



“Is that a coincidence?”: Exploring health perceptions and the causal attributions of physical health conditions in British nuclear test veterans



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ABSTRACT

Since the British nuclear testing programme, there have been several claims in the media and from the veterans themselves that their health (and descendants' health) has been adversely affected by ionizing radiation exposure. Many health conditions associated with ionizing radiation exposure are also age-related. Therefore, the purpose of this study was to explore how British nuclear test veterans, with varying health conditions, perceive their health and attribute causes 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. Semi-structured interviews were conducted with 19 British nuclear test veterans and were analysed using thematic analysis to generate broad themes describing the data. Four themes were generated: (i) Sources of health risk information over the life course, (ii) Luck, (iii) What is 'normal'? and (iv) Experience with healthcare professionals. Health conditions perceived as not 'normal' considering one's age, lifestyle, and hereditary risk, or perceived as incurable, appeared more likely to be attributed to radiation exposure. Recommendations relating to transparency for authorities dealing with exposure scenarios, and subsequent genetics and epidemiological research are discussed. Healthcare professionals may benefit from understanding patients' narratives in healthcare consultations with individuals who perceive radiation exposure to have impacted on their health.

1. Introduction

Following the atomic bomb events dropped by the United States of America (USA) during the second world war, nuclear weapons testing proliferated during the early 1950s. Some 22,000 men participated in the British nuclear testing programme between 1952 and 1958 and in clean-up operations extending into the 1960s at Christmas Island/Kiritimati and Malden Island (present-day state of Kiribati) and Australia (Monte Bello Islands, Emu Field, Maralinga) (Darby et al., 1988; Kendall et al., 2004; Rake et al., 2022). British personnel were also involved in underground testing and atmospheric testing at the Nevada Test Site in co-operation with the USA (Kendall et al., 2004). Despite only 8% of the cohort receiving a non-zero dose and only 37 individuals (predominantly Royal Air Force personnel) receiving a dose greater than 100 mSv (the maximum dose recorded was 300 mSv according to available dose records; Kendall et al., 2004), there have been claims their health and the health of their descendants has been affected by ionizing radiation exposure. Previously, there had been no evidence to suggest an increased

risk of cancer incidence or mortality in this veteran population (Darby et al., 1988, 1993; Muirhead et al., 2003, 2004) but a recent updated analysis reported a 2% increased risk of overall mortality compared to veteran controls, driven by 2% and 3% increased risk of mortality from all cancers combined and non-cancer diseases (Gillies & Haylock, 2022). Outside of the British testing programme, the incidence of certain cancers (Haylock et al., 2018), cataracts (Azizova et al., 2018; Little et al., 2021), and cardiovascular and circulatory diseases (Azizova et al., 2015; Tapio et al., 2021), for example, have all been associated with ionizing radiation exposure but at doses higher than what most British nuclear test veterans (BNTVs) are recorded as having experienced. Interestingly, these health conditions are also age-related (North & Sinclair, 2012; Richardson, 2009; Seddon et al., 1995; White et al., 2014).

The linear no-threshold model (the commonly used model by regulatory authorities for radiation protection) implies there is no threshold for stochastic health effects, such as cancer, to occur (i.e. there is no safe dose level of ionizing radiation) (National Research Council, 2005). Despite this, specific attribution of stochastic effects to ionizing radiation

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is difficult because the effect manifests many years after exposure. Further, confounders such as exposure to other mutagens or carcinogens through lifestyle, occupation or medically mean that epidemiological studies often lack statistical power to support evidence for a radiation effect, especially at very low doses (Shore et al., 2018). As such, veterans of nuclear testing programmes may face considerable uncertainty in understanding any health conditions or symptoms in the light of (perceived) exposure. This uncertainty could be further influenced by allegations regarding inadequate protective equipment or inconsistencies in safety procedures, and the limited proportion of British veterans with available dose data (generally limited to external gamma radiation) (for further information please see Arnold, 1987; McClelland, 1985).

The term 'attribution' refers to inferences that people make about the causes of events or of states of being (Michaela & Wood, 1986). Causal attributions of medically explained and unexplained health conditions tend to include genetics, lifestyle, psychological stress, or mystical/spiritual explanations (Bennett et al., 2016; French et al., 2001; Gall & Bilodeau, 2017; Kimber et al., 2021; Shiloh et al., 2002). Studying attributions is important because they are associated with subsequent behaviours (e.g. lifestyle change, treatment adherence) and psychological outcomes (Bennett et al., 2016; Gall & Bilodeau, 2017; Harvey & Weary, 1984; Leventhal et al., 1980; Roesch & Weiner, 2001; Weinman et al., 2000). Moreover, understanding how people attribute their symptoms and conditions is a key aspect of narrative medicine: an increasingly popular patient-centred approach which accounts for varying perspectives regarding health conditions and how to use these interpretations in a treatment plan (see Cenci, 2016 for overview). Indeed, understanding perspectives of symptoms and conditions is critical for good patient-centred care when the causes are difficult to ascertain. Emerging research involving Gulf War veterans with medically unexplained symptoms (MUS) attests to this (Bloeser et al., 2021; Phillips et al., 2017): a providers' attribution of MUS to ageing may result in patient dissatisfaction and reinforce perceptions of institutional betrayal (Bloeser et al., 2021).

While causal attributions have been well examined in samples characterised by 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 this in a cohort which shares the experience of a singular profound event (e.g. nuclear weapons testing). Therefore, the purpose of this article is to report qualitative findings exploring how BNTVs, with varying health conditions, perceive their health and attribute causes 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.

2. Materials and methods

2.1. Participants

Research packs were distributed to 246 BNTVs listed on a mailing list (compliant with data protection principals) provided by the Nuclear Community Charity Fund (<http://thenccf.org/>). An advert with information about the study and contact details was also placed in the quarterly charity fund magazine. Fifty-nine BNTVs consented to being contacted regarding in-depth qualitative interviews. Of these, 29 veterans were invited to take part based on geographical clusters with the aim of conducting between 15 and 20 interviews. Fifteen BNTVs agreed to participate in a face-to-face interview and a further four agreed to a telephone interview. Thus, a total of 19 BNTVs (aged between 75 and 89) were interviewed.

Thirteen participants were stationed at Christmas Island (Kiritimati), four at Maralinga, one at the Monte Bello Islands, and one at Malden Island. Fourteen participants witnessed one or more weapons tests, and the participants who did not witness any tests were primarily involved in the clean-up operations. Most, but not all, participants had various health conditions. The specific diagnoses are not reported here to protect

participant anonymity. Participants received study information prior to the study, and on the day of the interview they were briefed, assured full anonymity, and were made aware that they were free to withdraw from the study at any time with no consequences. Participants provided informed consent.

2.2. Interviews

The interviews were biographical in nature. Each interview began by asking the participant to describe what life was like in the few years leading up to their service in the nuclear testing programme. Participants then described their nuclear testing experience and continued until the present day in a chronological fashion. The interviews were semi-structured and loosely followed a schedule covering a broad range of topics: identity, uncertainty, risk perception, health, subsequent life events, and cognitive function. The topic of health came up naturally in most interviews, but otherwise to elicit discussions on the topic of attributions of health conditions, participants were asked "do you have any health conditions?", followed by "what do you think caused these?" depending on the response. Responses were then probed to elicit in-depth data.

Since the interviews were biographical, and relied heavily on the recall of past events, face-to-face participants were encouraged to have ready photographs significant to their testing experience, drawing on aspects of photo-elicitation (Silver, 2013). Some participants presented photographs taken during the testing programme and photographs taken from medical imaging of descendants, while some participants also presented documents such as health reports, newspaper clippings, brochure-type documents from their service, and other relevant documents (e.g. safety protocols). Individuals can find significance and meaning in objects or documents aside from photographs which facilitates memory and discussion regarding potentially sensitive topics (Barton, 2015). These photographs and documents were used solely to facilitate discussion and were not used in any analysis.

The face-to-face interviews took place in the participants homes, while the telephone interviews were conducted in a private, secure room in a university department building. Veteran family members were present in three of the face-to-face interviews and were aware that the purpose of the research was to interview the veteran, specifically. In these interviews, the family members would engage in discussion with the veteran, and these discussions were encouraged to continue to gain further perspectives on the topics. All interviews were conducted before the Covid-19 pandemic. The interviews were audio recorded and ranged from 45 min to 2 h 17 min in duration.

2.3. Analysis

The interview recordings were transcribed verbatim and analysed using thematic analysis following the guidelines by Braun and Clarke (2006) to generate themes giving a rich description of the verbal data. A reflexive diary was kept by the lead researcher which included thoughts pertaining to potential themes and any key interactions between participants and family members present during the interview. After all interviews had been recorded and transcribed, the coding process 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. By examining highlighted segments as a visual indicator of trends, relevant codes and quotes (obtained from digital versions of the transcripts) comprising potential themes and subthemes were inputted to digital tables and further refined. Notes to facilitate the writing of themes and to identify quotes which may overlap multiple themes were included in the digital table. The reflexive diary played a role in noting areas of importance. Themes were identified with the intention of an inductive approach to analysis.

3. Results

The topics elicited through the interviews were broad: the participants talked about a range of physical, social, and psychological aspects relating to their time in service. While details relating to the psychological impact are provided in a separate article (Collett et al., 2021), this article focuses on the health perception findings.

Four themes were generated: (i) *Sources of health risk information over the life course*, (ii) *Luck*, (iii) *What is 'normal'?* and (iv) *Experience with healthcare professionals*. These are presented generally in chronological order for convenience, where the first theme includes subthemes relating to the testing experience specifically, while the remaining themes relate to experiences and perceptions after the tests.

3.1. Theme 1: Sources of health risk information over the life course

3.1.1. Observations during the testing experience

Most participants, especially those who had witnessed weapons tests, were keen to describe their experience of the British nuclear weapons testing programme. Generally, they described the detonation to be an extraordinary and awesome experience, and recollections of the visual aspect of the nuclear weapons tests were vivid. Some participants would recall the weather and other details which would otherwise be considered as mundane. 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. Six participants described the wind or the sensation of heat from detonation. These sensations were sometimes used to demonstrate the perception of being irradiated and, in a couple of interviews, were sometimes linked to specific health problems:

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. (Veteran J)

In addition to the sensate experience, four participants would comment on the non-existent sensate experience of radiation itself. While, with hindsight, they believe the area was contaminated, they were unable to smell, touch or see it at the time, and as such are unable to determine the extent they had been exposed to ionizing radiation. Despite this, six participants described the impact of the tests on the environment around them, for example the wildlife and the trees, and molten sand or rock from the heat of the blast, as an indicator of the risks of nuclear weapons testing. The following quote illustrates this effectively, though it is unclear whether these perceptions were current at the time or in hindsight:

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? (Veteran K)

3.1.2. Availability of risk information

Many participants described how their present-day perceptions contrasted with their perceptions at the time of the nuclear testing programme. In general, the participants described how they had no initial consideration for risk to their future health. For example, a couple of participants said while at the time they knew what a nuclear bomb was because of their awareness of the atomic bomb events of the second world war, this had limited significance to them in terms of health risk. What appeared pertinent in the interviews was the relatively limited availability of knowledge about radiation, or perhaps, limited access to the knowledge existing at the time compared with the present day:

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. (Veteran Q)

The perceived limited risk during the tests may also be influenced by their young age at the time. For example, nine participants mentioned this, suggesting that young adults are generally unlikely to be concerned about health risks in this context.

3.1.3. Subsequent indicators of risk: health-related events, veteran associations, and media

For most participants, the limited perceived health risk persisted throughout the next decade following their service. The actual duration of this varied between veterans due to specific events that followed, such as the birth of descendants, experiencing health conditions, formation of the British Nuclear Test Veterans Association (BNTVA), and the emergence of press reports about nuclear testing health effects. In one case Veteran N who witnessed weapons tests at Christmas Island, had little concern over his lifetime for the risks of radiation exposure on his health:

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? (Veteran N)

Even in the scenarios where first-generation descendants were born with serious health conditions, or partners' miscarriages, these few veterans said they initially had no reason to attribute it to their prior service. This was because their awareness of other veterans with similar problems had not come to light yet. Without the knowledge of perceived ionizing radiation effects then there was no reason to link any health conditions in themselves or family members to their exposure:

... 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. (Veteran F)

The 1980s appeared to be a central transition period, marked by the formation of the BNTVA, and the emergence of media reports describing perceived health effects and mortality attributed to ionizing radiation exposure. For several veterans, attending BNTVA and other veteran meetings were sometimes described in the context of perceived health risk. Some told of their experiences socialising at these meetings and learning of health issues in other veterans, or learning through BNTVA magazines:

On top of that, my wife had two miscarriages, and nobody could think of the reason why. Not long after that I went to Blackpool for a meeting with the nuclear veterans and I found that quite a number of the chaps that were there had lost babies in the same way and could only surmise that it was through radiation. (Veteran K)

To summarise the first theme, any perceived radiation risk to participants' health or family members' health was not persistent over a lifetime. The young age, excitement of visiting a foreign land, and limited access to radiation-related risk information at the time of the weapons tests were reasons for limited perceived health risk. This limited perceived health risk persisted for several years for most participants. Even in cases where a serious health condition was realised in family members, these participants recalled not associating this with ionizing radiation exposure. The 1980s appeared to be a central period marked by

the formation of the BNTVA and emergence of newspaper articles. The lifetime of experiences and exposure to information disseminated through media reports and through communications with other people forms a set of present-day health beliefs and perceptions. These will be detailed in the subsequent themes.

3.2. Theme 2: Luck

The notion of luck was especially salient across the interviews and was discussed in many regards. For example, many participants described themselves as 'lucky' regarding their own health, their survivorship, or their family's health. Eight of these expressions of luck were described in the light of involvement in the weapons testing programme. Furthermore, one participant (Veteran Q) described himself as lucky to have witnessed a nuclear weapons test. As such, luck might be a central part of the nuclear test veteran identity, for example Veteran L describes what it means 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 ... I've been very lucky. Not to be on the test but to survive it. (Veteran L)

To further illustrate this perception of luck in the context of perceived ionizing radiation exposure, Veteran I described how everyone that was present was perceived (in hindsight) to be vulnerable to radiological contamination. Whether a radiation-related health condition developed was perceived to be due to luck:

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 thisyou think how lucky you are really, and it does make me cry. (Veteran I)

This perception of luck was discussed in relation to some participants' family's health:

There were no after affects, fortunately. That's why I've been blessed with the luck of that as well. We didn't know at the time, but she's suffers from none of the effects at all which I know goes against what I've read about other people, you know. I know that but once again I couldn't say. With luck on my side or her side, she's not suffering from any effects of me. (Veteran L)

As indicated above, some participants' (3) perception of luck stemmed from reading media reports of nuclear test veterans elsewhere. Interestingly, Veteran D 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. This suggests that the perceived luck may be influenced by media reports disseminating negative health outcomes in BNTVs.

The perception of luck may also be linked to the general ageing process. For example, following a discussion regarding multiple transient ischaemic attacks, which he did not attribute to radiation exposure, Veteran D notes: "You're very lucky to go through life without getting something wrong with you".

Veteran M also alludes to luck in relation to general ageing:

But these things, life's a horrible thing you know? But for some people they run right through life with no problems, other people nothing but trouble, you know? That's what I say, at my age I say to myself "I'm bloody lucky", you know? Because, well next door, he did his national service but he only did it down in Kent, never went abroad and that, but he's got arthritis in his legs and can hardly walk. Now he's exactly the same age as me but more or less stuck in doors. (Veteran M)

It is interesting to note that Veteran M draws comparisons between himself and another veteran who did national service, albeit not in the context of any nuclear weapons testing. He demonstrates that arthritis

can occur in veterans with no perceived ionizing radiation exposure. These comparative processes form the next subtheme labelled 'What is normal?'.

3.3. Theme 3: What is 'normal'?

3.3.1. Social influence on health perceptions

The social processes veterans use to understand which health conditions are attributed to radiation exposure was a prominent feature. Common questions asked by those with health conditions (particularly those that are unexplained) were akin to 'why me?' That is, why should I have this health condition, but others do not? Why should I have this condition, and what makes me different to others of my age group? This was also relevant when explaining their family members' health conditions:

Why have I got 3 grandchildren that've each had a problem and then I can think of many of my friends who have got nothing wrong with them. Is that a coincidence? I don't know. Why have my two daughters both having major gum problems? Don't know. (Veteran D)

Above, Veteran D compares his situation to non-veteran friends and asks himself whether it is a coincidence or not. In answering this, veterans may identify ionizing radiation exposure as the unique factor distinguishing themselves from others. Like Veteran D, Veteran F draws comparisons between his immediate family and the families of his close relatives to understand his wife's ectopic pregnancies:

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?" (Veteran F)

Similarly, Veteran H perceived that a "normal father" is one who has not been exposed to radiation, and this was used as his explanation for his descendant's health condition.

3.3.2. Perceived age norms and lifestyle influence

Participants would also consider what the "normal" health conditions are that can be expected for a male older adult while accounting for lifestyle factors. It appeared that the conditions which are perceived as common or expected given one's age or lifestyle are less likely to be attributed to radiation exposure. As such, most health conditions experienced by the veterans in this study were generally not attributed to radiation exposure because they were not experienced early in life, or they could be explained by lifestyle or heredity factors.

To illustrate, Veteran D described how heart attacks and knee pain, for example, are unlikely to be caused by any exposure because they are also observed in older men and in active individuals through wear-and-tear, respectively. Veteran B described how he doubts the possibility that his heart condition could have been caused by exposure due to developing the condition as an older adult. Veteran M described how his polyps could be explained by his prior occupation which had scientifically been linked to polyps and cancer. Veteran R, who was involved in the clean-up operation at Maralinga, explains why prostate cancer and lung conditions could be expected due to his age and lifestyle:

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. (Veteran R)

This focus on age when understanding which health conditions are "normal" could be speculated to apply to their descendants' health conditions. While it was not explicitly discussed in relation to age, there appeared to be a tendency to attribute any health conditions in descendants to the veteran's radiation exposure, relative to the veteran's own health conditions. This could be because health conditions, generally, are less common in younger adults than older adults.

To further illustrate, one topic explored was cognitive health. This was elicited by asking "do you ever think about your memory?" Given that declining memory was often viewed as a typical sign of ageing, the veterans did not perceive any declining memory to be related to radiation exposure. This was further reinforced through instances where veterans described their wives' cognitive health (and age-similar others) as being comparable to their own, like the above processes of considering what conditions are normal for someone of that age.

3.4. Theme 4: Experience with healthcare professionals

3.4.1. Medical uncertainty

The experience with healthcare professionals was also a prominent feature in the discussions. Generally, the interactions between the veterans and healthcare professionals often described uncertainty regarding attributing their conditions and symptoms to ionizing radiation:

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]. (Veteran P)

While most participants did not have any real resentment at the standard of healthcare that they had received, three participants noted the reluctance of healthcare professionals to confirm that a health condition was caused by ionizing radiation exposure. Some participants acknowledged the medical uncertainty regarding many health conditions, even outside the context of ionizing radiation exposure. But one veteran suggested that the ambiguity regarding causes for certain conditions can lead to an easier explanation, namely age:

But whether any of that is attributed to radiation, who can say? Because 4 years ago, of course was 76 so age- Always get away with it with age. Whatever you've got they can say well your age. That's it. (Veteran B)

Whether or not the health conditions were curable by healthcare professionals also appeared relevant to determining causality. While not all veterans attributed medically unexplainable conditions to ionizing radiation exposure, it appeared that if medical staff were unable to cure it, or unable to explain it, then this could be a reason for attributing it to ionizing radiation exposure. For example, one veteran (Veteran E) attributed his daughter's bronchitis and his son's numerous health conditions to radiation due to the persistence, incurability, and not observing such conditions in other families. Further illustrating curability as a factor, Veteran I describes the development of a strange blister on his palms:

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. (Veteran I)

In a separate case, Veteran K described healthcare professionals detecting radioactivity in his bone marrow when he was taken into hospital for an unspecified illness. Later in his life, following an operation on his knee, radiation in his bone marrow was given as a suggestion for his knee problem. This also appeared to influence Veteran K to attribute later health conditions in himself and in his wife (miscarriages) to ionizing radiation, despite healthcare professionals being unable to determine causality.

3.4.2. Perceptions towards healthcare providers

While most participants did not explicitly describe any real dissatisfaction with healthcare providers, the notion of trust appeared important, where a couple of veterans expressed disbelief in healthcare professionals' alternate explanations for health conditions. For example, some veterans' skin cancers and keratosis had been attributed by healthcare professionals to sun damage, which was treated with scepticism because they do not sit out in the sun often. Despite Veteran F acknowledging that Maralinga is a location marked by strong sunlight, he nevertheless maintains ionizing radiation from weapons testing as a possible explanation for his skin conditions. The scepticism towards healthcare providers suggestions is further illustrated by Veteran I:

But as soon as I mention "do you think it is some sort of development from radioactive stuff?", "Oh no, no, no, no. Nothing of the sort." How can they be so quick to say that when they don't know? You're only asking the question, and never got an answer, so. (Veteran I)

Veteran I's scepticism was explained by stating that most medical staff were not old enough to be present at the nuclear testing programme and, like most of the public, they have limited knowledge or awareness of the British testing programme. In two cases, medical staff were perceived to avoid the topic of radiation exposure, possibly due to the political nature of the nuclear weapons testing programme. For example, Veteran J described feeling let down, due to the perceived reluctance of healthcare professionals to consider ionizing radiation as a potential cause:

The only problem with the hospital, I used to say, "this being I've got bone problems, anything to do with Christmas Island?" "Don't want to go there" he said. "Nothing to do with us, not interested". And I thought "great, thank you very much." Another one said, "we're not allowed to talk about it." I said, "talk about what?". "Well, your problems and how you got them. Nothing to do with us". And I thought "well why can't someone just say I'm not allowed to talk about it and do this that and the other but get your doctor to write to Mr or Mrs so and so who deal with that sort of thing". But no, no one would.

Interviewer: And when they said, "yeah we don't want anything to do about it". Can you describe how that felt?

Well, I felt sort of let-down. Still no one. Nobody wants to know. (Veteran J)

4. Discussion

Overall, we have presented how BNTVs understand the causes of their health conditions, how they perceived health risk over the life course, and we have highlighted their experiences with healthcare providers. These findings can inform general practice as they are exemplars of when understanding the context of health beliefs might improve satisfaction with health service. It must be noted that most participants in this study did not explicitly state dissatisfaction with healthcare received. It is difficult to compare the level of dissatisfaction with healthcare providers with similar recent studies with Gulf War veterans (Bloeser et al., 2021), but we do observe a parallel finding: some BNTVs indicated dissatisfaction at the provider's attribution of some health conditions to ageing due to a perception that it was an 'easy' explanation.

The fact that some veterans may be convinced that some health conditions are caused by ionizing radiation despite receiving alternative explanations from medical staff raises important questions regarding the perceived validity of medical attributions, and suggests that participants' health beliefs can be as strongly influenced by interactions with fellow nuclear veterans and health risk information in the media. This is not to say that attributing physical health conditions to radiation exposure in this context is irrational, because ionizing radiation exposure has been associated with various health conditions in other contexts (Azizova et al., 2015, 2018; Baselet et al., 2016; Haylock et al., 2018; Little et al., 2021). The crux is that accurate dose records are unascertainable in the BNTV cohort, so without definitive information veterans will make varying causal attributions especially considering the continued scientific debate regarding low-dose radiation health risk (Doss et al., 2014; Shore et al., 2018; Vaiserman et al., 2018). Indeed, it is suggested that scientific uncertainty and distrust in authorities (which may have been exacerbated by government secrecy) can drive social groups to amplify health risk in the context of low-dose ionizing radiation exposure (Kasperson, 2012; Kasperson et al., 1988). Without definitive information regarding their health risk and the ambiguous causes of some health conditions, it is expected that some veterans will attribute them to ionizing radiation exposure. This also raises important questions as to how the nuclear test veteran community may process the findings of ongoing genetics and cytogenetics research in BNTVs (Moorhouse et al., 2022; Rake et al., 2022). Due to the perceived lack of transparency and trust in authorities (Collett et al., 2021), effective scientific communication is required to allow veterans to form a balanced opinion in the light of amplified risk (Kasperson, 2012).

We argue that narrative-based medicine could have brought benefits to nuclear test veterans' experience with healthcare providers (Fioretti et al., 2016; Greenhalgh & Hurwitz, 1999; Koffman et al., 2015), particularly since BNTVs have previously expressed perceptions akin to institutional betrayal (Collett et al., 2021) – a concept recently discussed regarding Gulf War veteran interactions with health providers (Bloeser et al., 2021). Biomedical models of illness are reductionist (Kleinman, 1988), and illness is not just constituted by the physical symptoms but includes the individual's interpretations or beliefs about the symptoms and the emotions which accompany this. Similar recommendations can be made, based on the present study and previous work with Gulf War veterans (Bloeser et al., 2021), to ageing populations exposed in other contexts such as nuclear power plant accidents.

Aside from the potential to inform clinical practice, our findings provide insight into how unique veteran subgroups perceive their health in older age. Most participants in this study felt lucky regarding their survivorship and health status in the context of ionizing radiation exposure and ageing. Generally, environmental (e.g. radiation, pollution) and genetic causes (e.g. age, heredity) of health conditions are perceived as relatively uncontrollable (and incurable) compared to behavioural causes (e.g. lifestyle; Ferrucci et al., 2011; Shiloh et al., 2002). Perceived ionizing radiation exposure is entwined with genetic causes, where believing one has been exposed may increase one's perceived risk for genetic health conditions. This may explain the perception of luck when health conditions are attributed to uncontrollable and incurable factors (e.g. ionizing radiation and genetics). It would be interesting for future research to examine whether perceptions of luck are common across all older adults (regardless of perceived exposures) and whether perception of luck influences subsequent health behaviours.

Our findings also shed light on how this unique population attributes causality to their health conditions. It appeared that health conditions considered as incurable were generally attributed to ionizing radiation exposure (in the absence of an alternate explanation), demonstrating that individuals may turn to profound environmental events when interpreting the causes of such health conditions. Generally, it is the *causes* which are thought to vary in their perceived controllability/curability rather than the health condition (Shiloh et al., 2002). The present study indicated that, in a few participants, perceiving a health condition as

uncontrollable/incurable preceded attributing to ionizing radiation. However, it could be that attributing a condition to ionizing radiation precedes perceiving a health condition as uncontrollable/incurable and the veterans point to the characteristics of their health conditions as evidence for their attribution, but this particular sequence cannot be verified in this study.

Another factor was whether the condition was considered 'normal' for a non-irradiated older adult while accounting for lifestyle factors (e.g. smoking). Health conditions in themselves or family members perceived as being not 'normal' relative to the age at which a condition was realised appeared more likely to be attributed to ionizing radiation exposure. Thus, social comparison processes appeared central to participants understanding the causes of their health conditions: observing similar health conditions in other nuclear test veterans may lead one to attributing the conditions to ionizing radiation. Likewise, observing similar health conditions in similarly-aged others (e.g. a spouse) may serve as reassurance that the health condition is caused by ageing. This was evident particularly when considering the perceived impact of ionizing radiation on cognitive decline.

While age was not explicitly discussed when considering descendants' health conditions, we can speculate that it plays a similar role in determining the causes of health conditions in family members. The veterans tended to attribute any health conditions in descendants to paternal ionizing radiation exposure (involving genetics), presumably because serious health conditions are generally uncommon in younger/middle-aged adults. This is an interesting scenario since attributing one's own health conditions to uncontrollable causes (e.g. genetics) appears to improve mental health outcomes by shifting responsibility, in comparison to behavioural causes (Else-Quest et al., 2009; Roesch & Weiner, 2001; Staal et al., 2020). But in the context of descendant health, attributing cause to genetics (perceived altered by paternal radiation exposure) may lead to a sense of controllability for their descendants' health and a sense of responsibility for their descendants' health conditions (Collett et al., 2021; Hollowell et al., 2006; Strømsvik et al., 2011). This complicated scenario must be addressed which may be a fruitful avenue for promoting psychological well-being in exposed older populations.

5. Conclusion

Overall, this article explores how BNTVs perceive their health and how these veterans understand the causal nature of any existing health conditions. Unlike most research examining perceived causal attributions, it is difficult to provide a comprehensive framework for exposed populations because the participants vary greatly in their health conditions. Due to relatively small numbers of nuclear test veterans, it is not feasible to have a sample where health conditions are all standardised. None the less the findings highlight causal attribution processes in a unique older population which has not yet been examined in this context. We can offer a set of implications which one can speculate are rooted in the issue of transparency and the marked ambiguity regarding dose levels and related health effects: i) authorities dealing with exposure scenarios must emphasise transparency to avoid amplifying perceived health risk in affected populations, ii) subsequent genetics and epidemiological research must emphasise transparency and clarity of findings to allow populations to arrive at balanced conclusions in the light of amplified perceived risk, and iii) healthcare professionals may benefit from understanding an exposed individual's narrative regarding their health condition.

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Ethical approval

The study was approved by the Brunel University Research Ethics Committee (Project ID 12920).

Ethical approval and consent

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human participants were approved by the Brunel University Research Ethics Committee (Project ID 12920). Informed consent was obtained from all participants.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request. The data are not publicly available due to privacy reasons.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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