A recent meta-analysis of 48 cohort studies reported that low socioeconomic position was the third most important risk factor for premature mortality. It was estimated that low socioeconomic position is associated with a 2.1-year reduction in life expectancy between ages 40 and 85 years.

In contemporary New Zealand, larger gaps have been reported, with absolute differences in life expectancy between high and low income groups being 6.5 years for males in 2001, and 4.7 years for females. The gradients have been strongest for income, followed by small area deprivation and education. There are also notable ethnic health inequalities in New Zealand and these have been described over long time courses. In 2011, there was a Māori vs. non-Māori gap of 7.4 years for male life expectancy and 7.2 years for females.

However, data on the historical relationship between socioeconomic position and health is sparse for New Zealand. Indeed, the earliest reported social class gradients in all-cause mortality in New Zealand are for 1974 to 1978, with a two-fold higher mortality rate in the lowest social class compared to the highest one on a six-category scale for men in 1974 to 1978. Higher mortality among lower social class men was found “for virtually all causes of death”. One earlier study did not report social class but found that, for the period 1959 to 1963, there were higher rates of all-cause mortality among unskilled workers compared to professionals among non-Māori males.

It is unclear whether socioeconomic mortality gradients have been in existence prior to the Second World War in countries like New Zealand (although such evidence exists for the United Kingdom). For example, with increasing post-war knowledge about risk factors for health, and earlier take up of healthier lifestyles by higher socioeconomic groups as knowledge developed, it is possible to run an argument that socioeconomic mortality gradients need not be present prior to the Second World War. Conversely, prior to the Second World War, infectious diseases – in particular tuberculosis – were a more common cause of mortality, and such diseases are associated with crowding and poverty.

Studies of official records in New Zealand have shown that in the late 19th century “stature varied by social class, with professionals and men in rural occupations substantially taller than their peers”. However, studies of specific diseases have found no evidence of early social class
gradients, e.g. studies on pandemic influenza mortality in New Zealand in 1918\textsuperscript{15-17} (albeit in contrast to some other international work on this pandemic).\textsuperscript{18,19}

Given this background, we aimed to apply two new approaches to the study of lifespan by occupational class for New Zealand populations in the late 1800s and early 1900s, making use of improved online access to historical records and particularly death registrations.

**Methods**

**Electoral roll data in Dunedin**

We extracted data on men listed on the Caversham Project database\textsuperscript{20} for the oldest populations in the late 1800s and early 1900s, making use of improved online access to historical records and particularly death registrations.

We then used the same methods as in two previous New Zealand studies\textsuperscript{21,22} to identify date of birth and date of death (from which we calculated lifespan) from: any online military files (Archway database), the national Births, Deaths and Marriages (BDM) database; the Ancestry.com database; and other genealogical sources such as cemetery records. The most straightforward matching process was when there were military records (which always had the date of birth) and if these also had the date of death added into the files. This was sometimes in the format of an official death notification form sent to the military authorities from the civilian authorities. Where this was not the case, the matching was facilitated by most of the records having at least one middle name for the individual, so that in the BDM data it was possible to obtain the date of death for a single individual with that same name. Usually the linkage of individuals with death dates was supported by the BDM death data having the named individual’s age at death or date of birth also listed. Nevertheless, this process would sometimes fail if there was only a name such as ‘John Smith’ in the BDM death records with no additional age or birth date information. Failures to identify dates of death also probably arose for individuals who died in countries that currently don’t have extensive online records for people buried in cemeteries.

Where only the year of birth was identified and not the exact date, we used a mid-year point (1 July) for lifespan calculations. But when the calculated age at death differed from the reported age at death (given in years in the records), we improved the fit by adjusting forward or backwards the estimated date of birth by one-month intervals until it then matched the reported age at death. Where birth dates were missing, baptism dates were used as a proxy, but this was rare (see Table 1).

**Data on First World War military personnel**

Data extracted from the dataset compiled for another study\textsuperscript{23} were also considered for the purposes of identifying lifespan gradients by occupational class. The earlier study was conducted to study the potential impact of pandemic influenza on long-term lifespan (with no such adverse effect being identified). It involved sampling all the personnel on one New Zealand troopship and random sampling of those on another two contemporaneous troopships. The personnel studied were all male military recruits on troopships that sailed from New Zealand in late 1918, with these men not being involved in actual combat, since the war had finished before they had completed training. When excluding those who died of pandemic influenza in 1918 and 1919 (given the possibility of a socioeconomic gradient in sudden mortality risk),\textsuperscript{18,19} and those with incomplete occupational and lifespan data, a total of 2,046 men were included in the full analysis (median age 26.0 years). Occupational class was classified in the same way as the first study detailed above and based on the stated occupation in online military files (see Table 1 in the Supplementary Material for the full list of occupations and their associated classifications and rurality status). For the military population, a linear regression model was used to estimate the lifespan by category of occupational class with adjustment for age (age as stated in 1918) and rurality of occupation, including 95% confidence intervals (95%CI) and the Wald p-values. Rurality was considered of likely relevance given previous New Zealand work.

<table>
<thead>
<tr>
<th>Table 1: Data characteristics and results for the first study of the lifespan of men by occupational class from electoral rolls: 1893 to 1902 (Dunedin City suburbs of Caversham, South Dunedin and St Kilda).</th>
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</thead>
<tbody>
<tr>
<td><strong>Characteristic</strong></td>
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<td>Missing lifespan data (i.e. either date of death or death not identified)</td>
</tr>
<tr>
<td>Missing country of birth data (for those with lifespan data)</td>
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<tr>
<td>Reliance on just year of birth (no day or month) for those with lifespan data</td>
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<tr>
<td>Reliance on baptism dates as a proxy for birth dates (for those with lifespan data)</td>
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<td>Year of birth (for those with lifespan data) – median year (n=114 and n=145)</td>
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<td>Interquartile range (IQR)</td>
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<td>Range</td>
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<td>Results (for those with lifespan data and occupational class, n=259)</td>
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<tr>
<td>Mean lifespan (SD)</td>
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<td>Mean lifespan for overseas born (SD)</td>
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<td>Mean lifespan for NZ born (SD)</td>
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<td>Proportion born overseas</td>
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has found that men in rural occupations were substantially taller than their peers14 (possibly reflecting better health status), and they appear to have had lower rates of rejection by the military as conscripts (see Table 2).

The analysis was done separately for all ages and limited to men aged <35 years in 1918. The latter was an attempt to use restriction to address potential age-cohort effects and selection biases around military recruitment of older men, since healthy worker selection effects might have varied by age-group. Models included age and rurality status as covariates. A range of groupings was explored, given the possibility of small effect sizes, including grouping the occupational classes into just three combined categories (as in our previous work).23 Analysis was done in SAS 9.4.

Results

Study of men in Dunedin

It was possible to achieve only a 76.4% ascertainment of lifespan data, i.e. both a date of birth and date of death. Lifespan data were absent more frequently in the lowest class group (24.9%) compared to the high class group (21.9%), see Table 1. The lowest class group was also more likely to be missing information on country of birth and the details of the exact date of birth (vs. just year) were slightly less complete.

The results suggested no significant differences between the two occupational classes at 70.2 years and 69.9 years for the high and lowest class groups respectively (Table 1). The overall sample was dominated by those born overseas at 70.0% (156/223). Lifespan was shorter among those born in New Zealand vs. those born overseas (means of 67.0 and 71.1 respectively, p=0.044).

Study using military personnel

This second study included 2,046 male military personnel who travelled to England but did not participate in combat (and for whom complete lifespan and occupational data were obtainable). Results in Table 2 indicate that the top two occupational classes had longer lifespans than the two lowest classes (73.6 years vs. 70.8, albeit a non-significant difference). There was also a suggestion of a gradient of declining lifespan with declining occupational class when considering the nine individual classes or three groupings of class, but again these differences were not statistically significant.

In the multivariable analysis, there were also no statistically significant differences in lifespan by occupational class when adjusting for age in 1918 and rurality of occupation (Table 3). But when more appropriately considering just those under the age of 35 years in 1918 (see Methods), then the top three occupational classes had a lifespan that was 3.3 years (95%CI: 0.1 to 6.6) longer than the bottom three occupational classes in the age-adjusted model. In the fully adjusted model (both age and rurality) this difference was slightly larger: 3.5 years (95%CI: 0.3 to 6.8 years).

Discussion

**Main findings and interpretation**

The cohort of men in Dunedin showed no statistically significant lifespan differences by occupational class, but our analysis of the larger cohort of military personnel is...
the first to suggest such significant lifespan differences in New Zealand prior to the 1960s. The gap between the top-ranked and bottom-ranked occupational categories (3.5 years) is similar to that reported recently (2.1 years) in a review of mortality according to socioeconomic position based on 48 cohort studies in seven developed countries.1 But the difference is smaller than that observed in contemporary New Zealand (see Introduction). They are also less than the 4–14-year life expectancy gaps between the highest- and lowest-income American men reported since the 2000s.24

Our findings for differences by occupational class are consistent with historical reports of social class25,26 and material differences across New Zealand society27 (see Figure 1 in the Supplementary Material for NZ incomes). Compared with the circumstances in Britain at the same time (see Figure 2 in the Supplementary Material), New Zealand society was seen as relatively egalitarian, but a gradient was seen in height (professionals tended to be taller)28 and this is likely to be a proxy for better health in childhood and adolescence. Such factors as the widespread access to adequate and relatively high protein food,2 the small size of cities and the limited levels of industrialisation may have contributed to minimising health differences across social groups. However, there were sources of social disadvantage, such as the small areas in some New Zealand cities (e.g. the Te Aro district in Wellington).29

**Strengths and limitations of these studies**

Increasing availability of online historical records permitted this first exploration of social class and lifespan in the late 1880s and early 1900s for New Zealand. But both studies are likely to suffer from some measurement error concerning the assigned ‘occupational class’ and this will tend to diminish the apparent size of any underlying class-gradient in mortality. First, all measures of social class have limitations, and the Caversham Project researchers who developed the New Zealand classification system used in the two studies reported here have discussed these in detail.21 In particular, the classification system development was focused on work skills in generating the occupational class categories (outlined in Table 2) and so may not adequately capture class differences in income and asset wealth. The classification system was also particularly designed around the urban (rather than rural) workforce and so may not adequately capture the status of rural workers (and similarly for people with multiple occupations, seasonal workers or those whose occupation subsequently changes). In some cases, it was necessary to make assumptions in the application of the Caversham Project classification system, e.g. for students, cadets and apprentices who were not included in the original system (see Table 1 in the Supplementary Material). Our findings may have been affected by differences in age cohorts with younger men tending to have lower class occupations, although in the multivariable analysis adjustment for age (i.e. age in 1918 for the military population) did not have a large effect on results. Indeed, the addition of rurality to the model appeared to be a more important confounder. Nevertheless, these studies had the advantage of coding of occupation class being performed prior to lifespan calculations.

More specifically, the first study for men in Dunedin suffered from limitations with ascertaining dates of birth and death. When data were obtained there were still some quality limitations around having only a year of birth in the records (and sometimes having to use baptism data – an event that was potentially not always in the year of birth). There were also differences between the characteristics of the two samples in terms of data availability (country of birth), and a higher proportion of the high-class group being born overseas (with the higher lifespan of this group possibly reflecting a healthy migrant effect). Finally, this small study with lifespan data on only 259 individuals was restricted to men living in one part of just one New Zealand city. Hence, this study provides only very limited information on lifespan by occupational class for New Zealanders at this time in history.

The second study was based on a much larger sample and included men from around New Zealand, nearly all of whom were of European ethnicity and who were a mix of conscripts and volunteers (probably mainly the former – though the military records do not detail this characteristic). Specific limitations with this study were that military personnel represented a selected group who were subject to both ‘healthy soldier’29 and ‘healthy warrior’ effects,30 that probably made them healthier relative to the general adult male population. Indeed, the overall rejection rate for military recruits between November 1916 and November 1918 in New Zealand was 58%,31 and there is some evidence for a differential rejection rate by occupational class (i.e. statistically significantly higher rejection rates for general labourers vs. professionals – see Table 2 in the Supplementary Material). Such selection effects may have flattened the social class gradients observed in our study relative to the true ones existing in the whole of New Zealand society at this time.

Given these potential sources of error, this second study is also far from definitive in establishing differences in lifespan by occupational class – but it is still suggestive.

**Possible future research implications**

To better quantify occupational class gradients in lifespan for European men living in New Zealand in the late 1800s and early 1900s, larger datasets are desirable. This is now possible with the full digitalisation of all First World War records for New Zealand military personnel, and similarly for 6,336 New Zealand military personnel who took part in the South African War (Boer War) of 1899 to 1902 (all records are freely available online).

Using the full Caversham Project dataset in future research projects would also seem highly desirable, as it provides occupationally coded electoral roll data for individual men and women spanning from 1893 to 1938. However, such research would require extensive genealogical work to obtain dates of birth and death and, ideally, additional consideration of variation in use of middle names by social class (since this may affect the likelihood of identifying the individual in birth and death datasets). Fortunately, the comprehensiveness of genealogical data is constantly improving for New Zealand and internationally, and the latter is important given that New Zealand residents of European ethnicity were frequently born overseas in this period and also often subsequently migrated and then died overseas. Ultimately, it seems feasible that the lifespan by occupational class can be more precisely calculated (and potential measurement error considered) for large cohorts of early New Zealand residents, if such research efforts are adequately resourced.
Acknowledgements

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References


Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Figure 1: Average annual assessed income in New Zealand (in pounds (£)) by population quintile for tax returns for the 1922-1923 period (calculated by the authors from the Yearbook data).

Supplementary Figure 2: Mortality rates (1921-1923) by social class as per the social class classification system proposed by Stevenson for the United Kingdom (data abstracted from Stevenson 1928).

Supplementary Table 1: Occupations in the online military records and our assignment of these to occupational classes as per the system developed for the Caversham Project Study.

Supplementary Table 2: Rejection rates by occupational group for conscripted men aged 20-45 year who were examined by military medical personnel from November 1917 to November 1918.