

## Severe impact of the 1918–19 pandemic influenza in a national military force

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### Abstract

The impact of pandemic influenza on the New Zealand Expeditionary Force (NZEF) in 1918–19 has never been studied using modern epidemiological methods. Therefore we analysed mortality and descriptive data from various sources for these military personnel. An estimated 930 NZEF personnel deaths from pandemic influenza occurred in 1918–19, making it the main cause of disease deaths, and representing 5.1% of all NZEF deaths from World War One (WW1). The epidemic curve was much more drawn out in the Northern Hemisphere compared with the Southern Hemisphere.

Mortality rates varied markedly by setting (e.g. in military camps, by country and by hemisphere). Significantly higher mortality rates were found amongst NZEF personnel: aged 30–34 years, those of Māori ethnicity, those with a rural background, and those who left New Zealand for Europe in 1918.

In conclusion, this work documents the heavy mortality burden from pandemic influenza amongst this national military force and highlights the large variations in mortality rates through host and environmental factors.

The 1918–19 influenza pandemic occurred during the final stages of World War One (WW1). It occurred in a series of waves (of varying severity) and claimed the lives of an estimated 50+ million worldwide.<sup>1</sup> The earliest outbreaks thought to be due to pandemic influenza occurred in March 1918 at two military training camps in the United States.<sup>2,3</sup> However, reports of the influenza pandemic and its high mortality did not reach New Zealand (NZ) officials until September 1918,<sup>4</sup> by which time the first deaths of New Zealanders from this pandemic had already occurred.

Some of these first deaths occurred amongst the NZ Expeditionary Force (NZEF) onboard the troopship the His Majesty's New Zealand Troopship (HMNZT) *Tahiti* in September 1918.<sup>5</sup> The impact of this pandemic has been described in other military groups around the world,<sup>2,3,6–9</sup> however the impact on NZEF personnel (Figure 1) has only be incompletely described to date.<sup>10–15</sup>

**Figure 1. Daily Mail (London): ANZACS in France. Off to the trenches (circa 1916) Alexander Turnbull Library. Official war pictures, no. 153. [Postcard. ca 1916]. Reference Number: Eph-POSTCARD-WWI-01. 2012 [cited January 2013]; Available from: <http://timeframes.natlib.govt.nz/>**



Military camps in NZ were hit hard by influenza in late 1918. Narrow Neck Camp in Auckland was the one of the first populations in NZ to experience an influenza outbreak; an October wave affected 30–40% of the camp (with no deaths), and the November wave affected ~50%.<sup>10,12,15</sup>

In the Featherston Camp (Wairarapa), over 3,220 troops required hospitalisation during the second wave period (November 1918), from a camp comprised of around 8000 men (40.3%).<sup>13</sup> The camp's hospital was quickly overwhelmed with the influenza outbreak.

Awapuni and Trentham Camps both experienced the pandemic's November wave and like other institutions with confined populations in NZ, such as mental hospitals and prisons, reported high morbidity and mortality rates.<sup>10</sup>

Around 600 NZEF personnel located overseas and in NZ were reported as dying from pandemic influenza in 1918.<sup>10,12</sup> However, given the limited detail on the epidemiology of the pandemic we thought this figure was likely to be an underestimate.

Consequently, this study aimed to provide a more detailed description of the impact (at least in terms of mortality) of the pandemic amongst the NZEF personnel.

## Methods

**Historical context**—Historical information was obtained from a variety of documentary sources, describing particular aspects of the influenza pandemic amongst the NZEF personnel in various locations and times.<sup>5,11,16</sup> One of the authors (JS) also conducted interviews with various military historians.

Archival records (known as the Chronicles<sup>17</sup>) containing hospital pandemic morbidity information on NZEF personnel in the United Kingdom was accessed (as part of a PhD thesis<sup>18</sup>). However the lack of clearly defined admission totals meant that it was not possible to extrapolate case fatality estimates without consulting the personnel file for each hospitalised individual, which was beyond the scope of this study.

Presently, there are no other known archival records from this period that contain individualised morbidity information for this military population. Therefore, this current study focuses on mortality from the pandemic.

**Denominator data**—Individualised data (Cenotaph dataset) on the vast majority of NZEF personnel were obtained from the Auckland War Memorial Museum. These data were used as the main source for variable denominator populations after adjustment for pre-pandemic NZEF personnel deaths.

Additional denominator information was obtained from various sources: New Zealand military camp size numbers,<sup>10,13</sup> Monthly totals for the NZEF personnel numbers during WW1,<sup>16</sup> and estimates of the numbers of NZEF personnel stationed overseas during various time periods.<sup>11,19</sup>

**Mortality data**—An electronic dataset (Roll of Honour [RoH]) covering all deaths amongst NZ military personnel during WW1 was obtained courtesy of the compiler, Professor Peter Dennis (University of New South Wales at the Australian Defence Force Academy). The total number of NZEF personnel deaths during WW1 is estimated to be 18,000+.<sup>19</sup>

Individual archival records were then used to confirm an individual as a pandemic influenza case. Initial investigations identified 1113 potential influenza cases, based on NZEF personnel dying from disease or unclear causes in 1918 and 1919. For the purposes of this analysis, pre-pandemic or ‘herald’ waves (prior to 1918) were not explored further.

The individual military files for each of these NZEF personnel were accessed to confirm the specific cause of death. The military files were from the following sources: digitised PDF personnel files held at Trentham Military Camp NZ (permission obtained in January 2011 from the NZ Defence force), online PDF military files freely available online through the Archives New Zealand website ([www.archway.archives.govt.nz](http://www.archway.archives.govt.nz)), NZ Death Registers held at the NZ Department of Internal Affairs: Births, Deaths and Marriages (permission obtained in December 2011), online death notices freely available online through the NZ National Library Papers Past website ([www.paperspast.natlib.govt.nz/cgi-bin/paperspast](http://www.paperspast.natlib.govt.nz/cgi-bin/paperspast)), and the publicly available Casualty Rolls held in Archives New Zealand.

Cases of pandemic influenza were defined as NZEF personnel whose specified cause of death was one of the following: influenza, pneumonia and/or bronchitis in the time considered to be the pandemic period as described in results.

Deaths occurring at sea (aside from those identified onboard the HMNZT *Tahiti*) were excluded as the numbers were negligible and were not part of any documented influenza outbreak.

**Demographic and military data**—The variables of place of death, first deployment year, and military rank were obtained from the RoH and Cenotaph datasets. Not all records held information on the variables of interest, and it was assumed for this analysis that there was an equal distribution of missing data amongst the individual NZEF records.

Military rank was divided into four categories based on a key military text.<sup>20</sup> These categories consist of officers, non-commissioned officers, health-care workers and others (mainly privates).

Few records within the Cenotaph dataset (n=1,186) contained age information. Therefore, a 1% simple random sample (adjusted for those still alive during the pandemic) was used as a basis for estimating the age at enlistment for the entire NZEF.

Given the difficulty in obtaining date-of-birth (DoB) information, a larger number of randomly selected records (n=1521) were researched using the three above methods, to obtain a sample size of 1000.

Age at time of enlistment was derived from DoB records. These records were obtained from a number of sources: the Cenotaph dataset, Casualty Rolls, and an online searchable dataset which was used in a previous study<sup>5</sup> for births, deaths and marriages in NZ.<sup>21</sup>

All NZEF personnel identified as pandemic deaths were assigned to one of the following three ethnic groups: European/Other, Māori or Pacific peoples.

The classification of Māori is described in a previous study.<sup>14</sup> For Pacific peoples this classification was defined as having come from a Pacific Island country and having: (i) a Pacific name; or (ii) having a parent with a Pacific name; or (iii) coming from a village (because some Europeans were living in the major towns in some Pacific Islands at this time). All other personnel were categorised as 'European/Other'.

As the Cenotaph dataset does not identify ethnicity for each individual, a 1% sample of the Cenotaph dataset was used to estimate the ethnic distribution of NZEF personnel as a whole. The sample was selected using a simple random sampling method, after restriction to NZEF personnel who were still alive at the start of the pandemic period.

All listed pre-enlistment occupations were classified and given a measure of occupational class (based on occupations in the 1919 year)<sup>22</sup> and a rurality index was used (based on pre-enlistment address and pre-enlistment occupation), as described in previous studies.<sup>5,23</sup>

As only a small number of women were in the NZEF (n=536, mainly nurses, and with n=3 deaths from pandemic influenza) we did not conduct further analyses by gender.

**Analysis**—All statistical work was performed using MS Excel 2007, EpiInfo, and SAS version 9.1 software.

## Results

**Time and place of outbreaks**—From 27 August 1918 to March 1919, a distinct increase in the number of non-combat deaths was observed amongst NZEF personnel in the Northern Hemisphere.

These deaths can be described as consisting of two waves; a late 1918 wave (27 August 1918 to 31 December 1918) and an early 1919 wave (1 January 1919 to 31 March 1919). Outside of this period there is little evidence for an influenza outbreak causing any mortality. This fits with historical records,<sup>3</sup> which reported little mortality from a first pandemic wave amongst the NZEF in France. From April 1919 onwards, the total number of personnel recorded as dying from non-combat causes returned to pre-pandemic levels.

NZEF personnel in the Southern Hemisphere experienced a distinct increase in the number of non-combat deaths occurring between 1 November to the end of December 1918. The timing of these deaths and the available specific disease records strongly support the evidence for a November pandemic outbreak amongst the NZEF in the Southern Hemisphere, mainly occurring in NZ.

From January 1919 onwards, the numbers of non-combat deaths returns to pre-pandemic levels, providing little evidence of a subsequent pandemic wave amongst this population.

**Estimated total of cases**—The final estimated pandemic influenza mortality burden amongst the NZEF was 930 deaths. Using the two estimated denominator values of the total number of NZEF personnel, adjusted to those alive during the pandemic gives a mortality rate of 8.8 per 1000 (Table 1).

**Table 1. Sociodemographic and military characteristics of New Zealand troops dying of pandemic influenza (1918–1919)**

Variable (denominator populations)	Pandemic-related deaths (N)*	Mortality rate (per 1000 population)	Crude mortality rate ratios (95% CI)
<b>Setting and time</b>			
Second Wave, Northern Hemisphere (n=58,399)	255	4.4	1.00 Reference
Third Wave, Northern Hemisphere (n=48,954)	89	1.8	0.4 (0.3–0.5)
Southern Hemisphere/Transit (n=51,844)	519	10.0	2.3 (2.0–2.7)
At sea	67	60	–
Total for all NZEF personnel using total estimated NZEF personnel alive during pandemic period (n=105,520)	930	8.8	–
<b>Age group (years)</b>			
Under 20 (n=2321)	5	2.2	1.0 Reference
20–24 (n=36,193)	258	7.1	1.4 (1.4–8.0)
25–29 (n=30,706)	288	9.4	4.4 (1.8–10.5)
30–34 (n=17,094)	195	11.4	5.3 (2.2–12.9)
35–39 (n=10,130)	112	11.1	5.1 (2.1–12.6)
40–44 (n=5909)	48	8.1	3.8 (1.5–9.5)
45+ (n=2958)	21	7.1	3.1 (1.2–8.2)
<b>Ethnicity</b>			
European/Other (n=103,199)	887	8.6	1.0 Reference
Māori (n=1,583)	32	20.2	2.4 (1.7–3.3)
Pacific (n=739)	11	14.9	1.7 (1.0–3.1)*
<b>Occupational class (pre-enlistment)</b>			
1–3 (highest most privileged) (n=4757)	38	8.0	1.0 Reference
4–6 (n=38,028)	289	7.6	1.0 (0.7–1.3)
7–9 (n=62,735)	439	7.0	0.9 (0.6–1.2)
<b>Rurality index (base on location and occupation)</b>			
0 (highly urban) (n=46,218)	228	4.9	1.0 Reference
1–2 (n=28,174)	210	7.5	1.5 (1.3–1.8)
3–4 (n=15,723)	137	8.7	1.8 (1.4–2.2)
5–6 (n=9,391)	90	9.6	1.9 (1.5–2.5)
7–8 (highly rural) (n=6015)	64	10.6	2.2 (1.6–2.8) †
<b>Military rank</b>			
Privates / Other (n=83,995)	728	8.7	1.0 Reference
Non-commissioned officers (NCOs) (n=16,881)	143	8.5	1.0 (0.8–1.2)
Officers (n=4049)	37	9.1	1.1 (0.8–1.5)
Health care workers (n=595)	3	5.0	0.6 (0.2–1.8)
<b>Deployment year in the NZEF</b>			
1914/1915 (n=32,036)	150	4.7	1.0 Reference
1916 (n=32,094)	181	5.6	1.2 (1.0–1.5) ‡
1917 (n=28,717)	123	4.3	0.9 (0.7–1.2)
1918 (n=12,673)	192	15.2	3.2 (2.6–4.0) §

\*p-value = 0.044 (1-tailed test)

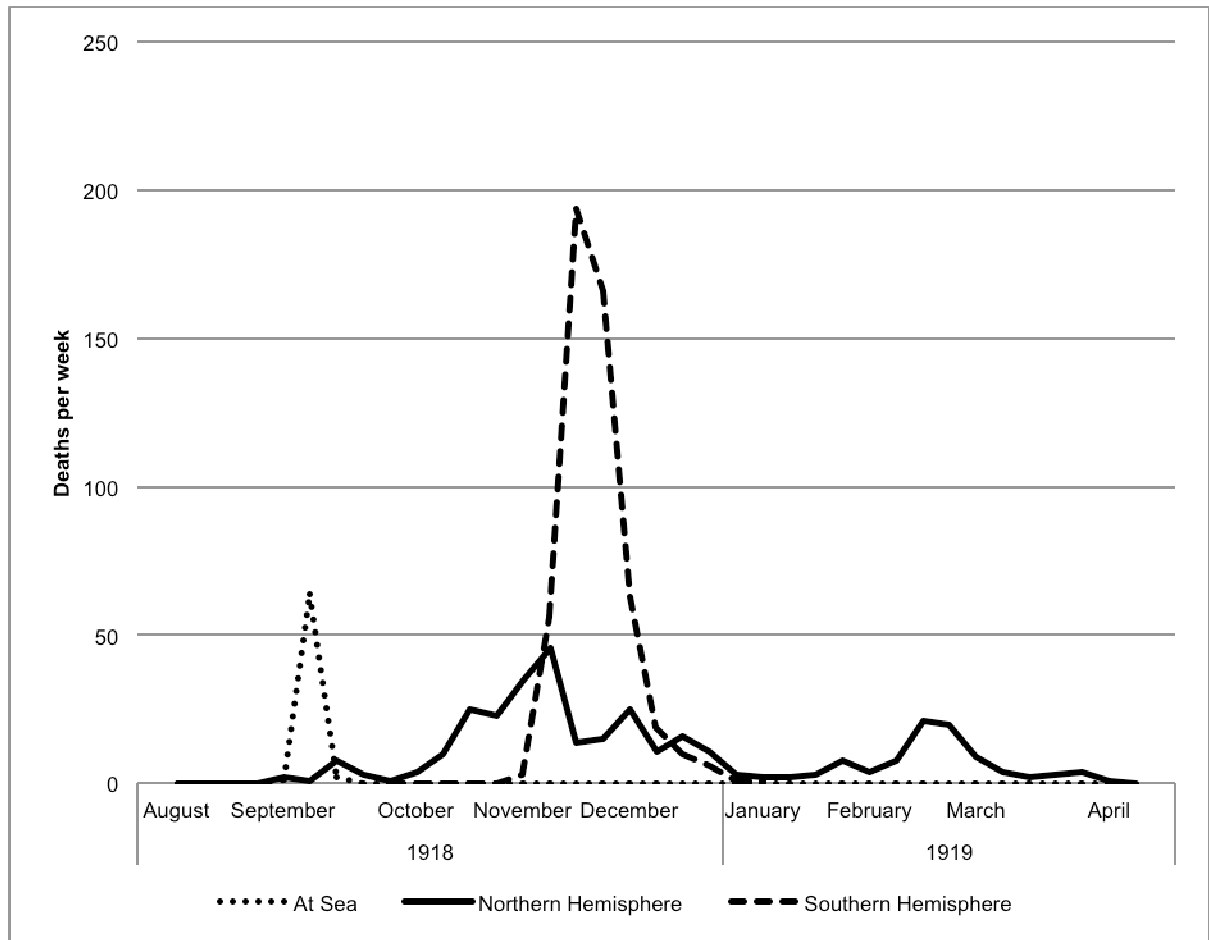
†Chi Square for Linear Trend = 53.31 (p-value <0.000001)

‡p-value = 0.046 (1-tailed test)

§Chi Square for Linear Trend = 75.57 (p-value <0.00001)

The pandemic wave passing through the full NZEF is estimated to have occurred over a period of 33 weeks. However, the Southern Hemisphere experienced a shorter pandemic period compared to the Northern Hemisphere (Figure 2), consistent with other research.<sup>19</sup>

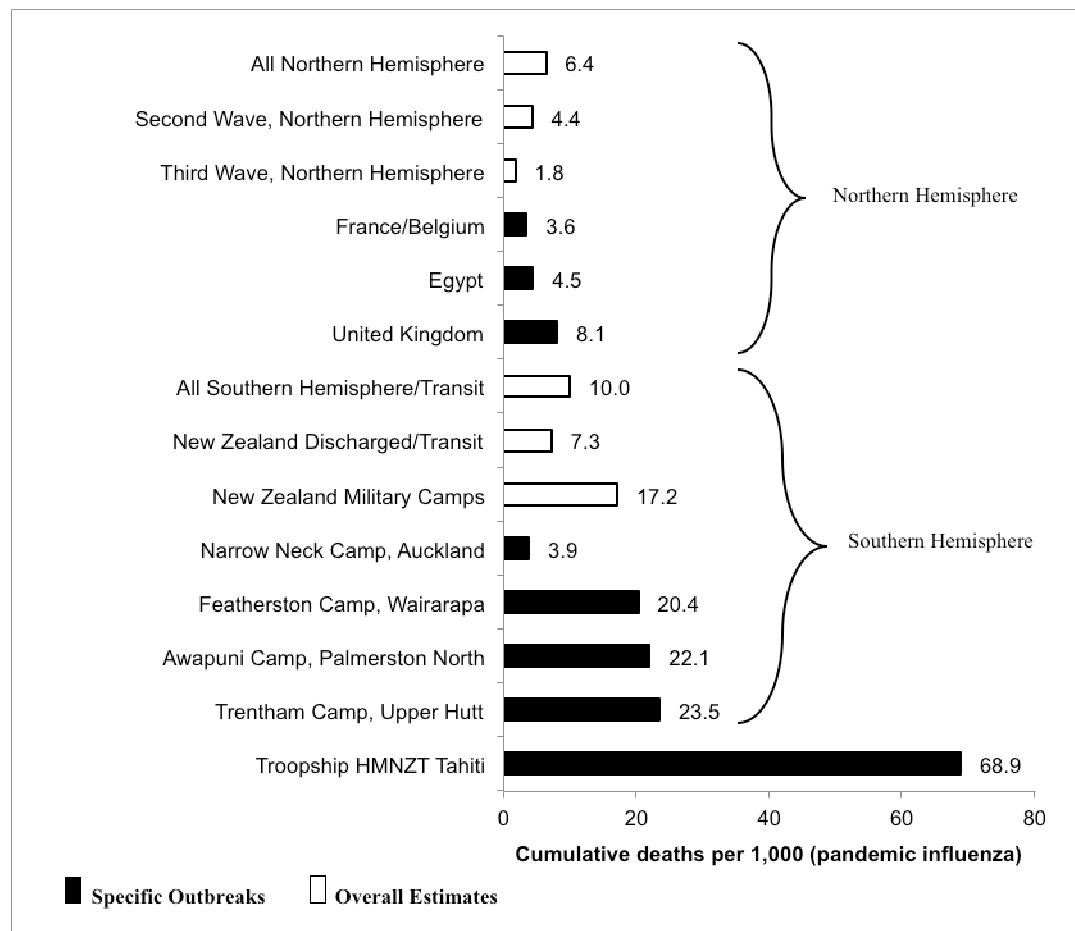
**Figure 2. Pandemic Influenza deaths amongst NZEF personnel (1918–1919)**



**Specific outbreaks:** Figure 3 shows estimated mortality rates for specific outbreaks and regional outbreaks of pandemic influenza amongst the NZEF, with the denominator values obtained from various sources.<sup>5,10,13,16,19</sup>

A reliable denominator value could not be determined for NZEF personnel located in the Southern Hemisphere (outside military camps), therefore the total includes NZEF personnel who were in transit during the pandemic.

**Figure 3. Pandemic influenza mortality rates amongst NZEF personnel at different locations**



**Ethnicity**—Both Māori and Pacific NZEF personnel experienced significantly higher pandemic mortality rates (20.2 per 1000 and 14.9 per 1000) when compared to European/Other NZEF personnel (9.2 per 1000) (Table 1). The majority of European/Other and Māori pandemic deaths occurred in the Southern Hemisphere, whilst deaths of Pacific personnel were equally distributed in both hemispheres.

**Deployment year**—NZEF personnel for whom 1918 was the first year of recruitment experienced the highest pandemic mortality rate (15.2 per 1000), which was statistically significant when compared to those whose first embarkments occurred in 1914–15 (with a mortality rate of 4.7 per 1000) (Table 1).

**Age distribution**—The average age for NZEF personnel dying from the pandemic was 29.0 years, slightly higher than the estimated average age for all NZEF personnel during 1918 of 28.0 years of age. The largest proportion of deaths occurred amongst the 25–29 year olds, consisting of 31.1% of pandemic cases (Table 1). However, the highest mortality rate was experienced by 30–34 year olds (11.4 per 1000), which was statistically significant when compared to under 20 year olds.

**Occupation and rurality**—NZEF personnel classified in the higher (most privileged) occupational classes of 1 to 3, experienced a higher mortality rate compared to the other occupational classes, but these differences were not statistically significant (Table 1).

NZEF personnel classified as highly rural in the rurality index had statistically significant higher mortality rates when compared to those from urban areas (Table 1). The Chi-squared value for linear trend for mortality rates with increasing rurality index was statistically significant (p-value <0.001).

**Mortality by military rank**—Similar mortality rates were experienced by Privates/Others, Non-Commissioned Officers and Officers (8.7, 8.5 and 9.1 per 1000 respectively). Health care workers experienced the lowest mortality rate amongst all military ranks (5.0 per 1000). However, there were no significant statistical differences between any military rank.

## Discussion

The influenza pandemic of 1918-19 was a substantial cause of death amongst the NZEF personnel during and after WW1. The estimate of 930 pandemic deaths identified in this study indicates that previous assessments,<sup>10,12</sup> of the mortality burden amongst the NZEF were underestimates. This finding suggests that the total number of New Zealanders killed by the pandemic, NZ's largest natural disaster ever, needs to be revised upwards.<sup>10</sup> For example, this current study adds 258 more military specific deaths from the pandemic to the total found by Rice (n=603), resulting in a new grand national New Zealand total of 8831.

Overall, the mortality from this pandemic accounted for 28.3% of all estimated deaths from disease in the military in WW1, and an estimated 5.1% of all deaths amongst the NZEF personnel of WW1.

This research provides evidence that NZEF personnel located in the Southern Hemisphere military camps during the pandemic suffered disproportionately severely, in terms of mortality, compared to the Northern Hemisphere based NZEF and discharged/transiting NZEF personnel.

The Northern Hemisphere NZEF personnel experienced a more temporally dispersed outbreak, with a second pandemic wave in early 1919. There was no evidence in this mortality-orientated study of a subsequent pandemic wave occurring in 1919 amongst Southern Hemisphere/transiting NZEF personnel, which is consistent with the general NZ population with no increased mortality rates occurring post 1918.<sup>10</sup>

The majority of NZEF personnel who died from influenza in the Northern Hemisphere during 1919 were troops awaiting transport back to NZ after discharge.

The high pandemic mortality experienced by NZEF personnel who left for Europe in 1918 is consistent with other research in other military populations (Australia, USA and Britain) which suggests that 'fresh' recruits suffered disproportionately during the pandemic compared with 'seasoned' troops.<sup>8,9,24,25</sup>

Some commentators have suggested that newly recruited soldiers lacked immunity due to lack of exposure to influenza infections earlier in 1918. This mechanism may also partially explain the low mortality rate observed in Narrow Neck Camp



(previously exposed to the reportedly mild wave in October 1918<sup>12, 26</sup>) relative to the other three main military camps.

The lower overall mortality rate for personnel in the Northern Hemisphere and amongst health care workers (although not significant, is consistent with a previous study<sup>25</sup>) suggests that some level of acquired immunity may have existed in these subsections of the NZEF. This has been hypothesised in previous research regarding a range of WW1 military populations in Europe.<sup>7</sup>

Of the three regions in the Northern Hemisphere in which mortality rates were able to be calculated, it is notable that NZEF personnel located in France/Belgium experienced the lowest mortality rate. This was potentially partially due to the veteran status of the fighting soldiers, with few recent recruits. It is also perhaps another example of the potential protective role of immunity from a greater exposure to other infectious pathogens (e.g. to the bacteria that caused the secondary pneumonia in many influenza-related deaths in 1918).

The pattern of mortality rate by age, with a peak experienced by 30 to 34 year olds in this study is consistent with findings amongst the general NZ population<sup>10,27</sup> and in other populations.<sup>28-30</sup> There is still no established explanation for this unique and distinctive pattern of mortality by age during the influenza pandemic of 1918–19.

Māori and Pacific NZEF personnel experienced a much higher pandemic mortality rate when compared to the European/Other ethnic grouping. The findings for Māori personnel are consistent with other research which found a marked ethnic gradient in mortality in the overall NZ population in this and two subsequent influenza pandemics.<sup>10,14</sup>

Previous research investigating indigenous populations differential mortality outcomes during the 1918–19 pandemic has suggested that this may be the result of having lower socio-economic status (relative to the European/Other ethnic group), higher levels of rurality (potentially less acquired immunity through past respiratory pathogen exposure), poorer access to health care, and possibly higher rates of comorbidities.<sup>14,31,32</sup>

All these factors may have been relevant in the military setting—as there is no evidence for differential access to health care or to other basic provisions such as food and accommodation amongst the NZEF personnel in WW1.

A history of rural location was a risk factor in this study and not a protective factor as suggested by previous studies amongst the NZ civilian population,<sup>23</sup> and civilian populations in Australia and the USA.<sup>24</sup> However, the latter may have been due to social-distancing during the pandemic—which would not be relevant in crowded military populations during WW1.

In this military population, a history of rurality may instead have been a proxy indicator of lower cumulative exposure to respiratory pathogens and therefore possibly lower immunological protection when exposed to the influenza pandemic strain and associated bacterial pathogens.

It is plausible that other strains of influenza and pneumonia were circulating both during and pre/post pandemic periods. There are no known serological samples that exist from this NZEF population; but given that the NZEF personnel mortality burden

between 1915–1917 averaged a total of around ~330 non-combat deaths per year, it is plausible to assume that of the 1143 non-combat deaths which occurred amongst NZEF personnel during the pandemic period alone, the 930 pandemic deaths identified in this study are close to the accurate total.

A further limitation of this study is that all the mortality rate ratios are not age adjusted. However, this was not felt to be important for this study given that most of the NZEF personnel were in a fairly narrow age-band. Nevertheless, multivariate analyses has been undertaken as part of an unpublished PhD thesis as part of a case-control study.<sup>18</sup> When published, this will provide information on risk factors with age adjusted results (e.g. enlistment year and military rank as risk factors).

Examining the course of the influenza pandemic amongst the NZEF personnel is of strong historical and epidemiological importance. In terms of epidemiology, the study of past pandemics has the potential to provide knowledge beneficial to the planning and management of future pandemics. For example, the current study has demonstrated evidence that personnel of different ages but in similar regions experienced strikingly different mortality rates, a strong indication of the impact that host factors had during this pandemic.

Whilst it is plausible that pre-existing immunity (to virological and/or bacterial pathogens) provided protection amongst certain groups of the NZEF, it is not possible to be certain due to lack of surviving pathological specimens. The 1918-19 influenza pandemic represents one of the worst pandemics, of any kind, experienced by humans in recorded history. Therefore understanding the great lethality of this pandemic is relevant to preparations for future pandemics.

As more historical records become available and are analysed, the events that occurred around 1918 can potentially provide today's health sector planners a better basis for justifying allocation of scarce health care resources to pandemic preparations and to particular populations when another influenza pandemic arises.

**Competing interests:** Nil.

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