

## Health effects of Vietnam service

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AUSTRALIAN DEFENCE FORCE PERSONNEL participated in the Vietnam Conflict from 1962 to 1973. This was the most significant military commitment of Australian Forces since World War II, involving nearly 60 000 personnel, of whom over 500 died during service and 3131 were severely physically wounded.

Service during the Vietnam conflict presented distinctive health challenges. The nature of the conflict meant that troops were under combat-like conditions for extended periods. Herbicides and pesticides were used extensively. The United States military sprayed more than 76 000 000 L of herbicides over Vietnam in their Air Force Ranch Hand and Operation Trail Dust programs.<sup>1</sup> The herbicides were used to strip the jungle canopy in order to reveal enemy positions, as well as to destroy crops and clear the perimeters of US and allied base camps. The most heavily used of these herbicides was agent orange, contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin, a known toxic agent. Other chemicals used widely in Vietnam included other herbicides (paraquat and dimethylarsenic acid), pesticides (picloram and DDT), antimalarial drugs (dapson) and solvents (toluene).

Since the Vietnam conflict, ex-Service organisations (ESOs) have maintained that Vietnam service adversely affected the health of veterans. Initial studies into the health of veterans done in the 1980s showed no excess risk attributed to their service. However, more recent studies have shown that Vietnam veterans have excess incidence and mortality rates from several conditions, such as cancers and heart disease. In addition, environmental and occupational studies on the toxic effects of chemicals of interest have been useful in assessing health risks of Vietnam service.

This article reviews Australian and overseas studies on the physical health effects of Vietnam service.

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Fogging a Vietnamese village house in Phuoc Tuy province. Insecticides, usually DDT, were used to reduce the incidence of malaria. Australian War Memorial Negative Number ERR/68/0842/VN.

### Abstract

- ◆ Australian studies since the mid 1990s have found statistically significant increases in mortality and morbidity among Vietnam veterans.
- ◆ Overall mortality, mortality from neoplasms, circulatory diseases and external diseases are elevated when compared with the similarly aged male Australian population.
- ◆ The number of cases of motor neurone disease and chronic lymphatic leukaemia observed among Vietnam veterans suggest that significantly increased incidence may be revealed with continued follow-up.
- ◆ Overseas studies of health effects of herbicide exposure on Vietnam veterans have found sufficient evidence of an association between exposure and chronic lymphocytic leukaemia, soft-tissue sarcoma, non-Hodgkin's lymphoma, Hodgkin's disease, and chloracne.

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### Australian studies

Several key studies on the health of Australian Vietnam veterans have been published since the Vietnam conflict and are summarised in the following sections. In addition, the Box details a comprehensive list of the government studies and peer-reviewed published papers concerning research into the physical health of Australian Vietnam veterans.

### Australian Veterans Health Studies

In 1980 the Australian government commissioned the Commonwealth Institute of Health (now known as the Australian Institute of Health and Welfare, [AIHW]) to conduct a series of studies into the health of Vietnam veterans and their families. A retrospective cohort mortality study of 46 166 Australian National Servicemen, Part 1 of the Australian Veterans Health Studies, was completed in 1984.<sup>2</sup> The study compared the mortality of National Service veterans who served in Vietnam to National Service personnel who remained in Australia. This study found no significant increase in mortality among veterans compared with non-veterans. Both veterans and non-veterans had signifi-

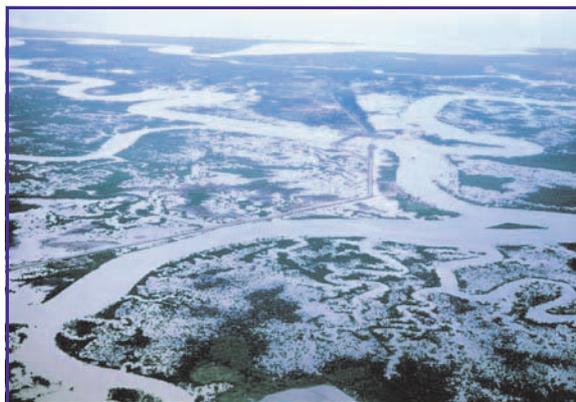
cantly lower mortality rates than expected for a similarly aged cohort of Australian males.

A factor that may have influenced the results of this study is the healthy worker effect.<sup>3</sup> Military personnel are screened at recruitment and are generally fitter than the Australian population. Personnel with diseases from congenital anomalies, mental disorders, and endocrine, nutritional and metabolic diseases are ruled out in the screening process. The healthy worker effect lasts for many years after service and it is not clear what the magnitude of this effect may be over time.<sup>4,5</sup>

### Dapsone study

Dapsone was an antimalarial drug used by Army and land-based Navy personnel serving in Vietnam from 1968 until 1972. The AIHW examined the relationship between dapsone exposure, Vietnam service and cancer incidence among 115 407 Australian Army personnel, 40 274 Vietnam veterans and a comparison group of 75 133 serving members.<sup>6</sup> Dapsone had been shown to be associated with toxicity in white blood cells and other adverse reactions, such as haemolytic anaemia and peripheral neuropathy. Concerns were also raised about the possible carcinogenicity of this drug. The study compared cancer incidence among Regular Army and National Service veterans and non-veterans and also correlated cancer incidence with lifetime dose of dapsone received. The study concluded that there was no definite evidence for an association between dapsone exposure and overall cancer incidence. Nor was there definite evidence of association between Vietnam service and overall cancer incidence.

However, the study did describe a statistically significant increase in pancreatic, lung, and brain cancers among National Service veterans compared with National Service non-veterans.



*Aerial view over Rung Sat (foreground) and Vung Tau (background) at high tide. Tropical Vietnam presented many natural hazards to the Australian troops, and the herbicides, pesticides and prophylactic medicines used in response were themselves not without dangers. Australian War Memorial Negative no. P02382.001.*



*Cargo of Centurion tanks en route to Vung Tau in 1969 on Army vessel 1356 Clive Steele. Photograph courtesy of David Perham, veteran of 32 Small Ship Squadron.*

This association was not seen among all veterans or Regular Army veterans. As 29 different cancer sites were tested for significant association, the authors reasoned that the three cancers showing increased rates could be a statistical anomaly. In addition, the authors concluded that, given the follow-up period was at most 24 years, it was too early to expect a significant increase in rates of solid cancers.

### Vietnam veteran mortality study

A second Vietnam veteran mortality study was completed in 1997.<sup>5</sup> This study compiled a comprehensive nominal roll of all Vietnam veterans, including civilians, medical personnel, entertainers, and female veterans. The mortality rate for all male military personnel and individual service branches was compared with the mortality rate for the male Australian population. Not all deaths among Vietnam veterans could be identified within the databases used for the study. This resulted in an underestimation of the observed deaths and consequently an underestimation of the standardised mortality rate (SMR). Thus the results reported were adjusted for under-ascertainment based on the proportion of deaths found on the National Death Index and the Department of Veterans' Affairs client database.

Mortality was assessed from 1980 to 1994, as this was the period in which data from the National Death Index, which was begun in 1980, was available. The mortality rate for male veterans was significantly higher (SMR=1.07; 95% CI, 1.02–1.12) compared with the male Australian population of the same age. There was statistically significant increased mortality from all neoplasms, ischaemic heart disease, and suicide. The significant increase in neoplasms was attributed to elevated rates of prostate and lung cancers, cancers of the tongue, "other" digestive organs, and male breast, although the latter was due to only three cases.

Of the three service branches, Navy veterans had the highest overall mortality (SMR=1.37; 95% CI, 1.23–1.52) and the only significantly elevated overall mortality. The SMR for Army veterans was 1.00 (95% CI, 0.99–1.05) and for Air Force veterans 1.12 (95% CI, 0.97–1.27). The SMR for deaths from neoplasms among Navy personnel was 1.58 (95% CI, 1.31–1.89). Navy veterans also had significantly increased mortality due to diseases of the circulatory system (SMR=1.26; 95% CI, 1.04–1.52) and external causes (SMR=1.48; 95% CI, 1.15–1.86).

### Mortality of National Service Vietnam Veterans study

A supplementary study to the Vietnam veteran mortality study was undertaken to examine mortality among National Service veterans and non-veterans.<sup>7</sup> This analysis eliminated the healthy worker effect inherent in comparing a military population with the general Australian population. It also extended the Australian Veteran Health Studies with an additional 13 years of death data. The total follow-up time was 22 to 29 years.

Mortality from all causes was significantly higher in National Service veterans (relative risk [RR]=1.15; 95% CI, 1.00–1.33). Death from all cancers was elevated, but not significantly. The lung cancer rate was twice that among non-veterans (RR=2.2; 95% CI, 1.1–4.3) and cirrhosis of the liver nearly triple (RR=2.7; 95% CI, 1.22–6.4). Brain cancer was also significantly elevated (RR=5.6; 95% CI, 1.53–>10), based on three cases.

As discussed above, the mortality for Army personnel was normal compared to the Australian male population. However, when a cohort of National Service Vietnam veterans (a subset of the Army personnel in the previous study) were compared with a cohort of National Service men who served in Australia, a statistically significant elevation in mortality was observed, although both groups had a lower mortality than the Australian male population. This suggests that a healthy worker effect could still be contributing to the mortality results.

### Morbidity of Vietnam veterans studies

A series of studies assessing the morbidity of Vietnam veterans was begun in 1996. A self-completed health questionnaire was distributed to 49 944 male veterans<sup>8</sup> and 278 female veterans.<sup>9</sup> More than 80% of the veterans contacted completed the survey. The questionnaire asked veterans to assess their own health, and provide details of their marital status, and the health of their partner and children.

The results of the survey were compared with expected community norms obtained from several surveys including the 1995 National Health Survey conducted by the Australian Bureau of Statistics.<sup>10</sup> The comparisons suggested that the health of Vietnam veterans and their families was worse than that of the Australian population. Even though the results were compared with the National Health Survey, there was no specific comparison group used for this questionnaire. As with all self-reported questionnaires, there may be mis-reporting due to misclassification of specific illnesses or respondents' unfamiliarity with medical terminology.

A series of validation studies were undertaken to assess the reported elevated rates of illness. The number of validated cases of melanoma and cancer of the prostate were significantly higher than expected.<sup>11</sup> There were 483 validated cases of melanoma compared with 380 expected cases according to community norms (95% CI, 342–418). For cancers of the prostate, 212 cases were validated and 147 expected (95% CI, 123–173). However significantly fewer lung cancers, soft tissue sarcomas, and cancers of the testis were observed than expected. For lung cancer, the authors noted that the fewer than expected cases was probably an artefact due to a number of veterans having died from lung cancer and consequently having been missed by the morbidity study. The number of confirmed cases of leukaemia was within the expected range, although the number of cases of chronic lym-



RAN and Army of the Republic of Vietnam (ARVN) personnel attaching charges to wooden stakes. The Vietcong drove wooden stakes into the river bed to obstruct local traffic. Australian War Memorial Negative Number P03654.099.

phatic leukaemia was at the upper limit of the confidence interval. Non-Hodgkin's lymphoma was elevated, with 66 validated cases, 48 expected (95% CI, 34–62).<sup>12</sup>

The rare conditions of multiple sclerosis and motor neurone disease were validated among respondents to the morbidity questionnaire.<sup>13</sup> Based on clinical notes and death certificates, 20 cases of multiple sclerosis were validated among Vietnam veterans while 17 cases were expected, (95% CI, 9–26). Three cases of motor neurone disease were validated, compared with 1.2 expected, (95% CI, 0–3.3). This is the upper limit of significance for the expected number of cases of motor neurone disease. While the validation study was taking place one more validated case of motor neurone disease and two probable cases developed in Vietnam veterans who did not participate in the original morbidity survey.

### Synopsis of results of the Australian studies

The Australian studies conducted since the mid 1990s have demonstrated a number of statistically significant increases in mortality and morbidity among Vietnam veterans. Specifically, overall mortality, mortality from neoplasms, circulatory diseases and external diseases are elevated when compared with the similarly aged male Australian population. In addition, the number of cases of motor neurone disease and chronic lymphatic leukaemia observed among Vietnam veterans suggests that significantly increased incidence may be revealed with continued follow-up. It



In flight view of a spray boom (seen below the machine gun) on a UH-1B helicopter of No. 9 Squadron RAAF. Crop destruction and defoliation operations were conducted around the Nui Dat and Thua Tic areas. Missions used 4 man crews, 30 gallon tanks and spray booms. Australian War Memorial Negative no. P01733.002.

should be noted that the Australian studies since 1996 have been government reports, and results have not been published in peer-reviewed journals. Nevertheless, independent scientific committees oversaw these studies.

## Overseas studies

Major American studies have investigated the effect of dioxin exposure among Ranch Hand Air Force personnel, the unit involved in spraying agent orange in Vietnam. To date, five health assessments of Ranch Hand Air Force personnel and a comparison group matched on age, race and military occupation have been undertaken (in 1982, 1985, 1987, 1992 and 1997). A sixth and final examination during 2002–2003 is scheduled to be reported in 2005. This study used serum dioxin measurements from 1987 to assess the level of exposure. In the latest report,<sup>14</sup> type 2 diabetes and cardiovascular abnormalities demonstrate the clearest positive association with dioxin exposure. In the 15 years of surveillance, the study has not shown any statistically significant association between dioxin exposure and malignant neoplastic disease among the Ranch Hand personnel.

For Vietnam veterans who were not in the Ranch Hand program, it has been difficult to reconstruct exposure to agent orange. However, in assessing the possible health effects of exposure to herbicides and pesticides experienced during Vietnam service, studies of occupational exposure of chemical and agricultural workers to dioxin and other herbicides or pesticides and studies of environmental contamination have been useful. For example, an accident in 1976 at a small Italian chemical plant exposed the local population to dioxin. This population has been extensively studied, which has contributed to the understanding of the human health effects of dioxin.

The Institute of Medicine publication *Veterans and agent orange*<sup>15</sup> provides researchers with an extensive review of information on the health effects of dioxin exposure and Vietnam service. This literature review, first published in 1994, is updated every two years and draws on veteran studies and studies of occupational and environmental exposure. The report categorises the association between specific health outcomes and exposure to herbicide into four groups: conditions with sufficient evidence of an association, conditions with limited/suggestive evidence, conditions with inadequate/insufficient evidence, and conditions with limited/suggestive evidence of *no* association. These categories are based on statistical association reported in the literature, not on causality. The strength of the reported association is assessed on the quality of the study and the extent to which chance, bias, and confounding were addressed.

In the latest update of *Veterans and agent orange*,<sup>16</sup> five diseases were classified as having sufficient evidence of an association with herbicide exposure. These diseases are: chronic lymphocytic leukaemia, soft-tissue sarcoma, non-Hodgkin's



*The Army Vessel (AV) 1355 Vernon Sturdee on the Mekong River, 1967, with US riverine boat. Note the defoliated riverbanks and lack of protective clothing worn by the gunner. Courtesy of David Perham, veteran of 32 Small Ship Squadron.*

lymphoma, Hodgkin's disease, and chloracne. An additional seven diseases have limited or suggestive evidence of an association between herbicides and outcome. That is, there is at least one high quality study that shows a positive association, but the results of other studies are limited and inconsistent. The seven conditions are: respiratory cancer, prostatic cancer, multiple myeloma, acute and subacute transient peripheral neuropathy, porphyria cutanea tarda, type 2 diabetes and, in children of veterans, spina bifida maxima.

## Recent developments

The difficulty for epidemiological studies of Vietnam veterans has been the inability of researchers to accurately quantify and separate the exposure associations of herbicides and other wartime hazards with long-term health outcomes. Australian studies have generally assessed exposure as Vietnam service and refined this only to the level of Service branch, corps grouping, and time in Vietnam.

A recent Australian report by the National Research Centre for Environmental Toxicology has identified a potential exposure of Navy personnel to dioxins through potable water produced by evaporative distillation.<sup>17</sup> By constructing a model of the evaporative distillation system used on *HMAS Sydney*, this study has shown that, in the process of evaporative distillation of potable water, organochlorine pesticides and dioxins, if they had been present in the source sea or estuarine water, would have co-distilled and been concentrated. Possible exposure to dioxin for Navy members through the ingestion and personal use of the potable water was estimated to have been several orders of magnitude above what are acceptable standards today.

Exposure assessments in US studies have relied on the US Department of Defense HERBS file. This is a comprehensive file of the Air Force Ranch Hand herbicide spray missions. However, the file did not contain sufficiently coherent data to formulate an exposure reconstruction.

Recent advances by the Columbia University group led by Stellman have greatly increased the potential for researchers to make more accurate assessments of exposure to herbicides for specific military units deployed during the Vietnam conflict.<sup>18</sup> The group has developed a geographic information system that characterises exposure to herbicides in Vietnam. The system has combined several databases, some only recently discovered in US Defense archives, which incorporate flight paths of aerial spray missions, the amount and type of agents sprayed, identification and location of military units and troops, land features, soil typology, and location of civilian populations to produce an exposure opportunity index (EOI). The EOI is based on the proximity in time and space to spraying. It does not measure dose, but provides a systematic method for assessing potential exposure. A user-friendly system is being developed which will

## Reports and published peer-reviewed papers on health issues for Australian Vietnam veterans

Study*	Year	Type of study	Results
"Pesticides and the health of Australian Vietnam veterans" <sup>21</sup>	1982	Senate inquiry, public hearings	Concluded insufficient evidence that birth abnormalities, psychiatric disorders or mortality were excessive. Recommended mortality study to be done.
"Australian Veterans' Health Studies: the mortality report. Part I" <sup>22</sup>	1984	With AIHW, ABS. Cohort study of National Service veterans (19 209) v non-veterans (26 957)	Data to 1982. Overall mortality lower than Australian population. No elevated mortality by corps grouping, nor elevated cancer deaths, nor any other categories. Number of deaths too small (523 total) and follow-up time too short for meaningful conclusions.
"Australian Veterans' Health Studies: the mortality report. Part II" <sup>22</sup>	1984	Case-control study	Compared characteristics of deceased veterans with those of random sample of survivors. Poorer education and psychological health related to deceased. Engineering corps members had excess mortality.
"Australian Veterans' Health Studies: the mortality report. Part III" <sup>23</sup>	1984	Descriptive risk analysis	Correlated the risk of becoming a combat casualty in Vietnam with location of service and subsequent mortality. Increased mortality with engineering corps. No association with locality and mortality.
Vietnam service and the risk of congenital anomalies. A case-control study <sup>24</sup>	1984	Case-control study	Investigated 8517 case-control pairs of children and correlated birth anomalies with fathers' Vietnam service. Found no increase in birth defects among children of Vietnam veterans.
Birth defects and Vietnam service <sup>25</sup>	1984	Editorial	Commenting on Donovan study. Offered two caveats: non-inclusion of defects not evident at birth and lack of power to look at any single defect or category of defects.
Mortality among Vietnam veterans compared with non-veterans and the Australian population <sup>26</sup>	1985	Retrospective cohort study. Compared 19 205 Vietnam national service veterans with 25 677 non-veterans.	Followed until the beginning of 1982. Also compared with Australian population. Found no excess mortality.
"Commission on the use and effects of chemical agents on Australian personnel in Vietnam" <sup>27</sup>	1985	'Evatt' Royal Commission, interviewed 2000 veterans, 150 written submissions	Concluded Vietnam veterans significantly healthier than rest of population but National Service veterans slightly more likely to suffer from circulatory and digestive diseases. Recommended further study on dapsone carcinogenicity.
The Agent orange controversy after the Evatt Royal Commission <sup>28</sup>	1985	Editorial	Article summarising findings of royal commission.
Mortality among Australian conscripts of the Vietnam conflict era. I. Death from all causes <sup>29</sup>	1987	Retrospective cohort mortality study	Published results from AVH study of National Service veterans/non-veterans. Reported OR = 1.2 (95% CI, 1.0–1.4) adjusted for corps grouping and OR = 2.5 (95% CI = 1.4–4.0) for Royal Australian Engineers.
Mortality among Australian conscripts of the Vietnam conflict era. II. Causes of death <sup>30</sup>	1987	Retrospective cohort study	Detailing causes of death from AVH study. National service veterans. Diseases of digestive tract and external causes were statistically elevated for Vietnam veterans compared with non-veterans. Follow-up period of 9–16 years too short to say anything definitive about neoplasms.
Mortality of Australian veterans of the Vietnam Conflict and the period and location of their Vietnam service <sup>31</sup>	1987	Retrospective cohort study	Correlated death rates with phase of conflict and location in Vietnam. Found no significant variations in death rates between time in Vietnam or location of service.
Risk factors for mortality in Australian Vietnam-era national servicemen: a case-control study <sup>32</sup>	1988	Case-control study of national servicemen	Extended the analysis of AVH study part II to identify risk factors for Vietnam veteran mortality.
Reproductive behaviour and consistent patterns of abnormality in offspring of Vietnam veterans <sup>33</sup>	1988	Analytical approach — 436 Tasmanian veterans and nominated neighbour "control", questionnaire survey plus validation	Found greater fetal loss, more stillbirths and more deaths of offspring. Children had increase in chronic health problems and learning and behavioural problems.
The logic of a controversy: the case of agent orange in Australia <sup>34</sup>	1989	Commentary	Analyses the sociological and psychological processes around the continued rejection by the veteran community of the Evatt report findings.

\*Studies in quotes are reports. Other studies listed are published papers in peer reviewed journals. Many of the papers are reporting results from government or agency reports. The table does not include psychosocial studies on effect of Vietnam service.

ABS = Australian Bureau of Statistics; AIHW = Australian Institute of Health and Welfare; AVHS = Australian Veterans Health Studies; CI = confidence interval; MND = motor neurone disease; MS = multiple sclerosis; OR = odds ratio; POWs = prisoners of war; RR = relative risk.

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Study*	Year	Type of study	Results
"Dapsone exposure, Vietnam service and cancer incidence" <sup>6</sup>	1992	Cohort study by AIHW of 115 407 Australian Army personnel	Looked at cancer incidence, did dose exposure comparisons and compared malaria antibody positive and negative groups. No increase in overall cancer incidence for veterans.
Mortality of former prisoners of war and other Australian veterans <sup>4</sup>	1992	Epidemiological review	Reviewed studies of WW II POWs and Fett et al on Vietnam veterans. Discussed healthy worker effect and need for continued surveillance.
Did Vietnam veterans get cancer from dapsone? <sup>35</sup>	1993	Editorial	Highlights findings of AIHW Dapsone study.
"Vietnam service, dapsone use and cancer" <sup>36</sup>	1994	AIHW. Female veterans (N=46), cancer incidence and toxic reactions in male veterans — case histories (N=10)	Complemented larger dapsone study. Numbers small but females showed elevated cancer incidence.
Suicide risk factors among Australian Vietnam era draftees <sup>37</sup>	1995	Cohort study of suicide victims	Used log-linear model to assess risk factors for suicide in veterans. Found much higher rate of suicide among those who scored low on intelligence test score, lacked postschool education, faced absent without leave charge during service, or had a history of diagnosis and treatment of psychological problems.
The Australian Vietnam Veterans Health Study: I. study design and response bias <sup>38</sup>	1996	Prospective cohort study. Random sample of 1000 veterans, 641 interviewed, 50 deceased, 309 non-responders.	Veterans self-reported lower perceived health and happiness compared with Australian population, had greater frequency of medical consultations, especially for neoplasms and musculoskeletal complaints, and higher use of alcohol and cigarettes.
The Australian Vietnam Veterans Health Study: II. self-reported health of veterans compared with the Australian population <sup>39</sup>	1996	Cohort study of random sample of veterans — self-reported questionnaire survey	Correlated relationship of combat with physical health. Combat exposure was associated with increased mental health complaints, eczema, ulcers, deafness, chronic infection, back pain.
"Mortality of Vietnam veterans" <sup>5</sup>	1997	Cohort study of 59036 veterans	Mortality study of death data to December 1994. Showed a number of increases: neoplasms, prostate and lung cancers.
"Mortality of National Service Vietnam veterans" <sup>7</sup>	1997	Cohort study of 43 595 National Service veterans and non-veterans	Comparison of mortality. Eliminated "healthy worker" confounder. Elevated RR for all causes, lung and brain cancers, cirrhosis, diseases of digestive system.
"Morbidity of Vietnam veterans: Vol 1: Male" <sup>8</sup>	1998	Questionnaire survey	Self-reported data from 40030 male veterans (80% response rate).
"Morbidity of Vietnam veterans: Vol 2: Female" <sup>9</sup>	1998	Questionnaire survey	Self-reported data. Could only locate 278/484 female veterans on nominal roll but of those 81% completed questionnaire.
"Morbidity of Vietnam veterans: validation study" <sup>11</sup>	1999	Validation of self-reported questionnaire survey	Found elevated rates of melanoma (483 cases v 380 [95% CI, 342–418] expected) and prostate cancer (212 cases v 147 [95% CI, 123–171] expected).
"Morbidity of Vietnam veterans: suicide in Vietnam veterans' children. Supplementary report no 1" <sup>40</sup>	2000	Validation of self-reported questionnaire survey	Found children of Vietnam veterans had suicide rate three times the expected rate for the general population.
"Morbidity of Vietnam veterans: adrenal gland cancer, leukaemia and non-Hodgkin's lymphoma. Supplementary report no. 2" <sup>12</sup>	2001	Validation of self-reported questionnaire survey	Incidence of adrenal cancer (10 cases, 1 [95% CI, 0–3] expected) and acute myeloid leukaemia (9–18 cases, 3 [95% CI, 0–6] expected) elevated in veterans' children. Non-Hodgkin's lymphoma higher than expected in veterans (66 cases, 48 [95% CI, 34–62] expected). All other leukaemia not elevated in veterans or their children.
"Morbidity of Vietnam veterans: multiple sclerosis and motor neurone disease in Vietnam veterans. Supplementary report no. 3" <sup>13</sup>	2001	Validation of self-reported questionnaire survey	MND elevated if deaths included in validation (3–5 cases v 1.2 [95% CI, 0–3.3] expected). No elevation of MS.

\*Studies in quotes are reports. Other studies listed are published papers in peer reviewed journals. Many of the papers are reporting results from government or agency reports. The table does not include psychosocial studies on effect of Vietnam service.

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allow researchers to input dates and locations of units or troops and receive a Microsoft Excel format output of EOIs.

## Conclusion and future directions

The numerous studies on Vietnam veterans over more than thirty years since the war have shown substantial physical health effects as a result of service during the Vietnam conflict. Elucidating the differential impact of the multitude of factors that may be associated with poor health outcomes for Vietnam veterans presents unique challenges for researchers. Nevertheless, research into the health of Vietnam veterans continues. The Australian Department of Veterans' Affairs is currently conducting the Third Vietnam Veteran Mortality Study and Cancer Incidence in Vietnam Veterans Study.<sup>19</sup> This study will undertake a ship-by-ship analysis for Navy and Army small ships and will be the first time a cancer incidence study has been undertaken on Navy and Air Force Vietnam veterans.

Development of spatial epidemiological tools may substantially advance the understanding of the effects of environmental and occupational hazards on the long-term health of deployed troops. This new methodology has the potential to be applied retrospectively for Australian Vietnam veterans or prospectively for current deployments. Indeed, the United States has recognised the potential of this valuable methodology in the Iraq War where they have recorded the real time location of all personnel with a geographic information system in conjunction with surveillance of environmental health conditions.<sup>20</sup> In any future health study of Iraqi War veterans it may be possible for researchers to assess the association between exposures and health outcomes with more certainty than was previously achievable.

## Competing interests

The authors have no conflict of interests to declare.

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