Health impacts for New Zealand military personnel from the South African War of 1899–1902

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ABSTRACT

AIM: We aimed to update and provide more complete epidemiological information on the health impacts of the South African War on New Zealand military personnel.

METHODS: Mortality datasets were identified and analysed. Systematic searches were conducted to identify additional war-attributable deaths in the post-war period. To estimate the morbidity burden, we analysed a random sample of archival military files of 100 military personnel. Lifespan analyses of veterans included those by level of combat exposure (eg, a non-combat sample came from a troopship that arrived at the time the war ended).

RESULTS: We identified 10 additional war-attributable deaths (and removed three non-attributable deaths) to give a new New Zealand total of 239 war-attributable deaths. Given the average age of death of 26 years, this equates to the loss of 10,300 years of life. Most deaths (59%) were from disease rather than directly from the conflict (30%). Over a third (39%; 95%CI: 30%–49%) of personnel were estimated to have had some form of reported illness (26%) or injury (14%). The lifespan analysis of veterans suggested no substantive differences by exposure to combat (68.5 [combat] vs 69.1 years [non-combat]) and similarly when compared to a matched New Zealand male population.

CONCLUSIONS: The mortality burden was larger and the morbidity impacts on the New Zealand military personnel in this war were much more substantive than revealed in the prior historical literature. There is a need to more fully describe historical conflicts so that their adverse health impacts are properly understood.

It is important to research the adverse health impacts of war, given ongoing conflicts around the world that harm both civilians and military personnel. Analysis of past wars may also better inform society of the long-term health outcomes of veterans. It has been suggested that there may be different post-combat syndromes with different wars,[1] and some aspects of war may be particularly relevant (eg, there is fairly clear evidence for long-term harm to health from being a prisoner of war in the Second World War [WW2]).[2–4] Other studies also provide evidence of long-term harm to health among war veterans.[5–9] Nevertheless, an increase in all-cause mortality in war veterans has not always been identified,[4] and raised mortality rates sometimes only appear later in life.[10] Returning veterans may also experience adverse health impacts from unemployment in the immediate post-war period—a likely issue for some after the First World War (WW1). But, on the other hand, it is plausible that some war veterans may experience net benefits from their military experience via training funded by the military and on-the-job skills development, both of which may lead to improved subsequent careers (and associated higher incomes). Studying all these issues is compli-

cated by the 'healthy soldier effect', which is a selection effect analogous to the 'healthy worker effect'.[11] A further selection effect is the 'healthy warrior effect', whereby healthier personnel within the military are the ones involved in combat (relative to those away from the front lines).[11]

One war that has had relatively little study with modern epidemiological methods is the South African War, also known as the Second Boer War. This war was fought between 11 October 1899 and 31 May 1902. The forces of the British Empire (which included New Zealand) fought against two Boer states: the South African Republic (Republic of Transvaal) and the Orange Free State. The war resulted in over 100,000 casualties among the imperial forces and cost the British taxpayer over £200 million at the time.[12] There were over 7,000 deaths among the Boer combatants and between 18,000 and 28,000 Boers (men, women and children) died in concentration camps.[12] The death toll for Africans (at least those participating on the Boer side) was estimated at probably over 12,000.[12]

For New Zealand military personnel, the official death toll in the Parliamentary record of the South African War was 232 deaths.[13] But, given limited follow-up of personnel in the post-war period, we suspected that this mortality burden could be an underestimate. Similarly, given that the historical record has largely focused on the 166 wounded personnel[14] (ie, 2.7% of participating personnel, when using the denominator of n=6,080 participants[15]), we also suspected that the morbidity burden of the war may have been underestimated.

The significance of the South African War for New Zealand is that it was the first overseas war in which this country participated. It also symbolised the nation's extremely strong relationship to Britain and the British Empire at the time, as per the title of a book on New Zealand and this war: *One Flag, One Queen, One Tongue*.[16] The war also established the trend for future deployments of New Zealand military personnel in conflicts of the twentieth century. That pattern was to send an expeditionary force to operate alongside allies and fight as a junior partner in a coalition. The South African War has also been identified as contributing significantly to cementing New Zealand's national identity.[17] Finally, the war also triggered a major societal response in terms of memorialisation, with far more memorials per 1,000 deaths than for other mass-death events in New Zealand's history (ie, seven times the level for both WW1 and WW2 combined, nine times the level for the New Zealand Wars and 266 times the level of the 1918 influenza pandemic[18]).

Given this background, we aimed to provide updated and more complete epidemiological information on the health impacts of the South African War on New Zealand military personnel.

Methods

Mortality analyses

We used a dataset on all the war-attributable deaths among New Zealand personnel involved in the South African War (10 contingents). This dataset was built from a list in the Parliamentary record,[13] modified slightly by comparisons with a list published in a book from 1999[19] and information from the Cenotaph website database[20] and the New Zealand War Graves Project database[21] (see Appendix Table 1). Also, to better identify at least some missed deaths, we searched the 'Newspapers' section of the Papers Past database.[22] The search period was from the end of the war (31 May 1902) to 31 December 1904. The search term was: "trooper" AND "death" AND "South Africa" AND ("wounds" OR "fever" OR "consumption" OR "measles" OR "invalid") (n=228 items). More specific searches of individual names were used to follow-up deaths that were potentially attributable to war, where this was suspected. In select cases where the cause of death was not clear, we purchased death certificates.[23]

Definitions of war-attributable deaths

To define a war-attributable death in this study, we required that the following criteria were all met:

- The person dying had to have been in the New Zealand military at the time of attestation (ie, we excluded New Zealanders who only participated in other militaries during this war, such as the Australian or UK militaries).

- The death occurred during military service (including in military training camps) or in the post-war period up to 31 December 1904. For deaths in this post-war period, we made an assessment based on the balance of probabilities and informed by the available information (and sometimes the death certificates) concerning the war being the likely main contributor to the death or not. That is, if the cause of death predominantly related to war wounds or diseases that began while in military service (eg, tuberculosis and enteric fever), it was considered to be a war-attributable death.

Random selection of military personnel potentially exposed to combat (for lifespan analyses)

We randomly selected 253 names from the whole list of 6,339 New Zealand military personnel who were listed on the Cenotaph website database as having served in this war.[20] Once their specific contingents were identified (by examining data in the Cenotaph database and personal military files), we removed those who participated in the last contingent (Tenth Contingent) whose troop ship arrived in South Africa just days before the war ended and who were not involved in military action.

Random selection of non-combat military personnel

We randomly selected names of those who were in the Tenth Contingent (n=1,022). We then removed from that group those who had also previously participated in Contingents One to Nine. For both this and the 'combat exposed' group above, we also removed duplicates, female participants and those who had participated in non-New Zealand military forces (eg, the UK military). Due to a large number of exclusions (particularly due to participation in other contingents being revealed), we conducted a second batch of random sampling to boost numbers for the analysis, which left a total of 333 selected names.

Lifespan data

We collected data on birth dates from the online military files.[24] Date of death was also sometimes in these files, but otherwise we used a range of genealogical sources. These include the Births, Deaths and Marriages database, which contains records of all New Zealand-based deaths in this cohort[23] (albeit for those records where there was an exact match between the name, and age and year of death/date of birth, with the data from the military file). In some cases, only the birth year could be identified, in which case we used the mid-year point of that year (eg, 1 July 1880) in the analyses.

In the lifespan analyses, we excluded those who died during the war and those who died in the period from the end of the war (31 May 1902) to 31 December 1904 (if there was any indication of their death being war-related). The latter was on the assumption that such deaths may have been from wounds or diseases related to their war experience. Further analyses took account of the participation and death in WW1.

To compare lifespans with the overall lifespan for New Zealand men, we took the approach of a WW2 study[25] and created a synthetic cohort matched to each real veteran in the random samples. That is, in the synthetic cohort we matched each real veteran with a life expectancy value based on that of the average New Zealand man who was born in the same year. Furthermore, this was for life expectancy at the age that these veterans were in 1903 (ie, the year after the one when the war ended). These values have all been estimated for five-year intervals by a large Stats NZ study,[26] and we interpolated the values for birth years in between the five-year values provided by Stats NZ. Such a comparison is not unreasonable, in that there is evidence from an analysis of the occupations of the soldiers relative to men aged 25–45 years (as per 1901 Census data) that "although the total force was small, it was a remarkably representative sample, socially and geographically, of the male population."[15]

Morbidity data

To assess levels of morbidity, we took a random sample of 100 names from all the 6,339 New Zealand military personnel who were listed as serving in this war (as detailed above). All the medical information in their online military files[24] was then examined.

Results

Mortality

Our analysis identified ten additional cases that were probably war-attributable deaths and three that were unlikely to be war-attributable, resulting in a new total estimate of 239 deaths from this war (Table 1). This gave an overall 3.9% risk of death for the total participants (Appendix Table 1). The major cause of death was disease (59%), followed by direct conflict-related causes (30%) (ie, being killed in action or dying from wounds). A statue of one of those killed in action is shown in Appendix Figure 1. 'Accidental' deaths were relatively high (11%) and these were caused by a single train crash (15 deaths) and horse-related injuries. The pattern of deaths over time was one of fairly consistent monthly dominance of disease deaths over war-attributable injury deaths (Figure 1).

The major disease groupings were enteric diseases (with dysentery and typhoid) at 36% of all deaths, followed by respiratory disease (10%) and then measles (5%). Disease deaths were more than twice as likely during winter months compared to all the other seasons (risk ratio of 2.08; 95% confidence interval [CI]: 1.65 to 2.63; Appendix Table 1).

The worst year of the war in absolute terms was 1902 (Appendix Table 1; Appendix Figure 1). It had the worst month for war-attributable injury deaths (the military action at Langverwacht Hill), the worst month for disease deaths (a measles outbreak) and the worst month for accidental deaths (the railway crash referred to above).

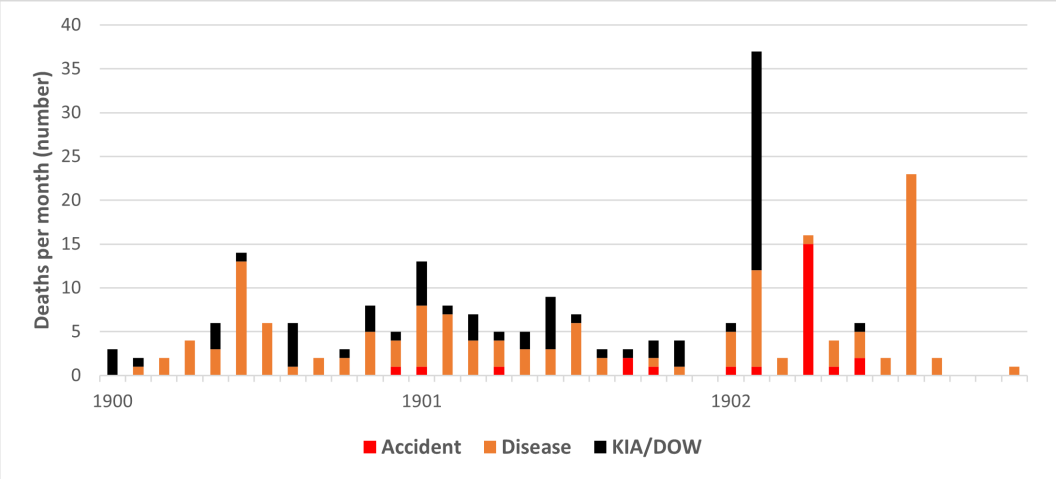
The risk of death was highest for the first three contingents, peaking at 10.3% for the Third Contingent (Appendix Table 1). It was lowest in the last two contingents—though deaths from disease continued to impact on these groups after the end of the war. Nevertheless, when just considering conflict-attributable injury deaths (killed in action and death from wounds), the Seventh Contingent stood out with a 5.4% risk of death. The Seventh Contingent sustained 50% of all such deaths, due to the action at Langverwacht Hill.

The average age of death at 25.5 years (Table 1) can be compared to the lifespan of the veterans of 68.6 years (for Contingents One to Nine, exposed to combat, Table 3). This suggests that these soldiers lost around 43 years of life of average. For the 239 deaths, this sums to around 10,300 years of lost life.

Morbidity impact

Based on the random sample of military files, an estimated 39% of personnel suffered some form of reported injury or illness

Figure 1: Deaths of New Zealand military personnel attributed to the South African War by month of death (from January 1900 to December 1902 [ie, not showing 1 death in 1899 and 10 deaths in 1903/04]).*



* The worst month for mortality (February 1902) reflected military action with 68% (25/37) of the deaths being KIA/DOW (particularly military action at Langverwacht Hill). The second highest peak in August 1902 reflected a measles outbreak. The third, in April 1902, represented a railway crash.

Table 1: Mortality in New Zealand military personnel associated with the South African War (see Appendix Table 1 for additional details).

Specific population	Number	%	Comment
Adjustments to the previous estimates for numbers of war-attributable deaths (n=232)			
Additions in this study to the original list of war-attributable deaths from 1903[13]	10	–	Most of these men died from diseases acquired during the war, based on death certificates and military file data (see details in Appendix Table 2).
Removals by us from the named list in the row directly above	3	–	See Appendix Table 2.
Demographics			
Male	239	100%	Although there were at least 35 New Zealand women working as nurses in South Africa,[19] none died as part of this service.
Māori (Indigenous)	Unknown	Unknown	Although some Māori served in this war,[27] there has not been the in-depth research to appropriately document ethnicity for all the participants.
Age at death	Mean = 25.5 years	–	Based on a random 20% sample of the deaths (ie, 48 deaths). Standard deviation (SD)=5.3; median=24.7; range=19 to 41 years.
Major groupings for cause of death			
Disease	141	59.0%	See the 'disease' section below for further details.
Killed in action (KIA) or died of wounds (DOW)	72	30.1%	See the 'killed in action' section below for further details.
Accident	26	10.9%	This list includes a death from poisoning from chloroform (although there were limited details in the military file, so this might actually have been a suicide). Also included in this category was a suicide that followed brain damage from a fall from a horse, so this prior event was considered as the primary cause of death (ie, 'accident').
Total	239	100%	
More detailed causes			
Directly war-attributable			
Killed in action (KIA)	61	25.5%	
Died of wounds (DOW)	11	4.6%	Included in this category are deaths where wounds became gangrenous, as we regarded the wound as the key component of the causal pathway (whereas some New Zealand historians[19] have previously categorised these as deaths from 'disease').
Disease			
Enteric/dysentery/typhoid	87	36.4%	Most of these deaths were described as 'enteric fever' in the records (ie, probably a mix of typhoid and dysentery in modern terms).

Table 1: Mortality in New Zealand military personnel associated with the South African War (see Appendix Table 1 for additional details; continued).

Specific population	Number	%	Comment
Respiratory disease (excluding tuberculosis)	23	9.6%	Some of these deaths may have been from pneumonia that was secondary to a measles infection and some from respiratory complications following malaria.
Measles	13	5.4%	The second worst month shown in Figure 1 for mortality was due to a measles outbreak (August 1902).
Tuberculosis	4	1.7%	Typically described as 'consumption' or 'phthisis' (pulmonary tuberculosis) in the records.
Meningitis	3	1.3%	
Malaria	2	0.8%	
Other infectious diseases	3	1.3%	
Other diseases—but not infectious	5	2.1%	Some of these deaths might not be primarily war related (eg, diabetes, brain tumour [when a prisoner of war]). Nevertheless, the war experience may still have played a role in increasing the risk of death.
Disease not specified	1	0.4%	
Accidents			
Railway crash	15	6.3%	For a single railway crash (the Machavie railway disaster) in the vicinity of Klerksdorp, South Africa. Using the dates of death, it appears that 13 died on the day of the crash (12 April 1902) and there were two delayed deaths among the 13 or 14 men who were injured (on 14 and 18 April).
Horse-related (eg, falls)	4	1.7%	
Other/not specified	4	1.7%	
Gun shot	3	1.3%	For one of these deaths (LH Arden), the Court of Inquiry could not determine whether death was due to accidental gun shot from a distance or murder (military file data with further discussion in a thesis[28]).
Total	239	100%	

(95%CI: 30%–49%; Table 2). The commonest grouping was infectious diseases (26% of all personnel), and this included enteric disease, malaria and measles. The next most common grouping was injury (14%). Horse-related injuries were more common than direct war-attributable injuries in this sample.

Lifespan of veterans

Many exclusions from the initial samples were required, particularly because around half (50.2%) of the members of the Tenth Contingent had already been in at least one earlier contingent (Table 3). There were differences between the combat and not-combat groups in the post-war period (mean lifespans of 68.6 years and 65.5 years respectively; Table 3), but the higher participation by the Tenth Contingent in WW1 contributed to this. When this was accounted for in the analysis, these differences narrowed, with this difference not being statistically significant (mean lifespans of 68.5 [combat] and 69.1 years [non-combat]; Table 3).

When compared to the lifespan of the matched synthetic cohort (using life expectancies for all New Zealand men at their respective ages in 1903), this military population had very similar lifespans (67.3 years in the military and 67.8 years in the matched cohort; Table 4).

Discussion

Mortality impact

This study identified an additional seven war-attributable deaths (net number), largely from the delayed impact of diseases experienced while in the military. It was also able to estimate the potentially lost years of life in those dying (ie, 10,300 life years lost). While the New Zealand authorities of the day did produce a final list of the dead (with deaths up to July 1903),[13] this should ideally have been updated five or even ten years after the end of the war to account for ongoing deaths. For example, some delayed deaths could have arisen from subsequent operations on war wounds (with operations being more hazardous in this pre-antibiotic era) or from suicide, since post-traumatic stress disorder can be long lasting. Furthermore, an additional aspect to the impact of this war on New Zealand society are the deaths among New Zealanders who joined overseas militaries. This ideally could be estimated in future work—but it may give a total of closer to 300 deaths as per an estimate reported soon after the war.[29] Other work shows that for WW1 there were 1,400 extra such deaths of New Zealanders with other military forces (ie, around 7% of the new total for WW1[30]). However, that work required extensive genealogical skills and resources.

In terms of the major cause of death being from disease (at 59%), this war represents the last time that disease was the dominant cause for wars that New Zealand has been involved in. That is, in WW1, this 'disease' cause was down to 7.8%,[31] despite the contribution of an influenza pandemic.[32] For Australia in the South African War, the proportion of deaths from disease was 47% (286/606).[33] For the British forces it was 63% (13,139/20,721[19]). The statistically higher burden of disease deaths in winter months may reflect the role of infectious diseases associated with close contact (eg, from more time spent inside buildings or in tents) or possibly the immune suppression associated with cold exposure.

Morbidity impact

Morbidity impacts were commonly reported in the random sample of military files, with over a third of personnel experiencing illness or injury (39%). This contrasts to the impression from official statistics, which only focus on the 2.7% prevalence of participating personnel being 'wounded' (see the introduction). Recorded illness (26%) was almost twice as common as injury (14%). Even if only focusing on injury, our new estimate of 14% is over five times that from the official records (2.7%).

Furthermore, the military files will have tended to reflect the more severe conditions, and so the true prevalence of morbidity would probably be even higher than our new estimate (eg, if considering lice infestation, non-hospitalised thermal injuries [heat stroke and from severe cold at night], dental injuries from the hard biscuits, non-hospitalised injuries from riding horses and so on). Furthermore, the morbidity would have been ongoing in some cases. One researcher reported cases of veterans experiencing what appear to be post-combat psychological problems and

Table 2: Mortality and morbidity impacts of the South African War based on a random sample of participating New Zealand military personnel.

Health condition	Number	%* (95%CI)	Comment
Died	3	3.1%	Denominator was n=98 when including Cenotaph records.* All were 'killed in action'.
Non-fatal morbidity impacts			
No morbidity reported in the military files	60	61.9% (51.9–70.9)	Included consideration of any morbidity in those who died, prior to their deaths. The inverse—those with any morbidity—was 39.2% (30.1–49.1)
Infectious diseases	25	25.8% (18.1–35.3)	
Enteric disease/dysentery	8	8.2%	
Malaria	5	5.2%	
Measles	3	3.1%	
Other infections	9	9.3%	Examples include bilharzia, tuberculosis, acute rheumatic fever, respiratory disease, abscess and conjunctivitis.
Injuries	14	14.4% (8.8–22.8)	
Horse-related injuries (falls etc)	6	6.2%	
Direct non-fatal war injuries (eg, gunshot)	4	4.1%	
Other injuries	4	4.1%	Included heat stress. Other work has identified lightning strike injuries.[28]
Other/multiple conditions			
Other illnesses (probably non-infectious)	10	10.3%	Examples include dental and rheumatological conditions; some, such as nephritis, could possibly have had an infectious origin. Some may not have been related to war.
Multiple conditions (more than one of the 8 categories directly above in an individual)	6	6.2%	Some had three separate conditions, but these were possibly related (eg, measles leading to respiratory disease).

*Out of the random sample of 100 military personnel there were two duplicates and one missing military file, hence variation in the denominator (ie, it was n=97 if not stated or n=98 as indicated otherwise). The sample includes personnel from all contingents, including those that departed in April 1902 just before the war ended. It included all illnesses documented in the military files, including those after the war until the military file was effectively closed.

Table 3: Description and lifespan results of the two cohorts of military personnel used for the lifespan comparison of veterans (exposed to combat vs non-exposed).

Characteristic	Random selection of the first nine contingents (exposed to combat) (n=253) N	%	Random selection of the Tenth Contingent (not exposed to combat) (n=333) N	%
Excluded from the analysed samples				
Repeated records of the same individual	1	0.4%	0	0.0%
Female (eg, army nurses)	2	0.8%	0	0.0%
Participated in another military force during the South African War (eg, UK forces)	11	4.3%	1	0.3%
In a named contingent in the New Zealand military but did not actually embark to South Africa on a troop ship	4	1.6%	16	4.8%
Individuals were not in the relevant contingent grouping or if their contingent membership was not entirely clear (n=2) (eg, for the first group they had also been in the Tenth Contingent, and in the second group they had also previously been in at least one of the earlier contingents [Contingents 1–9])	52	20.6%	167	50.2%
Not in the above groups, but who died during the South African War (disease or injury prior to it ending in May 1902)	7	2.8%	0	0.0%
Not in the above groups, but died after the war, between June 1902 and December 1904, from any cause considered likely to be military-service attributable (eg, from a measles outbreak on a returning troop ship or tuberculosis that became active during military service)	2	0.8%	5	1.5%
Not in the above groups, but lacked data to determine lifespan (eg, typically because they had a common name that prevented identification of their date of death, but also because of dying outside New Zealand)	25	9.9%	30	9.0%
Included in first analysis	**N=149**	**%**	**N=116**	**%**
Median birth year (interquartile range [IQR])	1878 (1875 to 1880)	–	1879 (1876.5 to 1881)	–
Mean birth year	1876.5		1877.9 (NS)	
Participated in other wars: Contingents 1–9: NZ Wars (n=1), WW1 (n=29), WW2 (n=1); Tenth Contingent: WW1 (n=43); WW2 (n= 2)	29	19.5%*	42	36.2%*
Died in WW1 (all injury deaths except two deaths from disease)	0	0.0%	14	12.1%
Died during the peak two months of the 1918 influenza pandemic (November and December, albeit not validated with death certificates)	2	1.3%	0	0.0%
Lifespan—median (IQR)	73.0 (61.0 to 79.9)	–	68.3 (56.6 to 77.2)	–

Table 3: Description and lifespan results of the two cohorts of military personnel used for the lifespan comparison of veterans (exposed to combat vs non-exposed; continued).

Characteristic	Random selection of the first nine contingents (exposed to combat) (n=253) N	%	Random selection of the Tenth Contingent (not exposed to combat) (n=333) N	%
Lifespan—mean (SD)	68.6 (16.3)	–	65.5 (16.0) (NS)	–
Lifespan—mean (SD) if in only one contingent out of Contingents 1–9 (n=133)	68.8 (16.1)	–	NA	–
Lifespan—mean (SD) if in two contingents (n=16)	67.4 (19.0)	–	NA	–
Lifespan—mean (SD) if in Contingents 1–4 (n=49)	69.2 (17.0)	–	NA	–
Lifespan—if in Contingents 5–7 (n=34)	69.2 (16.3)	–	NA	–
Lifespan—if in Contingents 8 or 9 (n=66)	68.0 (16.0)	–	NA	–
Adjusted analysis (excluding other war participation: New Zealand Wars, WW1, WW2)	**N=120**	**%**	**N=74**	**%**
Median birth year (IQR)	1878 (1874.5 to 1880.5)	–	1879 (1875 to 1881.5) (NS)	–
Lifespan—median (IQR)	72.4 (60.3 to 80.4)	–	70.3 (62.2 to 78.7)	–
Lifespan—mean (SD)	68.5 (17.2)	–	69.1 (12.8) (NS)	–

* Statistically significant difference in participation in multiple wars (p=0.0012, ANOVA). NS=not statistically significant when comparing the two groups.

Table 4: Mean lifespans for studied populations of military personnel compared to a matched synthetic cohort derived from Stats NZ life expectancy estimates for men by birth year and for their age in 1903.

Study population (after the exclusions detailed in Table 1 for participation in other wars)	Mean lifespan identified in this study (SD)	Estimated mean life expectancy for all New Zealand men (matched synthetic cohort)	P-value
Contingents 1–9 (n=149)	68.6 (16.3)	67.9	0.6008
Tenth Contingent (n=116) (non-combat)	65.5 (16.0)	67.7	0.1564
All the above personnel (n=265)	67.3 (16.3)	67.8	0.5956

further surgical operations (eg, an operation occurring in 1907).[28]

Lifespan of veterans

Our analysis suggested no major lifespan differences between veterans who were exposed to combat and veterans who weren't exposed to combat. International work on this topic used different methods but also identified no increase in mortality of Boer War veterans with post-combat disorders relative to controls with gunshot wounds.[34] Nevertheless, this finding in our analysis may partly reflect the modest sample size, which was diluted because of the much higher than anticipated number of exclusions owing to men joining multiple contingents). There might also have been self-selection effects between the two groups and also variation in the rigour of the selection process in the military over time (eg, initially men were sometimes rejected by military recruiters for being 'indifferent horsemen'[19]).

Our findings, that there is no significant difference in veteran lifespan, contrasts with research on WW1, where combat exposure appears to have resulted in reduced lifespan for surviving New Zealand veterans.[35] This may be accounted for by the more extreme nature of the military experience in these two latter wars (eg, trench warfare in WW1 and the more important role of artillery bombardment in both subsequent wars) and the longer amounts of time spent at front-line conditions for many military personnel in these wars. In WW2 there was also a much higher proportion of veterans who had been prisoners of war, which has been associated with adverse health outcomes (see the introduction).

The finding of similar lifespans for South African War veterans when compared to the average New Zealand male population also contrasts with our findings for WW2 veterans, where a five-year gap was found.[25] This could also reflect the more severe war experience of WW2 (as referred to above), but it might also have been that the role of 'health selection' was less important for the South African War (ie, less vigorous health screening at the recruitment offices). Indeed, various defects with the rigour of the selection process for New Zealand troops in this war have been described.[36]

An interesting finding from the lifespan analyses was the much higher subsequent participation by members of the Tenth Contingent in WW1, relative to earlier contingents. Possibly members of the Tenth Contingent were frustrated that, despite travelling to the war zone in 1902, they had not seen combat in the South African War. On the other hand, many of those who had participated (in Contingents One to Nine) may have decided that they had had enough of war and so had relatively lower rates of volunteering for WW1.

Strengths and limitations of this study

This study is the first such detailed analysis of the health of New Zealand military personnel involved in the South African War using modern epidemiological methods. It is also only the second such analysis at a country level, after UK research.[1,34] The study also benefited from the availability of online military files, online genealogical databases and the capacity to search online most of the New Zealand newspapers of the period in Papers Past (although this is not a completely comprehensive database).

Nevertheless, this study still has various limitations with the major ones being as follows:

- For the mortality work, we did not include deaths of New Zealanders participating in foreign militaries (since no list was available and creating such a list would require extremely extensive archival work). Our searches of Papers Past for additional war-attributable deaths would also probably have missed some individuals who died in the post-war period (eg, especially those dying outside of New Zealand and those who died after 1904).
- For the morbidity work, we only used a random sample of 100 personnel and the military files only focused on conditions causing hospitalisation and not less severe illnesses and injuries. Further research could use a larger sample and study any diaries of the troops.
- The lifespan analyses were also constrained by the modestly sized

random samples (as this was an unfunded study). Future research could attempt to follow-up all the participating personnel—and make more detailed comparisons with WW1.

To what extent were these war-attributable health burdens preventable?

Having considered the morbidity and mortality burdens for military personnel in this war, it is worthwhile to reflect on the extent to which these may have been preventable. Although the New Zealand Government could have chosen not to participate in this war, this counterfactual seems very unlikely, given the country's strong links to the UK[19] and the participation of similar English-speaking countries (eg, Australia and Canada). However, the Government could have decided to send fewer troops, which would have reduced the health burden; the Government did send disproportionately more than Australia and Canada (around 1.8 and 5.7 times more per capita respectively, based on our estimates from published participation data[37]). There was some opposition to the war in New Zealand,[28,38,39] but this does not appear to have prevented further New Zealand contingents leaving for the war during 1902.

More specifically, there were various problems that could all have been better addressed with knowledge of the day and that may have reduced the health burden among participating troops:

- The inadequate understanding of the military situation by the military leaders on the imperial side. That is, the guerrilla tactics used by the Boers, along with their use of trenches and recent developments with weapons (eg, long-range rapid-firing rifles with smokeless ammunition) that decisively shifted the balance towards favouring defence over offence.[12] This meant that imperial forces suffered high casualties when engaging with the Boer forces.[12]
- The lack of adequate training has also been noted: "New Zealand units, therefore, embarked on operations after receiving what can only be described as a most inadequate preparation for service in the front line of a major war".[36] Better training may have resulted in fewer combat injuries and accidents from falling off horses (especially among those volunteers who were not already skilled with horse riding).
- Inadequate military equipment included the outdated single shot rifles issued at the beginning of the war to New Zealand troops.[36] This was in contrast to the state-of-the-art weapons used by the Boers,[19] though rifles with magazines were supplied at a later stage to the New Zealanders.[36] There was also the problem of the relatively small horses for the size of the troops.[40] These New Zealand men were described as "fine, tall broad-shouldered men, half as big again as the average Tommy were sent out. Fine to look at, but Oh, the poor horses!"[40] The New Zealand horses were also given no time to acclimatise to the new country and were over-worked.[19] This situation meant that the horses were less effective in both combat (eg, range and speed of movement) and non-combat situations (eg, transporting supplies and the wounded).
- The inadequate supplies of clothing and provision of shelter for winter camping were problems: "New Zealand soldiers often endured severe daytime heat, then at night slept in the open with only an overcoat to protect them from the freezing cold."[41] Their clothing "quickly became ragged and was not replaced, which led men of the 6th Contingent to strike."[42]
- The inadequate supplies of food (and the minimal variety of food) and lack of water (for drinking and washing) were problematic.[41] "The troopers' equipment was poor, and on trek they had inadequate food – hard dry biscuits, bully beef (canned meat), sugar and tea. They tried to supplement this with much foraging… They were not issued with soap and their clothing quickly became infected by lice."[42] All these deficits probably contributed to increased risk of diseases.

- The inadequate medical support for the imperial troops in South Africa was a well described problem.[12] This issue was also combined with inadequate attention being paid to how injured troops were to be evacuated after combat (eg, shortages of ambulance wagons[12]). It has been noted for the New Zealand troops that "when they were wounded on the trek far from hospitals, sepsis (infection) often developed."[42] There were shortages of such basics as water in hospitals.[19] Inadequate medical care for New Zealand troops was reported on by a journalist,[28] and medical care on troop ships was also a source of complaints, though this problem was dismissed by authorities in an inquiry.[43]
- The crowding of New Zealand troop ships has also been described,[19] and this was of concern to the New Zealand public after an onboard measles outbreak. Although authorities at the time largely dismissed such criticisms, an inquiry did identify poor ventilation on a troop ship as a problem.[43] British troop ships were also described as overcrowded,[12] and the subsequent disease outbreaks on New Zealand troop ships in WW1 also suggested persisting problems with crowding and inadequate ventilation.[44]

Some of these preventable aspects have also been identified as issues with New Zealand's involvement in other wars. For WW1 these included the poor military planning that resulted in failed campaigns (eg, at Gallipoli and Passchendaele[45]), the initial lack of protective equipment such as helmets,[31] inadequate healthcare services (especially the Gallipoli campaign[46]), the poor food at Gallipoli[47] and outbreaks of diseases linked to crowding in various settings.[45] For WW2 there were also apparent examples of defective strategic leadership as per the loss of Crete to German forces (albeit still controversial[48]).

Other preventable aspects of this South African War were the harm done to the civilian population by the burning and looting of Boer homesteads, the killing of their livestock and the setting up of concentration camps containing thousands of Boer women and children. Many of these people subsequently died of disease (see the introduction).[12] New Zealand troops participated in the burning and looting activities,[19,28] but unfortunately there has been no full accounting for these activities and why the New Zealand authorities did not intervene or protest to the UK Government. Other actions, such as the looting of Boer bibles by New Zealand troops, may also not have been fully resolved, even to this current day.[49]

Conclusions

This study found that the mortality was larger and the morbidity impacts of this war were much more substantive than revealed in the prior historical literature for New Zealand, particularly for non-injury illness. The relative importance of death from disease (at 59%) was also a notable feature of this war. But, in contrast to other wars, this study did not identify any lifespan differences between combat and non-combat personnel, or relative to the average New Zealand man at that time. As with other wars involving New Zealand, there is evidence that some of the health burden for participating military personnel could have been prevented with knowledge of the day and better planning to utilise this knowledge.

Appendix

Appendix Figure 1: A statue of a New Zealand soldier killed in action in the South African war (Government Gardens, Rotorua, New Zealand; photograph by the first author).

NZMJ 26 March 2021, Vol 134 No 1532
ISSN 1175-8716
www.nzma.org.nz/journal

Appendix Table 1: Mortality in New Zealand military personnel associated with the South African War—additional details to Table 1.

Specific population	Number	%	Comment
Year of death			See Figure 1 in the main manuscript for deaths by month and year.
1899	1	0.4%	
1900	61	25.5%	
1901	68	28.5%	
1902	99	41.4%	The year with the most deaths. Most still died of disease (53%) but the largest death toll from military action also occurred (at Langverwacht Hill).
1903	7	2.9%	All died of disease.
1904	3	1.3%	All died of disease.
Total	239	100%	
Post-war (after 31 May 1902)	44	18.4%	1 was shot by Boers who did not know that the war was over. Others died of disease (n=41) and accidents (n=2).
Season for Southern Hemisphere deaths (n=237, given 2 post-war Northern Hemisphere deaths)			
Winter (June to August)	76	32.1%	
Spring (September to November)	31	13.1%	
Summer (December to February)	76	32.1%	
Autumn (March to May)	54	22.8%	
Total	237	100%	
Disease deaths by season (for deaths in Southern Hemisphere, n=141)			
Winter	59	42.5%	Relative to a uniform distribution by season, this was elevated with a risk ratio of 2.08 (95%CI: 1.65 to 2.63; p<0.0000001, Mid-P exact, 2-tailed).
Spring	18	13.0%	
Summer	34	24.5%	
Autumn	28	20.1%	
Total	141	100%	
Country where died—all deaths			
South Africa	182	76.2%	
New Zealand	44	18.4%	1 while in training, the rest on return to New Zealand.
At sea (troop ship)	7	2.9%	
Other	6	2.5%	Australia (1); Mozambique (1); UK (1); USA (1), (in the post-war period); and Zimbabwe (formerly Rhodesia) (2).
Total	239	100%	

Appendix Table 1: Mortality in New Zealand military personnel associated with the South African War—additional details to Table 1 (continued).

Specific population	Number	%	Comment
Contingent (date of departure from New Zealand)	**Number dying**	**Risk of death**	
First (21/10/1899)	17	7.9%	Risk of death was calculated using the numbers in each contingent departing from New Zealand.[50] But this is a relatively simplistic analysis which does not account for some personnel serving in multiple contingents and for varying time periods (eg, an estimated 335 personnel served in two contingents[15]).
Second (20/1/1900)	23	8.6%	
Third (17/2/1900)	27	10.3%	Highest risk of death was in the first 3 contingents.
Fourth (31/3/1900)	20	4.3%	
Fifth (31/3/1900)	25	4.2%	
Sixth (30/1/1901)	20	3.3%	
Seventh (6/4/1901)	49	7.3%	But for this Contingent there was a relatively high 5.4% risk of death from KIA and DOW combined. It sustained 50% of all such combat injury deaths (36/72), due to the action at Langverwacht Hill.
Eighth (8/2/1902)	38	3.4%	
Ninth (20/3/1902)	8	0.7%	
Tenth (19/4/1902)	12	1.0%	The war ended on 31/5/1902, soon after this Contingent arrived in South Africa. But deaths from disease continued.
Total	239	3.9% overall	This 3.9% estimate uses what is probably the most accurate denominator of 6080 New Zealand participants.[15] This estimate accounts for some personnel serving in multiple contingents (ie, there were actually only 6080 individuals leaving New Zealand on troop ships).

Appendix Table 2: Changes to the mortality burden associated with the South African War for New Zealand military personnel (relative to the available list of deaths from the South African War available at the start of this study in the AJHR dataset[13]).

Re-classification	Surname, first names	Comments
Added to the AJHR mortality dataset	3 names—see comments	The following men were initially in the New Zealand military forces in South Africa but at various times (eg, after completing their New Zealand service) they then joined British regiments/forces (NEAVE Arthur Cormack, PARKER John Henry, BUTLER J). They died while in these other forces. As per the approach taken by Crawford and Ellis[19], and our definition for war-attributable deaths (see Methods), we considered it reasonable to include these men in this analysis.
Added to the AJHR mortality dataset	CUTTS, Edward	He died in November 1903 'from causes originating in his battle-field trials' (Papers Past). Military file reports a back injury resulting in bleeding from his kidney when in South Africa. He had ongoing sickness during 1903 with the medical report stating 'kidney disease (Bright's)' (in modern terms: acute or chronic nephritis). A certificate indicated that his illness was as a result of active service in South Africa.
Added to the AJHR mortality dataset	JANSEN, George Frederick	He died in Hawaii in October 1903. 'It appears he had never thoroughly recovered from enteric fever, which he had while on active service' (Papers Past).
Added to the AJHR mortality dataset	LEARY, Percy Charles	He died from dysentery in a military training camp in New Zealand prior to his Ninth Contingent going to South Africa (Cenotaph record).
Added to the AJHR mortality dataset	LUND, John Vigo	He died from tuberculosis (death certificate) in October 1904 which he had had for 3 years (ie, since being in the military in South Africa). The military paid for his funeral expenses.
Added to the AJHR mortality dataset	MCLAUGHLIN, David	He contracted measles on his way to South Africa (Ninth Contingent), followed by a respiratory infection and then tuberculosis. He never recovered and died in October 1903 (Papers Past). In the media reports his name was spelt as: 'McLauchlan'. In his military file he is also recorded as having 'consumption' with the military paying for his care at the time around his death. It also reported his illness as starting on a troop ship.
Added to the AJHR mortality dataset	MERRY, Charles Donald	He died from tuberculosis (death certificate) in September 1904 which was diagnosed while he was in the military in South Africa.
Added to the AJHR mortality dataset	WARD, William Ernest	He had enteric fever in South Africa followed by consumption (tuberculosis). He was 'invalided' since his return to New Zealand and died in September 1904 (Papers Past). His military files reports that when hospitalised after measles on a troop ship he was found to have 'consumption'.
Assumed not war related—not added	MUIR, John	He died 'of consumption' (tuberculosis) in December 1904 (Papers Past). We did not include this as a war-attributable death as he seems to have been discharged from the military without any reported illness. Nevertheless, we acknowledge that there is still some chance that his illness was acquired, or its course accelerated during military service.

Appendix Table 2: Changes to the mortality burden associated with the South African War for New Zealand military personnel (relative to the available list of deaths from the South African War available at the start of this study in the AJHR dataset[13]; continued).

Re-classification	Surname, first names	Comments
Assumed not war related—not added	PRESTNEY, Arthur	He died after the war in October 1902. His death certificate says he died of 'Pneumonia' after '9 days' of illness, so it was assumed his death was not war-attributable..
Excluded as in other military force	Various names	New Zealand men who participated in other military forces for all of the war (eg, UK or Australian) and which may be war-attributable deaths. These were: Charles Peter CLARKE, Patrick LAMB, John Davidson ROBINSON, Stanley Rees SCOTT, GW SMITH, and T TAPLIN (all identified in Papers Past).
Not added as not in military	BROWN, Charles	Sailor who died an accidental death on a troop ship (August 1902, Papers Past). Such sailors were not enlisted military personnel.
Noted—but not added in	BAKER, Thomas de Foe	He died on 19 April 1904 in South Africa (Pretoria). His military file does not indicate any illness at the time of discharge. The media records indicated that he worked in business in Pretoria in the post-war period before going on a hunting expedition in East Africa.
Noted—but not added in	MONK, Berther Charles	He died of enteric fever on 22 August 1902 in South Africa. In his military records his discharge certificate indicated he had left the military on 7 April 1902 and his files have no record of him being ill (though some digitalised pages of his military record were not accessible online). Given this, it seems more likely that his enteric fever was contracted after his military service.
Noted (already in the AJHR dataset)	FREEMAN, Tom Molloy	He had severe enteric fever during the war and died in January 1902 shortly after being invalided back to New Zealand (Cenotaph Record). This man's name was not included in the list in the book by Crawford and Ellis[19].
Noted (already in the AJHR dataset)	TAYLER, Frederick Howard	He died of 'paralysis' on 29 May 1903 in New Zealand. The military file indicates that his widow was awarded a pension. It notes his 'weak heart' and a medical reports states: fall from horse, heart disease, cerebral embolism. Another document states that his death was 'due to original injury when on military duty'.
Noted (already in the AJHR dataset)	TOWGOOD, Edward Traherne (spelt: 'TOOGOOD' in Cenotaph record)	He died in London on 16 July 1903 from 'Heart-affection'. The Cenotaph record notes that 'while at Paardeburg Toogood had a revolver accident and was admitted to hospital. He was invalided to Cape Town in July 1900 and left for England aboard the S.S. 'Gothic'. (Stowers, p.179)'. His military file reports 'internal injuries sustained from fall from a horse' and also 'invalided from wounds while handling a revolver.' 'He also was reported having 'wound in foot and malarial fever'. Given all this information it seems more than likely that his premature death was war-attributable. This man's name was not included in the list in the book by Crawford and Ellis[19].

Appendix Table 2: Changes to the mortality burden associated with the South African War for New Zealand military personnel (relative to the available list of deaths from the South African War available at the start of this study in the AJHR dataset[13]; continued).

Re-classification	Surname, first names	Comments
Removed from the AJHR mortality dataset	STEPHENSON, Henry Tapua Athelstane	He died in the post-war period in South Africa (January 1903) after discharge and after working as a telegraphist there (Papers Past). No cause of death was stated in newspapers or his military files. We assumed on the balance of probabilities that his death was from a new condition in the year after the war and so was unlikely to be war-attributable.
Removed from the AJHR mortality dataset	TUDOR, Piers Lloyd	He died in the post-war period in South Africa (December 1902) from enteric fever (Cenotaph record). But there is no record in his military file about enteric fever. Furthermore, his obituary (Cenotaph record) suggests he was relatively well post discharge: 'When peace was declared he began to cultivate the land he had so well helped to annex. In a letter to a friend dated Nylstroom, 14th September, 1902, he said:-- 'I have just come into town to get seed potatoes, mealie, etc. A fellow named Hutton and I have taken up a place about fourteen miles from here… There are quite a number of New Zealanders up here… We have come down to riding mules; they are not the best of hacks, but as it is a bad district for horses one has to put up with them.' Given this information we assumed the enteric fever causing his death was (on the balance of probabilities) likely to have been acquired after his military service and so was not war-attributable.
Removed from the AJHR mortality dataset	NORTHE, Sidney (also NORTH in Cenotaph record)	He died in Rhodesia (now Zimbabwe) on 16 February 1902, with his death notice reporting the causes of death as: (i) typhoid fever; and (ii) malaria. He was discharged from the military in January 1901, with no evidence of injury/illness in his military file. We therefore assumed on the balance of probabilities that these infections arose after leaving the military and so his death was probably not war-attributable.

Competing interests:
Nil.
Acknowledgements:
We thank Hilary Day for assistance in identifying the morbidity burden from the military files.
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