, every towns a party, how to spend your parcels (?), christmas was brilliant. It was very good.

I: And you didn't think about the risks?

P: No risk at all because we weren't told there was any risk. If you're not told theres any risk then there isn't one. Guys from sort of 18 to 40 were out there. Most of them 18, 19, 20. How old was I? I had my 21st birthday over there. So I wasn't old. You just decide to enjoy yourself you know? Have a game of snooker, the MCOs club if there was a quiz on, spend most of the time in the in the OR's *inaudible*. Most people convened there because it didn't matter what rank you were. Well the ranks, it was aything. Even the senior MCOs used to come in, you know? Anybodies 21st, anybodies party it would be full. And of course you remember we had the army, navy, air force, civilians, RWAF, RWAN, and the aussie army so you

Participant 6

had all different service personell out there. Mixed quite well, sometimes there'd be a fight between the austrlaians and the UK. One night they'd try *inaudible* over the head with beer bottles. Two of our guys were locked up in jail *skip*

P: there was nothing else to do. You worked. Not everybody drunk, I must admit not everybody drunk, but unfortunately I did, I had quite a big problem which I'm not proud of now. 5 o clock we'd finish, shower, bar up, in the bar get 3 pint jug of beer, fill another 3 pint jug, go for a meal, come back, that'd be all because the bar shut at 6, so you have 3 pints, go in, come out, you've got one 3 pint jug waiting til 7 o clock til it opened again. Then the bars open again! It was alright *inaudible*. It was terrible. I have to say, as a person it was quite enjoyable. We all got on so well. Such good friends, you know? Really good. All in the same boat. No women at all so you had to make your own arrangement (?) and it was really really good. Everyone got on so well. And now when I talk to [name] who was a firemen, he remembers the good times as well. "We had a good time, didn't we Alan?". He got a photograph with me and he was leaving the night there, cause some of my friends were leaving that day, I went down that day to adelaide to see them off. He and I are on the airfield both smoking, and he said to me on the phone, "we'd be shot today smoking on the ground, near fuel" cause you're not allowed to smoke near fuel and we'd just stand there smoking our fags. Crazy. Any more?

I: So I think I've gone through most of my questions, haven't really looked at them.

P: Gone through your tick list?

I: final question, so maybe just another 15 more minutes if that's ok? This relates to identity. So can you tell me what it means to be a nuclear test veteran?

P: I think my view is, sorry got my hand over my. My view of a nuclear test veteran..is that we're all members of the msuhroom club, kept in the dark, shovelled shit from time to time. And that plaque up there tells you what else we are. Guinea pigs. Guinea pigs. That's what we are. That's my view of what nuclear test veterans are. A bunch of people who haven't a clue what they are doing who were sent out there as guinea pigs to work on tests. They would never have sent us to the forward area where theres nothing to pick up, to pick up bits, if that hadn't been part of being guinea pigs and beign part of the msuhroom club. That was a tactical..move...to see what the reaction would be. And being cold-blooded and cold hearted about it, that would have been absolutely necessary. Because the powers

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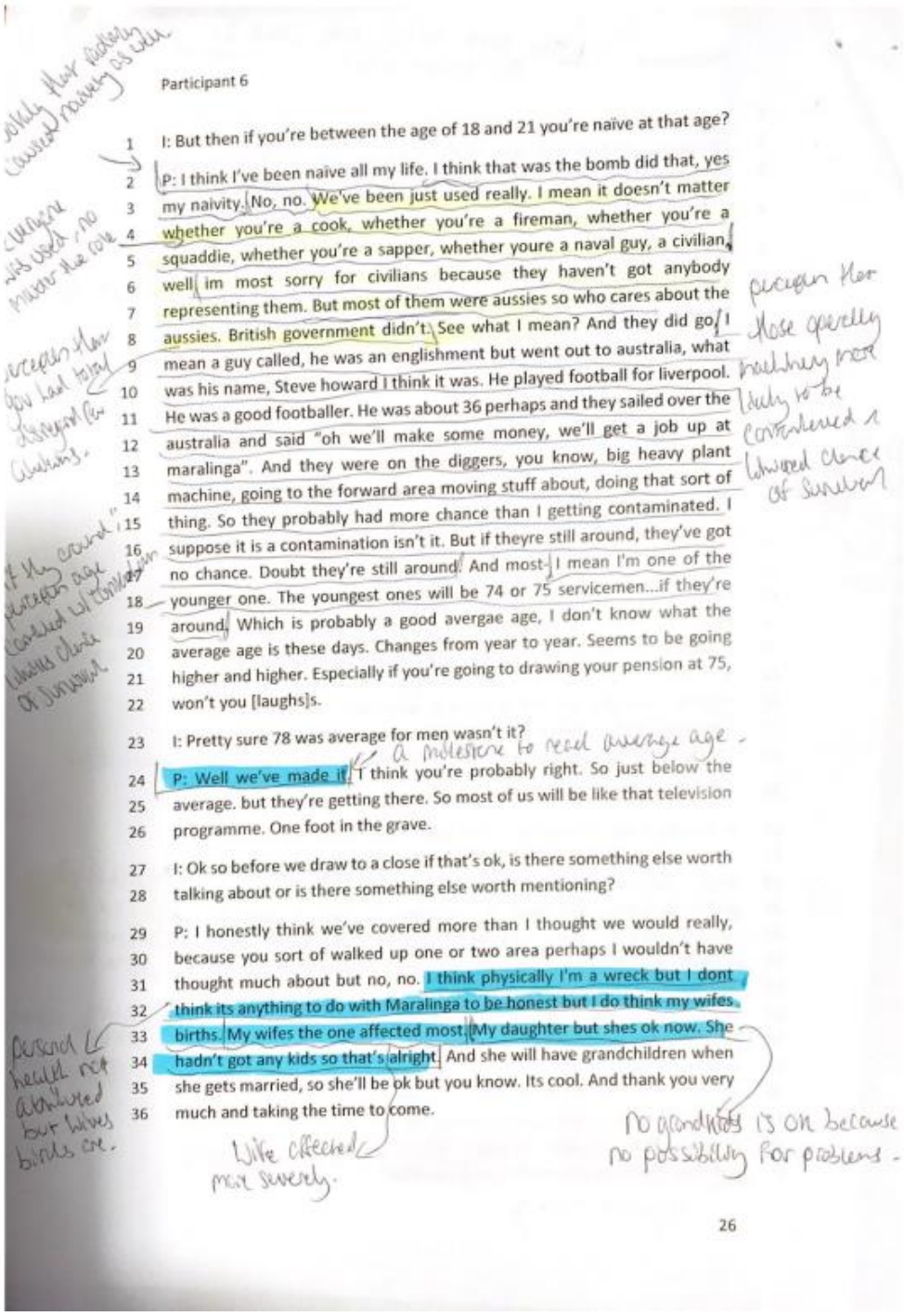
1 to be would have to know what the reaction to nuclear fallout would be.
2 They'd have to know it so they'd take precautions against it. So that's why I
3 think, you know, my view of what nulear test veterans were used for.

4 I: Even though we had hiroshima and nagasaki years before?

5 P: That- They couldn't, our government couldn't get samples from Japan to
6 assess how other people work. The only way they could do it was by using
7 our own troops. That's the only way they could do it. Think about it. That's
8 the only way they could do it. Now I'm using hindsight here for a person
9 who's relatively intelligent who's a bloody idiot to do it! I didn't know. None
10 of us knew! Simple as that. None of the guys who stood on the deck of the
11 ships when they did the first test, and watched the test, well they didn't
12 they put their hands over the face. Hands over the face! I mean come on
13 that's ridiculous. I mean that's hindsight. At the time everybody thought it
14 was brilliant. I had a friend who'd been to christmas island. Oh its brillint
15 seeing this mushroom, really good. Nobody thinks those things. Oh aren't
16 we lucky? Now of course but that's hindsight. Not at the time, nobody
17 knew. Well I lie, the scientists and the people really at the top must've
18 known. Why would be minister for air, hugh fraser I think it was? Why would
19 he bother to go out to the nuclear tests if it wasn't something really
20 important that he wanted to be involved in. Thats what i think. but as i say
21 at the time, thats (inaudible). Not a clue. But I think nuclear test veterans
22 what are we? We are- We're just used as guinea pigs. And part of the
23 mushroom club. And have been part of that service on numerous occasions.
24 But that's the services for you.

25 I: So you witnessed some of the tests did you?

26 P: By witnessing, I was there for the tests. I went out to the forward area,
27 but actually being within..6 or 7 miles of it, no. But I think that handling the
28 nuclear material, going out to the forward area, I think just being in
29 maralinga to be quite honest, I reckon maralinga would be contaminated
30 anywhere around there. *inaudible* so I think the airfield would be
31 contaminated because of the things like that fireengine coming in and out,
32 not being decontaminated, sometimes they hosed them down, the guys
33 coming in and out, I mean some of the firemen would have had their suits
34 on when they were hosing things down but other ones like the driver and
35 people who worked to do the hosing down would've been sitting in the sun
36 getting a tan. Because that's what you did. When you went out in the
37 forward area you'd walk across deserts, desolate place with these shiny
38 things "oht hat looks nice". No paper, "oh pick up some paper". How stupid
39 was that. Well how stupid were we. *inaudible*.



Participant 6

I: But then if you're between the age of 18 and 21 you're naïve at that age?

P: I think I've been naïve all my life. I think that was the bomb did that, yes my naivity. No, no. We've been just used really. I mean it doesn't matter whether you're a cook, whether you're a fireman, whether you're a squaddie, whether you're a sapper, whether youre a naval guy, a civilian, well im most sorry for civilians because they haven't got anybody representing them. But most of them were aussies so who cares about the aussies. British government didn't. See what I mean? And they did go, I mean a guy called, he was an englishment but went out to australia, what was his name, Steve howard I think it was. He played football for liverpool. He was a good footballer. He was about 36 perhaps and they sailed over the australia and said "oh we'll make some money, we'll get a job up at maralinga". And they were on the diggers, you know, big heavy plant machine, going to the forward area moving stuff about, doing that sort of thing. So they probably had more chance than I getting contaminated. I suppose it is a contamination isn't it. But if theyre still around, they've got no chance. Doubt they're still around. And most I mean I'm one of the younger one. The youngest ones will be 74 or 75 servicemen...if they're around. Which is probably a good avergae age, I don't know what the average age is these days. Changes from year to year. Seems to be going higher and higher. Especially if you're going to drawing your pension at 75, won't you [laughs]s.

I: Pretty sure 78 was average for men wasn't it?

P: Well we've made it. I think you're probably right. So just below the average. but they're getting there. So most of us will be like that television programme. One foot in the grave.

I: Ok so before we draw to a close if that's ok, is there something else worth talking about or is there something else worth mentioning?

P: I honestly think we've covered more than I thought we would really, because you sort of walked up one or two area perhaps I wouldn't have thought much about but no, no. I think physically I'm a wreck but I dont think its anything to do with Maralinga to be honest but I do think my wifes births. My wifes the one affected most. My daughter but shes ok now. She hadn't got any kids so that's alright. And she will have grandchildren when she gets married, so she'll be ok but you know. Its cool. And thank you very much and taking the time to come.

Participant 6

I: Thank you for taking part. Final question, have you looked on your wifes side of the family, her mother, her grandmother if they had issues with birth at all?

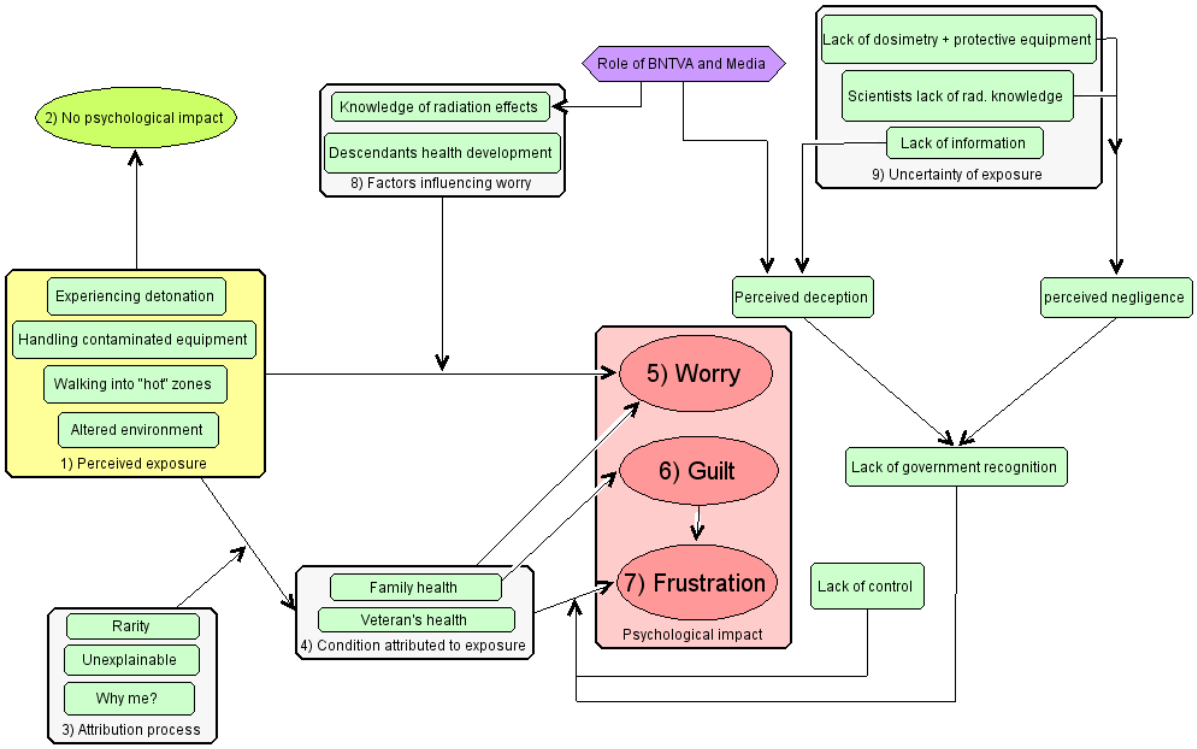
P: No I didn't. Families irish one side and I can trace her macclesfield side back to 1400 because the family were mayors of macclesfield. Very rich family years ago, they had son after son after son and traced her line out until the last generation it was the *inaudible* so they ended up with farms all over cheshire at one time. But it was easy to trace back because of the heriditary of it. So her and her fathers side were traced back. All big families. And on the mothers side, more difficult on the grandmothers side because she was irish and a lot of the irish records got blown up in the wars in dublin. When the prince and the irish were fighting so I have an inkling that her grandfather, great grandfather on her mothers side- no grandfather on the mothers side might have fought for the irish against the brits and my grandfather fought for the brits against the irish. My grandfather was born in dublin during the troubles. Right sir!

I: Perfect, I'll draw that to a close shall I?

P: Thanks very much!

Appendix O.

Chapter 6 (Continued): Draft Conceptual Model



Appendix P.

Chapter 7: Cross-Tabulation for Dichotomised Current Exposure Worry, Health Belief, and Clinically Relevant Anxiety Screening Variables

Cross-Tabulation for health Belief and clinically relevant anxiety.

		Clinically relevant anxiety	
		No	Yes
Health belief	1 (strongly disagree)	4	0
	2 (disagree)	9	4
	3 (agree)	14	6
	4 (strongly agree)	7	11

Cross-Tabulation for exposure worry and clinically relevant anxiety

		Clinically relevant anxiety	
		No	Yes
Exposure worry (dichotomised)	Disagree	28	3
	Agree	6	18