The New Zealand nuclear veteran and families study, exploring the options to assess heritable health outcomes

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ABSTRACT

AIMS: To describe health conditions in New Zealand nuclear veterans and their offspring, and examine the utility of tests to assess their heritability.

METHOD: An online survey, open to all veterans and offspring, with questions on health conditions, the GHQ12 to measure psychological distress, the Euroquol-5D visual analogue scale (EQ5D VAS) to measure health state, and free text items on veteran support.

RESULTS: Eighty-three responses (56%) were from veterans, 65 (44%) from offspring. Anxiety and depression were prevalent in both groups, with cancers (n=31, 37%) and joint conditions common in veterans (n=26, 31%). Few offspring reported cancer, rather problems with fertility (n=18, 40%). The free text themes fell into four domains, official commitment, health, emotional and information support; however, little support had been sought.

CONCLUSION: Cancers have utility in assessing heritability, but a low prevalence and lack of diagnostic data rules this out. Psychological conditions may be heritable, but the techniques to assess this are still developing. Chromosomal damage in veterans and offspring can be detected, but with present knowledge cannot explain health outcomes. Future work should assemble a veteran and family register with linkage to routine data-sets. Veterans and offspring should be encouraged to seek support.

Over the past century, knowledge regarding the harmful effects of exposure to radiation has increased. It is now known that exposure to radiation can damage living cells by altering DNA. Normally such damage is repaired, however this process is not infallible. As a result, alterations in DNA can persist and may lead to cancer. Furthermore, if cells containing hereditary information are affected, disorders may transcend generations.[1]

In New Zealand there are two principal cohorts of nuclear test veterans. Firstly, those who witnessed the operation Grapple atmospheric tests carried out by the UK at Christmas and Malden Islands in 1957-58, and secondly, the Mururoa veterans who witnessed the French nuclear explosions in 1973, both groups being concerned about radiation exposure, chromosome damage, and heritability.

In response to the growing concern among veterans in New Zealand regarding the effects of exposure to ionising radiation, the New Zealand Ministry of Defence commissioned a study analysing patterns of mortality and cancer incidence among New Zealand Operation Grapple veterans. The results of the cohort studies of the 528 servicemen were presented by Pearce et al in 1990[2] and 1997,[3] the latter follow-up finding a relative risk (RR) of mortality from haematological cancers of 3.8, 90% confidence interval (95% CI) 1.4 to 10.8 and from leukaemia RR 5.6, 95% CI 1.0 to 41.7.

In response to the findings of this study, the New Zealand government announced that test veterans who developed haematological cancers would be eligible for war pensions.

As knowledge regarding the hereditary nature of genetic mutations grew, an inquiry into the health status of the children of both Vietnam and Operation Grapple veterans was commissioned in 1998. This was informed by a report from the then Director of the National Radiological Laboratory, concluding that there was no evidence that Grapple veterans had been exposed to radiation that could give rise to health effects in themselves or their offspring, and that "no radiation-induced hereditary effects have been reported in human populations, even those exposed to doses giving rise to deterministic effects".[4] The inquiry subsequently found, for the children of Grapple veterans, evidence "limited/suggestive of no association" between their fathers' exposure to radiation and health effects.[5] However, the inquiry did note that scientific analysis at the time could not definitively disprove that children had been harmed as a result of their parents' service, recommending that children whose condition had sufficient or suggestive evidence of an association to their parents' exposure be provided with non-means-tested medical treatment and social care. In addition, they recommended the establishment of a special programme offering case management, family counselling and genetic counselling for natural-born children of Operation Grapple veterans, conceived after their parent's service.

The research effort then shifted to detecting genetic changes possibly attributable to radiation, and in 2005, the sister chromatid exchange study was commissioned by the Board of the War Pensions Medical Trust Fund. The study compared operation Grapple veterans to a referent group of military and police referents, finding elevated sister chromatid exchanges in peripheral blood lymphocytes in veterans.[6]

A subsequent cytogenetic analysis using three different tests to assess genetic damage found that one test method, Multicolour-FISH (mFISH) consistently showed an increase in the rate of rearrangement of chromosomal translocations and dicentrics at a statistically significant level.[7]

The study team indicated the presence of sufficient evidence that Operation Grapple veterans suffered long-term genetic damage, most likely from radiation exposure.

The Ministerial Advisory Group on Veterans' Health subsequently reviewed the cytogenetic studies, finding that "one of the three tests in the cytogenetic study showed statistically significant elevated frequencies of some chromosomal abnormalities in exposed veterans, which may indicate long-term damage from radiation exposure. However, causality cannot be definitively attributed to radiation alone. The actual health consequences or seriousness of these chromosomal changes are not certain."

Paternal transmission of environmental exposures in general has been suspected for decades, has been shown in animal studies, and is now starting to emerge in human studies.[8] A radiation-exposed father developing a condition, especially a cancer, and offspring developing the same condition would be good candidates to inform such research efforts.

We were asked by the Mururoa Veterans Group (MVG) to revisit the problem by investigating the health of New Zealand nuclear veterans and their offspring to establish the number of veterans and their offspring that could be contacted, assess their health for conditions held in common and evaluate the utility of genetic testing in this group.

Aims

The main health aims of this study were to obtain a 'health profile' of self- and doctor-diagnosed health conditions among veterans and family; undertake comparisons between the health of veterans and their offspring and evaluate what help, care and support has (or has not) been made available to veterans and their families.

The main feasibility aims of this study were to determine the study base; through identifying the health conditions reported, identify options for genetic testing and determine the level of interest among nuclear veterans in undergoing such testing.

Methods

Study population

The study base was members of the crews of HMNZS Otago and HMNZS Canterbury deployed to Mururoa on 21 and 28 July 1973 respectively, along with their offspring. The complement for each crew was 242 and 256 respectively, a total of 498 personnel. Veterans from Operation Grapple, 528 servicemen who served at Christmas (now Kirimite) and Malden Islands in 1957 and 58 during the British atmospheric tests were also encouraged to participate, as were veterans of J Force occupying Japan immediately after the Hiroshima and Nagasaki bombings. Apart from Grapple and Mururoa veterans, the number of the other nuclear veterans and their descendants is unknown. Participants were excluded from the study if they were younger than 18 years of age, were not a nuclear veteran or descended from a veteran.

Recruitment to this study was voluntary, primarily through MVG, who travelled to the major centres in New Zealand during 2018, also commissioning a media campaign. Potential participants registered their interest by enrolling with the MVG by email. These participants were then sent a link to an electronic survey, through which we collected our data. Paper or phone surveys were made available if participants felt unable to complete the electronic survey.

Survey design

The survey collected demographic information, and participants were asked about self-diagnosed and physician-diagnosed medical conditions.

Symptoms of distress were assessed using the General Health Questionnaire 12 (GHQ-12). This measure includes 12 items with a four-point response scale. Items are summed to yield an overall total score, with higher scores indicating greater distress.[9]

The EuroQol visual analog scale (EQ VAS)[10] is a vertical scale graduated from 0 to 100, which participants mark with a cross and write the indicated number into a box, with 100 indicating 'the best possible health you can imagine', and 0 'the worst possible health you can imagine'.

Support was assessed by asking whether or not they received any support as a nuclear veteran or a family member, (yes/no) what the support was (open text) and if so were they satisfied with it (very satisfied/satisfied/neutral/unsatisfied/neutral), also "what support or additional support do you think is needed".

Participants were finally asked whether they might be willing to give consent to genetic testing in a subsequent study, although it was made clear that there was no obligation to participate in such a study, nor would the refusal to do so have a negative impact.

The project was carried out by a group of Trainee Interns, final year medical students, carrying out a 'health care evaluation project' as part of their studies. Ethics approval was given by the University of Otago Human Research Ethics Committee, reference no. HE19/008, and the Ngāi Tahu Research Consultation Committee advised us on the implications of the project for Māori.

Analysis

The analysis of distress, health status and health conditions was descriptive, the STATA statistical package being used to calculate mean GHQ and EQ VAS scores and construct 95% confidence intervals (95% CIs) around these estimates where appropriate. An inductive analysis was carried out on the free text data, with grouping into themes by two team members and independent confirmation by a third.

Results

We received 148 completed responses to the questionnaire. Of these responses, 83 (56%) were from veterans of Mururoa or Operation Grapple and 65 (44%) were from family members of a veteran. Of the veterans who responded, nearly all served at Mururoa, a 77% response rate from the 111 members, and 95% of respondents were either a Mururoa veteran or a descendant of a Mururoa veteran. The majority of the veterans were of New Zealand European ethnicity, and aged between 65–74 years of age (Table 1). Of the family members, 95.3% were of New Zealand European ethnicity, and the majority of respondents were between 35–44 years of age. Approximately 3–4% of both groups identified 'other' for ethnicity, and these included Irish and Australian nationals.

Table 1: Demographics of participants.

Ethnicity	Veterans (%)	Descendants (%)
NZ European	64 (77)	52 (80)
Māori	13 (16)	9 (14)
Pacific Islander	0 (0)	1 (2)
Other	6 (7)	3 (4)
Age	**Veterans (%)**	**Descendants (%)**
18–24	0 (0)	9 (14)
25–34	0 (0)	9 (14)
35–44	0 (0)	35 (54)
45–54	0 (0)	6 (9)
55–64	14 (17)	4 (6)
65–74	67 (81)	2 (3)
>75	2 (2)	0 (0)
Total	**83**	**65**

Health conditions reported by respondents and diagnosed by health professionals were skin disease and cancer, predominantly in the veterans' group (Figure 1). These cancers included a number of skin cancers, both melanoma and non-melanotic skin cancers, prostate cancer, non-Hodgkin lymphoma and leukemia. Although thought to be associated with radiation exposure, very few identified thyroid conditions, and were more likely to be in offspring.

Anxiety and depression were reported by both, the former with greater prevalence in offspring, the latter in veterans.

Of note, 40% of offspring reported issues with fertility, citing endometriosis, miscarriages and polycystic ovarian syndrome (PCOS) as contributors. By contrast, only 16% of veterans identified fertility as an issue.

The mean values, along with 95% confidence intervals (95% CIs) for the GHQ-12

Figure 1: Selected self-reported and health professional-diagnosed* health condition.

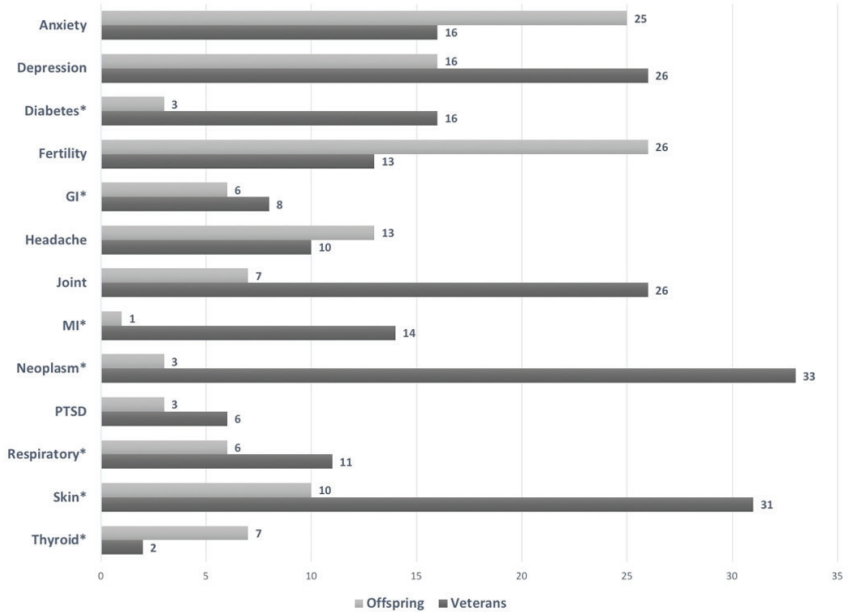

Table 2: Mean GHQ-12 and EQ VAS scores between groups.

	n (%)	GHQ-12 Mean Score (95%CI)	EQ-5-VAS Mean Score (95% CI)
Total	148 (100)	14.1 (13.1–15.1)	64.2 (60.2–68.2)
NZ European	119 (80)	13.9 (12.7–15.1)	65.7 (61.1–70.3)
Māori	22 (15)	13.5 (10.6–16.4)	63.1 (51.6–74.6)
Veteran	83 (56)	13.9 (12.4–15.4)	61.3 (55.8–66.8)
Family	65 (43)	14.3 (12.8–15.8)	66.9 (61.2–72.6)
Mururoa	141 (95)	14.2 (13.1–15.3)	63.9 (59.8–68.0)
Grapple	7 (5)	16.4 (10.6–22.2)	66.4 (50.8–82.0)
Support	27 (18)	15.0 (12.8–17.2)	60.9 (51.3–70.5)
No support	117 (79)	14.0 (12.8–15.2)	65.0 (60.4–69.6)

and EQ5D-VAS scores are shown stratified for demographic factors in Table 2, with no significant between-group differences. The mean of 14.1, 95% CI 13.1–15.1, can be compared with the mean GHQ-12 score in the Australian and New Zealand population of 8.98,[11] this latter value not falling within the confidence limits, meaning there is more distress in respondents than the general population.

The GHQ scores are also reflected in the self reported prevalence of anxiety and depression.

The mean EQ VAS scores lay the range 60.9 to 66.9. In New Zealand, the mean EQ-VAS scores are stable across the age range from 18–65, with lower and upper bound values of 82.4 (age group 18–24) to 81.6 (age group 55–64), falling to 79.6 in the 65–74 year old group.[12]

The free text themes fell into four domains, commitment, health support, emotional and 'other' supports, and information support. Commitment was mentioned by several veterans and family members, also in terms of government culpability: "some recognition of what they did was wrong would be a start." The need for health support was frequently reported, physical issues and mobility being specifically mentioned, along with the need for health and medical screening and 'checks', with the inclusion of families in these mechanisms.

The requirement for other supports included emotional support, one family member mentioning this as "emotional support, ie, recognition of how living with our father affected my mental, and possibly our physical health." The need for financial support was often expressed. The requirement for information also emerged, including the need to collate information, to gather information about long-term effects in this group, so that veterans could grow knowledge "just to understand what has happened to my body" and on the part of family members "just to understand what they went through". Only two respondents suggested genetic testing as a form of support, however 132 registered their interest in future research participation.

Only 21 veterans and three descendants received support, 77% not receiving any support. Some reported that although they felt support was available, they weren't aware of what, in specific terms, was available or how to access it. Thirty-five respondents felt that the Government, or the Government through New Zealand Veterans Affairs (NZVA), were responsible for providing support, five that NZVA alone were responsible and three the New Zealand Defence Force (NZDF).

Discussion

Although this is essentially a descriptive analysis, compared with population normative values, distress is higher and health status lower in Mururoa veterans and their offspring.

Cancers seem to be prevalent among the surveyed veterans, those reported including skin and haematological disorders. The prevalence of the former may however be explained by the average age of this population and the high incidence of skin cancers in New Zealand. The age-adjusted incidence rate for non-melanotic skin cancer in New Zealand is 786.1 per 100,000 people in the non-Māori population, and 51.0 per 100,000 people in the Māori population.[13] Based on the responses in our study, the cumulative incidence among the veterans may equate to 10,280 per 100,000 people, which may represent a greater proportion of the veteran population affected compared to the general New Zealand population.

By contrast, the rates of the remaining diseases associated with exposure to ionising radiation, including thyroid conditions diagnosed by a health professional, was equally low among both veterans and descendants.

Interestingly, a significant proportion of descendants (40%) reported having issues with fertility. When asked to specify, many reported endometriosis or polycystic ovarian syndrome. However, some reported taking a year to conceive children, but this does not meet the criteria for infertility. Some also said they had chosen not to have children because of their fathers' exposures to the nuclear tests.

The strengths of the study lay in the support of the veterans and their family members, however the main limitation was the response rate from both groups. A total of 498 men are on the crew lists of HMNZS's Canterbury and Otago. At least 80% will have survived to age 65, and as 16% of our Vietnam veteran cohort, of similar age, was living overseas it means that just in excess of 300 veterans would be alive and living in New Zealand. That being so, the 83 replies represent approximately 27% of the ships' complements and 75% of the 111 MVG members. The situation will be worse with families, as we do not know the study base. Bias is also possible, for instance, those involved in the MVG may already be more concerned about possible medical conditions relating to their exposure, be more distressed and more willing to participate in our study. The participation of Grapple veterans was extremely low, however they have their own association, the New Zealand Nuclear Test Veterans Association, whose view is that no further testing of veterans is desirable, the focus should be shifted to children.[14]

Furthermore, by conducting an electronic survey, we restricted our responses to people who not only had access to a computer but to those who were able to navigate the survey. We considered using a paper questionnaire distributed by post, but this six-week project presented a time constraint. Our results may not therefore represent the underlying distribution of distress and health status in this population.

Previous cross-sectional surveys have been carried out in Grapple veterans. Roff et al[15] reported in 1999 on a survey sent to 388 of the Grapple servicemen or their families with responses from 235 (62% of questionnaires, 45% of servicemen) and 97 from families (41%). The major conditions reported were skin (49), cardiovascular (47), respiratory (22), arthritic (20), infertility (18) and bilateral cataracts (10). In children, skin (33), respiratory (29), other skeletal (24), cardiovascular (20), arthritic and 'other' blood (14) conditions were reported.

In 2005, Podd et al[16] carried out a case-referent study on 50 Grapple veterans and 50 referents with military or police service. Cancers (n=24 v 2) and chronic skin conditions (40 v 12) were prevalent in veterans. Psychological problems were evident in veterans having higher scores, and variability, in the Geriatric Depression Scale, with a mean of 3.92, standard deviation (SD) 3.5, than referents mean 0.9, SD 0.97. They also had uniformly lower scores on the Short Form 36 Health Survey, including the general, physical and mental health items, which the authors ascribe to long-term stress.

The reason for the high levels of distress in the sample may be partly ascribed to worry about ionising radiation exposure, however a recent review has emphasised that distress is common in veteran populations, and the type of service undertaken, along with a unsuccessful transition from a military to a

civilian life, can also have a negative effect on wellbeing.[17] Contemporaneous external monitoring was carried out by the National Radiological Protection Laboratory, the results being more recently reviewed by the Institute of Environmental Science and Research Centre for Radiation Science.[18] Based on external gamma radiation monitoring, pocket dosimeters and pump systems on board the ships, they found that exposure was less than 0.001 mSv/h, with no airborne radioactivity detected on HMNZS Otago, and only 0.005mSv on HMNZS Canterbury. Personal monitoring was below the detectable limit of 0.12 mSv, similar to background radiation. Calculations also suggested that there was no fallout on either ship, that there would not have been any fallout into the sea and therefore no water contamination. Veterans however trust neither the equipment nor the calculations, and are concerned about internal, rather than external, radiation dose.

This idea is reflected in the results of our survey, where many veterans expressed their dissatisfaction at having been sent to observe nuclear detonations without being informed of the possible health consequences. There was significant ill-feeling among the veterans toward the Labour government in power at the time. The previous nuclear veteran health investigations all suggested support to deal with uncertainty, this need being reinforced by our respondents. When asked to elaborate on the support required, a large proportion emphasised the need to support the physical health of veterans, and help to access the benefits. There was strength of feeling that the New Zealand Government and New Zealand Veterans Affairs should provide this support. This support is however available, so it is essential that veterans actually seek it.

The support that is currently available for New Zealand nuclear veterans includes access to a war disablement pension provided their illness is on any one of the 'presumptive lists'. These lists include a list of illnesses linked to potential exposure to ionising radiation modelled on a US Department of Veterans Affairs list. Unfortunately, conditions that are on a 'regulatory list' of radiogenic diseases in the US are not automatically awarded in New Zealand; this because of additional requirements including the amount and duration of radiation exposure, and a minimum latent period between exposure and onset of the disease. New Zealand nuclear veterans can however make claims for conditions on this latter list under the provisions of the Veteran Support Act 2015.

Furthermore, in June 2002 the war pension status of Mururora Veterans was changed from 'routine' to 'emergency' service. As a result, any war pension claims from that time forward are now considered using more relaxed evidence requirements. In addition, claims that were declined prior to June 2002 can now be reconsidered if a veteran believes the condition is related to exposure to ionising radiation. By contrast, Australia does not give disability pensions to nuclear test veterans. Instead, all British Atmospheric nuclear test programme personnel in Australia can access treatment for all malignant cancers, even cancers not linked to exposure to radiation.

As regards future directions, this is a problem with no easy solution: paternal transmission of the effects of environmental exposure to radiation, just as with other public and environmental health problems, demands both epidemiological and technical approaches.

In terms of future work, assembly of a Mururoa veteran register is possible. Although the crew lists contain only surname and initials, forenames and dates of birth can be found in the NZDF archives. That being achieved, the National Health Index (NHI) number, unique to each individual, can be traced with an inception date in 1988, the date of first NHI assignment. The NHI can then be linked to the Mortality Collection and Cancer Registry data. Offspring would however have to register for the two sets of data to be linked for genetic testing.

An alternative for offspring would include tests for chromosomal abnormality testing, similar to those carried out in Grapple veterans. If offspring of both Grapple and Mururoa veterans were tested in comparison with a control group and a similar difference were found, it would add weight to the argument.

Another approach has been taken by a team from Brunel University London, who

are recruiting 50 nuclear test trios: veteran, child, child's mother.[19] The referent group will be veterans who served in the tropics at the same time. Cytogenetic evidence for radiation will be sought in veterans and, in the first-generation children of test veterans, differences in the frequency and spectra of DNA mutations and chromosomal aberrations will be compared with those in the control family group.

New Zealand nuclear test veterans might be offered a similar opportunity.

This however does not answer the question about disease outcome, which can only be answered epidemiologically. If offspring had the same disorder, for example cancer, a genomic investigation using stored tissue might have utility. Collating and updating the register should therefore be a priority.

Competing interests:
Nil.

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