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Body Sizes in Nineteenth Century New Zealand: An Empirical Investigation using the NZ Contingents in the Second Boer War

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Abstract

In this paper we report on the heights and weights of New Zealand soldiers who served in the Second Boer War (1899-1902). Adult heights are widely used as evidence on the standard of living. Interpreted as such, our results support the view that the standard of living in New Zealand was among the highest in the world at the turn of the twentieth century. One problem in using the heights of soldiers to make inferences about the population is the reliance on self-reported ages. When we use self-reported ages in our analysis we find that the youngest soldiers are also the shortest. This finding is common in the literature, and has been interpreted as evidence for a general decline in the standard of living. To explore the implications of using reported ages, we match 53% of the soldiers in our sample to their birth records to establish their true age. We document that young soldiers exaggerate their age and old soldiers under-state their age. When we use true ages in our analysis, the apparent shortness of the youngest soldiers disappears.

JEL classification: O56; I10; N37

Keywords: stature; Second Boer War; historic birth records; nineteenth century New Zealand

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1 Introduction

At the turn of the twentieth century output and income per capita in New Zealand were among the highest in the world. Angus Maddison estimates that in the fifteen years leading up to WW1, Australia, New Zealand, and the USA had the highest real GDP per capita in the world.[1] The most recent Maddison Project release places New Zealand in third place, behind Australia and the USA.[2] Data on wages are similar. Real wages for unskilled workers in New Zealand were among the highest in the world. By 1900 real wages in New Zealand had converged with those in Australia, and were around 30% higher than those in the UK.[3]

The high standard of living suggested by the output and income data is supported by data on infant mortality, life expectancy, and adult stature, so-called anthropometric measures of the standard of living. First, women born in New Zealand in 1900 had a life expectancy at birth of 60 years, an age reached only in the 1910s in Australia, the 1920s in the UK and USA, and the 1930s in Canada.[4] Second, the rate of infant mortality, the number of deaths under the age of 1 per 1,000 live births, was low in New Zealand. Between 1881 and 1905 it was 83, significantly lower than Scotland (123), England and Wales (146), the Australian states (112), or the USA (144) in 1900.[5] Finally, being tall is associated with improved health and nutrition, and New Zealand-born men were tall by international standards.[6] As we show below they were similar in height to, or taller than, men born in Australia and Canada. Collectively, the anthropometric evidence suggests a standard of living higher than would be expected from the output and income data, although as Neale points out, New Zealand benefited from good public health infrastructure, being remote, low population density in the urban centres, and an

[1] Maddison, 'The world economy'.

[2] Bolt, Inklaar, de Jong, and van Zanden, 'Rebasing "Maddison"'.

[3] Greasley and Oxley, 'Globalization and real wages'; Brooke, 'Three essays', p. 89.

[4] Human Life Table Database, http://www.lifetable.de. The data were last accessed on 21 February 2019.

[5] Phelps, 'Statistical study', p. 264. The estimate for Australia is an unweighted average of the individual states. The estimates for the USA are from the Twelfth Census for the Registration States of 1900: Connecticut, District of Columbia, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. On infant mortality in New Zealand see also Neale, 'A New Zealand study'; Lessof, 'Mortality in New Zealand'; and Sadetskaya, 'Infant mortality decline'.

[6] Inwood, Oxley, and Roberts, 'Physical stature'.

absence of heavy industry.[7]

We contribute to the literature on the historical standard of living in New Zealand by reporting on the heights and weights of New Zealand-born men who served in the New Zealand contingents in the Second Boer War (1899-1902). (We do not report on the approximately 1,500 New Zealand-born men who served in the Australian contingents.) In addition to the UK, the Boer War drew troops from Australia, Canada, and New Zealand, and non-combat, auxiliary troops from India. The heights of the Australian- and Canadian-born troops have been reported, although only briefly, as part of larger projects, and with relatively incomplete coverage. Whitwell, Nicholas, and de Souza report on the heights of 3,435 Australian-born men who served in the Australian contingents, out of a total of nearly 17,000 soldiers who served.[8] Cranfield and Inwood report on the heights of 2,629 Canadian-born men who served in the Canadian contingents, out of the more than 7,000 soldiers who served.[9] In addition, data on the heights of soldiers who served in WW1 are available for all three countries.[10] We offer comparisons between all three countries for both wars. The comparison is of particular interest because all three countries were overwhelmingly settled by migrants from the British Isles, in roughly the same period.

In adding to the time-series of the heights of New Zealand-born men, we also contribute to the debate over changes in the standard of living in New Zealand in the late nineteenth century. Despite the very high standard of living described above, it has been suggested that living standards declined at the very end of the century. There are two reasons for this expectation, although they are not mutually exclusive. First, there is the widely reported finding that living standards declined during industrialization. We return to this claim in the next section. Second, New Zealand and Australia both experienced depressions in the second half of the nineteenth century, and Australia experienced a record drought in the very last years of the century.

The evidence of an economic downturn in New Zealand is clear. According to Greasley and Oxley, real GDP per capita in New Zealand declined by approximately 10% between 1880 and 1886, returning to the pre-depression level in 1897.[11] In their study of the heights of WW1

[7]Neale, 'A New Zealand study'.

[8]Whitwell, de Souza, and Nicholas, 'Height, health and economic growth'.

[9]Cranfield and Inwood, 'A tale of two armies'.

[10]Cranfield and Inwood, 'The great transformation'; Inwood, Oxley, and Roberts, 'Physical stature'.

[11]Greasley and Oxley, 'Measuring New Zealand's GDP', Figure 3, pp. 363, 365. The Maddison Project data

soldiers, Inwood, Oxley, and Roberts suggest that the depression may have resulted in adverse health outcomes for those born in the 1890s, and offer the shorter stature of the soldiers born in that decade as evidence for this hypothesis.[12] We re-examine this hypothesis in the next section. The evidence for an economic downturn, or slowdown in the rate of growth, in Australia has slowly eroded. According to the traditional account of Australian economic history, living standards and output grew rapidly from 1850 to 1890 in the long boom, and then grew more slowly, or possibly even regressed, between 1890 and 1940.[13] However, McLean and Pincus offer non-income evidence that living standard improved between 1890 and 1940.[14] Further, Haig's revisions to historical estimates of real GDP per capita significantly reduce the growth rate before 1890, and as a consequence the extent of the slowdown in growth after 1890.[15]

The final contribution of this paper is methodological. The most frequently used sources for studies on historical heights are military and prison records. A feature of the military records is that they rely on reported ages, which are not verified at enlistment or subsequently. We match 53% of the soldiers in our sample to the New Zealand Birth, Deaths, and Marraiges records, and so are able to verify their actual age at enlistment. We confirm that young men did indeed lie about their ages to enlist, and then quantify the error that would result from relying on self-reported ages.

2 Literature

The use of anthropometric measures, including height, weight, infant mortality, and life expectancy, as measures of the standard of living has become widespread.[16] Collectively, they

shows a more than 20% decline in real GDP per capita from 1878 to 1888, returning to the pre-depression levels in 1900. This peak-to-trough decline relies on a large increase in GDP per capita from 1876 to 1877. Using 1876 as a starting point yields a decline more in line with Greasley and Oxley's estimate.

[12] Inwood, Oxley, and Roberts, 'Physical stature'.

[13] Whitwell, de Souza, Nicholas, 'Height, health and economic growth'; Whitwell and Nicholas, 'Weight and welfare'.

[14] Mclean and Pincus, 'Did Australian living standards stagnate'.

[15] Haig, 'New estimates'; McLean, 'Australian economic growth', pp. 333-334.

[16] Surveys of the literature on adult heights include Inwood and Roberts, 'Longitudinal studies'; Steckel, 'Stature and the standard of living'; and Steckel, 'Height and human welfare'. Surveys of the broader literature on anthropometric measures of the standard of living include Fogel, 'The escape from hunger'; Floud, 'The achievements

have a number of advantages over income-based measures of the standard of living. First, there are periods for which data on anthropometric measures are more reliable or more readily available than data on incomes, as for example in the recent literature on historical skeletal remains.[17] Second, anthropometric measures capture outcomes while GDP and real wages measure inputs. The problems in using GDP as a proxy for the standard of living are well known. For example, GPD per capita does not capture anything about the distribution of income. Further, historical estimates of GDP typically omit home production, a significant omission for the nineteenth century, and are typically estimated indirectly using the quantity theory of money, and so require additional, untestable assumptions. Real wages improve on GDP per capita to an extent as they are typically estimated for unskilled labourers, and so offer some insight into the distribution of income. However, they only capture the private means to consume, but nothing about the consumption of public goods (that are part of GDP) and nothing about the environment or prevalence of disease. Further, output and income-based measures of the standard of living do not capture the nutritional demands of different types of work. The use of anthropometric measures also avoids some of the problems inherent in intertemporal and cross-country comparisons of real wages.[18] Long-run cost-of-living series do not adequately capture changes in technology, as demonstrated most famously by Nordhaus in his study of the cost of lighting in the USA. [19] Cross-country comparisons based on real wages require additional assumptions to account for regional and country differences in diet and climate. The relative importance of income, public health and sanitation, medicine, nutrition, and fertility to health continue to be debated.[20] As Costa (p. 505) notes, there have been episodes where increased private consumption has been more than offset by adverse public health events, and episodes where low levels of private consumption have been offset by a benign public health environment. But these debates reinforce

of anthropometric history'; Komlos, 'Anthropometric history'; and Steckel, 'Biological measures of the standard of living'; Steckel, 'Biological measures of economic history'.

[17]Steckel, Rose, Larsen, and Walker, 'Skeletal Health'; Steckel, 'What can be learned'

[18]Feinstein, 'Pessimism perpetuated', pp. 626-627

[19]Nordhaus, 'Quality Changes'. Nordhaus estimates a conventional cost-of-lighting index and a cost-of-a-lumen-hour index for the USA from 1827 to 1997. The cost of lighting index shows a nominal price increase of 800%, while the nominal cost of a lumen-hour falls by 99%.

[20]Costa, 'Health and the Economy', p. 504.; Deaton 'The Great Escape: A Review'.; Deaton 'The Great Escape: Health, Wealth, and the Origins of Inequality'.; Floud, Harris, and Hong, 'The Changing Body'; Sharpe, 'Explaining the short stature'.

the argument that outputs are a better measure of the standard of living than inputs and the use of anthropometric measures avoids the problems of output and income measures by capturing the net outcome of all inputs relative to all demands.

The study of heights occupies a central place in the anthropometric literature, because heights reflect the outcome of numerous inputs, including maternal health, nutrition, work intensity, and exposure to disease. Adult height also predicts health outcomes, as being taller is associated with higher life expectancy and lower rates of disease.[21] Crucially for comparisons across populations, although heights are highly variable within populations, and although this variability is based in part on individual genetic differences, the mean height in a given population depends on net nutrition and health status of the members of that population. Genetic differences are not a cause of differences in population heights.[22]

Despite their advantage over income based measures, using heights as a measure of the standard of living introduces two difficulties. The first difficulty is the general problem of determining the age at which a person reaches their adult height. Growth occurs in two spurts, first during childhood and then later during adolescence. An early and important finding of the anthropometric literature is that the adolescent growth spurt can compensate for slow growth in childhood. Steckel demonstrates this for American slaves, who were short after the first growth spurt, but caught up in the second, and attained a taller stature than would have been expected given their childhood stunting.[23] This finding has been repeated for a range of other populations.[24] The timing of the adolescent growth spurt is variable, and depends in part on environmental conditions. Under poor environmental conditions, the adolescent growth spurt can be delayed, with adult height reached as late as 25. Conversely, in good conditions the adolescent growth spurt starts earlier, and is typically complete by age 21. An extension of this problem is determining where insults to growth will appear in adult heights.[25] Depauw and Oxley study the impact of deep agricultural depressions on heights in Flanders, and conclude that the famines have little impact on those born during the famine, and that the impact is felt by those who are in adolescence during the famine, and who have no further opportunity to

[21] Fogel 'The escape from hunger'.

[22] Steckel and Floud, 'Introduction', p. 4.

[23] Steckel, 'A peculiar population'.

[24] De Pauw and Oxley 'Toddlers, teenagers, and terminal heights'.

[25] ibid, pp. 1-5, surveys the literature.

recover. In light of this finding and others that Depauw and Oxley survey, the claim by Inwood, Oxley, and Roberts—that the short stature of the New Zealand soldiers who where born in the 1890s and who served in WW1 is evidence of a general decline in the standard of living associated with the depression—appears misplaced.[26] While it is true that people born during the depression may have suffered stunting during childhood, they had an opportunity to catch up from any shortfalls in stature during their adolescent growth spurt. It is more likely that if there is any effect, it will be found in the heights of those who were in their adolescent growth spurt during the depression. The cohorts of interest are then those born from the late-1870s to mid-1880s.[27]

The second difficulty that arises in using heights as a measure of the standard of living is the specific problem that the most readily available data are from military and prison records. The use of these data raises problems of the representativeness of the sample for the population. A common strategy for volunteer armies that are continuously recruited is to make inferences about the changes in the height of the population from changes in the height of successive cohorts of recruits. For example, Fogel uses changes in the heights of Ohio Guardsmen to fill gaps in a series on civilian heights for the USA.[28] An important finding that came out of this and other early studies was an apparent decline in average heights during industrialization. The apparent contradiction between a growing economy and declining adult height was captured in the title of John Komlos's paper, *Shrinking in a Growing Economy*.[29] All of the studies that we cite on Boer War and WW1 heights invoke some form of this argument as a motivation for their study, and all claim some form of supporting evidence for the argument.[30]

Underpinning the finding of 'shrinking in a growing economy' is the assumption that the soldiers were recruited in the same way over time. Bodenhorn, Guinnane, and Mroz offer strong evidence that this assumption does not hold and that there is no good evidence that average

[26] Inwood, Oxley, and Roberts, 'Physical Stature', p. 262.

[27] See also Engerman, The standard of living debate', p. 37, on this point.

[28] Fogel, 'Escape from hunger', p. 17.

[29] Komlos 'Shrinking in a growing economy?'.

[30] Sandberg and Steckel find no decline in heights during industrialization in Sweden, but their surprise at an apparently unexpected result is captured in the title of their chapter: *Was Industrialization Hazardous to Your Health? Not in Sweden!*.

heights declined during industrialization.[31] Rather than treating enlistment as a random drawing from an underlying population or class within a population (criminals and soldiers typically came from the lower classes), the authors treat enlistment as a labour market decision. As such, during periods of rapid economic growth, taller members of any class face increasingly good civilian labour market opportunities, making enlistment less attractive. An implication of this line of reasoning, that is supported by their re-examination of the empirical evidence, is that it is possible for the average heights of soldiers to fall, even as incomes and average heights in the population rise. While the findings described above relate to continuously recruited volunteer armies, they highlight the problem of making inferences about a population from samples that are selectively drawn.

Recruitment for individual conflicts, such as the Boer War, WW1, and WW2, raise related difficulties. For WW1 and WW2 the argument is typically made that because a large fraction of the adult male population enlisted, and because rejection rates were very low, the heights of those who enlisted can be used to make inference about population heights. Any truncation of the data from minimum height requirements can be accommodated using appropriate statistical techniques.[32] This argument ignores the fact that the sample of recruits represents a wide range of birth cohorts, and so a more appropriate question would be whether the recruits of different ages are representative of their particular birth cohort.[33] For example, the oldest soldiers who served in WW1 were born in the 1870s while the youngest were born in the 1890s.[34] While it may be reasonable to assume that those aged from their early-twenties to mid-thirties at enlistment were representative of their birth cohorts, it is not necessarily true for either youngest or oldest recruits. Recruits over the age of 40 (those born before 1875 for WW1) were very likely positively selected on physical attributes relative to the average 40 year old, particularly where they were recruited over applicants in their 20s. The situation for younger recruits is ambiguous. Some

[31] Bodenhorn, Guinnane, and Mroz, 'Sample-section biases'.

[32] Cranfield and Inwood, 'A tale of two armies'; Komlos, 'How to'.

[33] As Bodenhorn, Guinnane, and Mroz (p. 191, Figure 2) demonstrate, even small differences in ages at enlistment can be associated with differences in the selection of recruits. Consistent with their hypothesis that enlistment was a labour market choice, soldiers from the same birth cohort who enlisted at a younger age were taller than those who enlisted at an older age, even where the difference in age at enlistment is a matter of one or two years.

[34] Inwood, Oxley, and Roberts, 'Physical stature'; Cranfield and Inwood, 'A tale of two armies'

may have been attracted by the adventure–the Boer War was a popular undertaking in New Zealand. But for young men with good labour market prospects, a one-year enlistment to fight in a foreign war was likely unattractive.[35]

The problem is then of how one makes inference about a population from military personnel data of this sort. Any observed change in the heights of successive cohorts is the sum of changes in the population height and changes in the representativeness of the soldiers for their birth cohort. In addition, the problem of selection and representativeness for young soldiers (in particular) is compounded by the reliance on reported ages. Consider for example, Inwood, Oxley, and Roberts' claim that because soldiers who served in WW1 were shorter than previous cohorts, the standard of living in New Zealand declined in the 1890s. This claim rests on two unstated assumptions: that all cohorts of soldiers are equally representative of their birth cohort; and that all of the soldiers in their sample were 21 and had (probably) reached their adult height. The first assumption is not directly testable, and so makes any inference about an underlying population fraught. The second assumption is testable, and we offer evidence on this below. The one approach to making inferences that does appear to be robust is to compare like with like, to compare soldiers from different countries that were selected using similar criteria. We take this approach below in comparing soldiers from New Zealand with those from Australia and Canada.

3 New Zealand Recruitment

The Second Boer War (1899-1902) was New Zealand's first overseas military engagement, and it was politically popular. Anticipating war, on the 28th of September 1988 Parliament passed a motion to send troops to South Africa, with only five votes against.[36] By the 11th of October, the date on which the Boer ultimatum for the withdrawal of British troops expired, the First Contingent was already in camp at Karori, near Wellington. When the First Contingent em-

[35]The empirical evidence from the Australian, Canadian, and New Zealand soldiers who served in the Boer War and WW1 is mixed. For the Boer War, Australian and Canadian heights declined monotonically with decreasing age. The same pattern repeats, but not monotonically, for Canadian soldiers who served in WW1. Among the Australian soldiers who served in WW1, the oldest cohort was the tallest, but those born in the 1890s were taller than those born in the 1880s.

[36]Crawford, 'Boer War'.

barked on the 21st of October, a large crowd, reportedly 40,000-50,000 strong, gathered to cheer them on their way, and they were addressed by the Governor, the Premier, and Chief Justice before embarking.[37]

Over the course of the three years of the war, ten contingents were raised and sent to South Africa. Enlistment was for a one year term, and a small number of men from the early contingents reenlisted in the later contingents. In total there were 6,495 enlistments, from 6,159 unique men. In addition to those who enlisted in New Zealand, an estimated 1,500 to 2,000 men rejected for service in the New Zealand contingents enlisted in the Australian contingents.[38]

The ten contingents sent to South Africa were independent of the existing military structures in New Zealand, although they drew troops from them. Up to 1911, the New Zealand armed forces were composed of a small professional force, the Permanent Militia (renamed the Permanent Force in 1902) and the part-time and amateur Volunteer Force. The Permanent Militia was small, numbering around 270 men in the mid-1890s. The much larger Volunteer Force had 4,500 members in 1899. Although it was a part-time and amateur force—government sponsorship covered uniforms, but did not extend to horses—the Volunteer Force had legislated responsibilities for defense, including coastal defense. The first two contingents were drawn exclusively from existing members of Permanent and Volunteer Forces. While some later contingents were staffed with Volunteer Force members, most of those members joined after the start of the war, presumably in the hope of enlisting. Numbers in enlisted in the Volunteer Force peaked at 17,057 in 1901. The Volunteer Force was divided into five regional districts—Auckland, Wellington, Nelson, Canterbury, and Otago—and the selection of soldiers (discussed below) included variation in the districts from which they were recruited.

Recruited as mounted infantry, the New Zealand soldiers were to ride to battle and then dismount and engage on foot, with every fourth soldier remaining behind with the horses. The main qualification for recruitment was the ability to ride a horse and shoot. There are reasons to believe that up to 1899 the Volunteer Force, and particularly the mounted units, were drawn from the wealthy classes. As Crawford notes, the members of the Volunteer Force were required to cover all of their costs, including their horses, and they were required to perform Volunteer Force activities during work hours. Membership favoured those of means, as the cost of maintaining

[37] Phillips, 'Rugby, war, and the mythology'; Stowers, 'Rough Riders at War', p. 12.

[38] Stowers, 'Rough Riders', p. 5.

a horse and taking time to drill made membership relatively unavailable to the lower classes.[39]

The First and Second Contingents were drawn roughly equally from each of five district commands, and were raised and paid for by the New Zealand government. Although they were paid for their service, they were expected to pay for their own kit, including providing their own horse.[40] The Third and Fourth Contingents were raised and financed by public subscription. Soldiers for the Third Contingent were recruited from Canterbury, Hawke's Bay, Manawatu, and Taranaki. The Fourth Contingent was raised mainly from Otago. Known collectively as the "Rough Riders", the members of the Third and Fourth Contingents had no previous military experience, but were selected based on their horse-riding and shooting abilities.

The remaining six contingents were raised at the request of, and were financed by, the Imperial Government. The Fifth Contingent was raised from reserves recruited by the government in 1900. The Fifth drew recruits from the five district command areas, but was slightly overweight recruits from Wellington, at the expense of recruits from Nelson and West Coast. The Sixth Contingent was raised to replace the 2nd and 3rd Contingents. Recruitment was similar to the Fifth Contingent, as companies were raised from Auckland, Canterbury, Otago and Wellington (two), with none from Nelson and West Coast. The Seventh Contingent, raised to relieve the Fourth Contingent, was recruited from the five district command areas, with the addition of a supplementary contingent of unspecified origin.

The Eighth Contingent, raised to relieve the Sixth and Seventh Contingents, was composed of 1,011 recruits selected from 4,000 volunteers and was divided into North Island and South Island companies. The Ninth Contingent was raised from the remainder of the 4,000 volunteers for the Eighth, and was also split into North Island and South Island companies. The 10th Contingent was similarly divided into North and South Island companies. Overall, and barring the Third and Fourth Contingents, the individual contingents were drawn roughly evenly from the main population centres, and the overall force was broadly geographically representative.

Inwood, Oxley, and Roberts report in detail on the Maori and Pacific people who served in WW1.[41] Maori petitioned parliament for permission to serve in the Boer War, including offering either a Maori contingent or company. Despite the support of Prime Minister Seddon,

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[39] Crawford, 'Role and structure', pp. 50-1

[40] Hall, 'The New Zealanders in South Africa'.

[41] Inwood, Oxley, and Roberts, 'Physical stature'.

permission was declined on the instruction of the Colonial Office, on the basis that it was a white man's war. Despite this, a number of Maori did serve. Some had European surnames, some adopted European names for the purpose of enlistment, and in some cases it appears as though local recruiting officials simply ignored the prohibition on Maori enlisting.[42] As a result, although we know that Maori did serve in the war, we are not able to report on them separately.

4 Data

The main source of data is military personnel files.[43] In order to include a soldier in our sample we require at minimum information on height, age at enlistment, and the contingent in which they enlisted. In most cases this requirement was met with a completed attestation form, although in a small number of cases the Certificate of Discharge was used. The forms typically found in a personnel folder and the fields they include are detailed in Appendix 1. The 5,495 files available from the archives yield usable data on 4,921 soldiers, or about 80% of the enlistments in the contingents.

Table 1: Summary Statistics by Contingent

		Data Statistics (means)					
Cont.	Stowers (2002) head count	N	height (inches)	weight (lb)	chest (inches)	BMI	% agricultural
1	214	176	69.29	158.11	38.00	23.14	41.48%
2	258[a]	213	69.16	159.44	37.39	23.43	27.70%
3	265	175	68.91	156.25	36.33	23.12	58.29%
4	467	386	68.73	153.45	37.14	22.82	40.16%
5	527	481	68.90	155.26	36.89	22.99	37.84%
6	579	471	69.04	155.52	36.99	22.94	29.94%
7	594	514	68.75	153.09	37.02	22.76	28.02%
8	1,011	887	68.13	152.11	37.19	23.04	30.89%
9	1,056	919	67.64	149.45	36.90	22.97	27.86%
10	1,018	920	67.55	149.64	36.79	23.05	23.70%
Total	5,989	4921	68.31	152.66	26.97	22.99	31.17%

[a] *Note:* This count includes the Hotchkiss Detachment.

Table 1 summarises our sample broken down by contingent, including basic sample statistics. The second column shows the actual number of men enlisted in each contingent as reported by

[42]Stowers, 'Rough Riders', p. 5; McGibbon, 'Maori and the Boer War'; Robson, 'Counting the cost', p. 38.

[43]All files were from Archives New Zealand `https://www.archway.archives.govt.nz/`. They are identified by series code "18805", and years 1899-1903 (inclusive).

Stowers.[44] In addition to those who enlisted in the contingents, Stowers reports a further 506 enlistments in Reserves, bringing the total enlistments to 6,495. The enlistments by contingent reported by Stowers include re-enlistments; the total number of unique individuals has been established as 6,149.[45] The third column shows the number of soldiers from each contingent included in our sample. We only include soldiers at first enlistment, so the 4,921 total is directly comparable to the 6,149 soldiers reported by Stowers, and the coverage for the later contingents is more complete than a direct contingent by contingent comparison suggests. Our coverage does not appear to be biased, and our lowest coverage is 66% for the Third Contingent.

The mean height for all soldiers is 68.31 inches, although there are differences between the contingents. The first two contingents are tall, both averaging over 69 inches, and this is consistent with the Stowers' suggestion that the early Volunteer Force recruits were from the wealthier classes. In addition, the last three contingents, which accounted for more than half of all first enlistments, were shorter than the earlier contingents. The mean heights of soldiers in the first seven contingents ranged from 68.73 for the Fourth Contingent to 69.29 inches for the First Contingent, a range of slightly more than half an inch. The mean heights for soldiers in the last three contingents ranged from 67.55 inches for the Tenth Contingent to 68.13 inches for the Eighth Contingent, also in a range of slightly more than half an inch. Notably, the ranges themselves differ by more than half an inch—the average height in the tallest of the last three contingents was more than half an inch less than the average height of the shortest of the first seven contingents. Or put differently, the mean height in each of the first seven contingents is greater than the mean height for the full sample, while the mean height for each of the last three contingents is less than the mean height for the full sample. Column 5 shows weight in pounds The mean weight is 152.66lb, but as with the differences in mean heights, there are differences in mean weight by contingent. The average weight in each of the first seven contingents is greater than the average weight of the full sample, while the average weight for each of the last three contingents is less than the average weight of the full sample. The average chest circumference and body mass index (BMI) are shown in columns six and seven. There are no notable differences between the contingents on either of these measures. What is

[44] Stowers, 'Rough Riders at War'.

[45] ibid, p. 4. This number includes reserves, details, and reinforcements. Hall, New Zealanders in South Africa, p. 10, discuses some of the difficulties in estimating the numbers who served.

notable is that the mean BMI for all contingents is in the range that minimizes mortality risk.[46] The final column shows the proportion of the soldiers in each contingent from an agricultural background.[47] There is strong evidence that men from a rural or agricultural background are taller than men from an urban background. The differences in mean heights and weights between the contingents does not appear to be entirely due to differences in the proportion of soldiers from an agricultural background. While the earlier contingents include those with the highest proportion from an agricultural background, the second tallest contingent has one of the lowest proportions of soldiers from an agricultural background.

Figure 1: Distribution of height, weight, chest circumference, and BMI

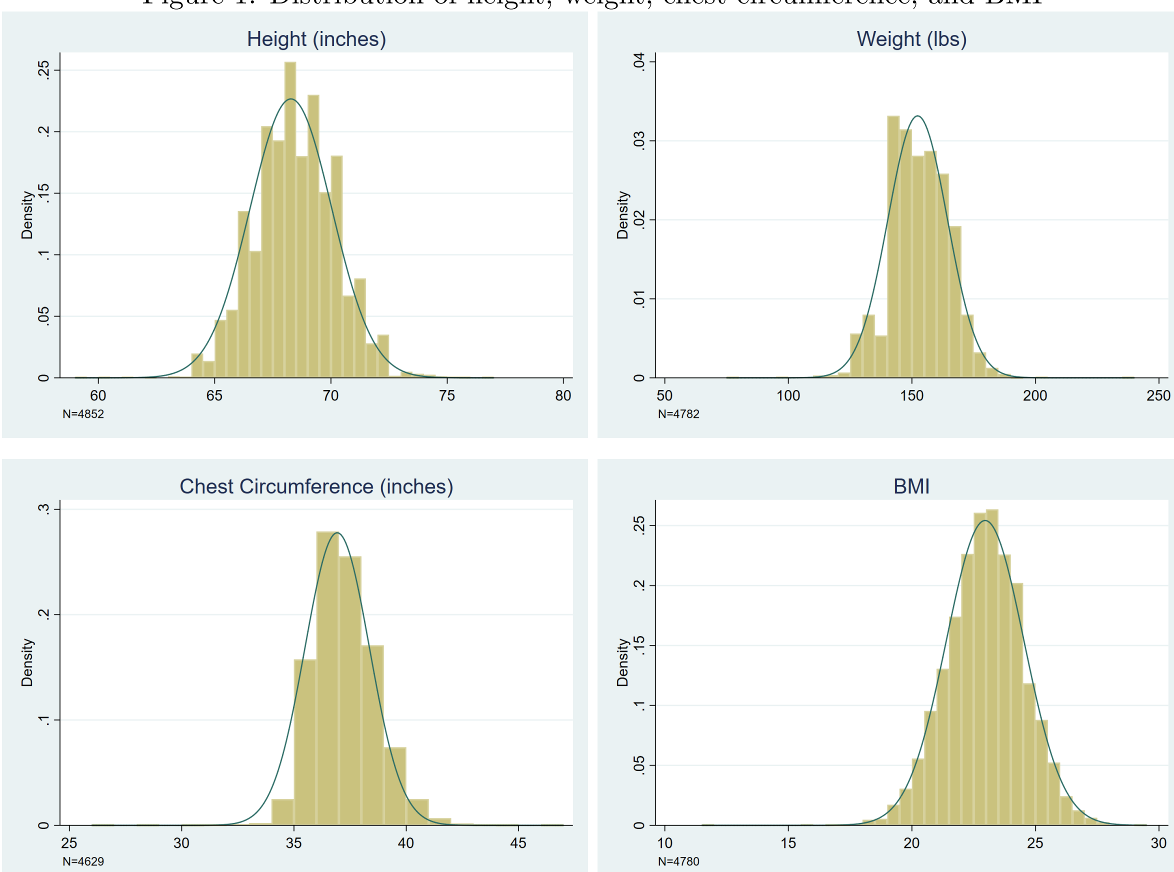


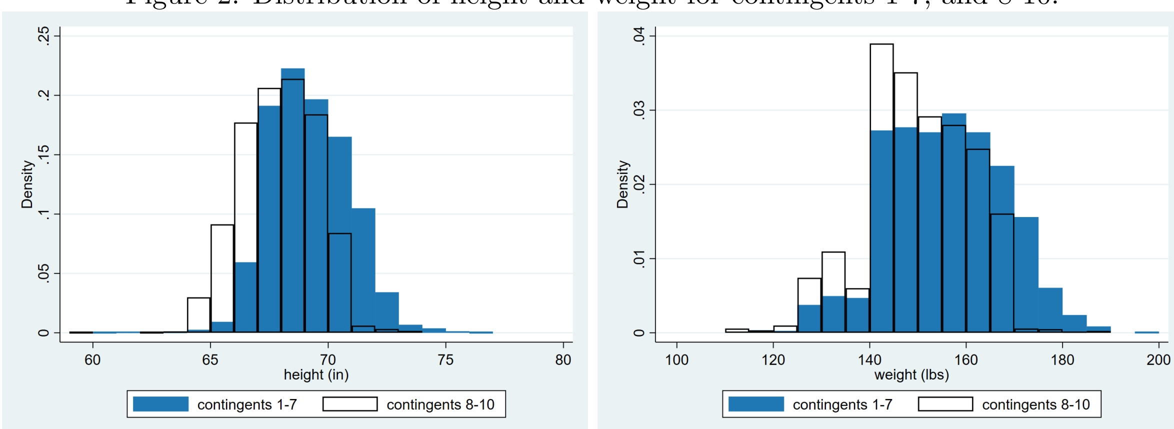
Figure 1 shows density plots for height, weight, chest circumference, and BMI. The number of observations used in each histogram is labelled N. Missing observations are the result of

[46]Fogel, 'Escape from hunger', pp. 23-45.

[47]We define the following occupations as agricultural: (in descending frequency) farmer, station hand, shepherd, bushmen, shearer, horsebreaker, rabbiter, musterer, or fruit grower.

incomplete or illegible forms. The distribution of raw records of height (in inches) do not appear as smooth as the superimposed normal curve largely because of the strong tendency to round measurements to the nearest integer. Height in the attestation form is recorded in feet and inches, and although some forms use fractions of an inch, most use an integer. Similar heaping can be seen in the weight histogram. Weight is measured in stones and pounds, and there appears to be truncation at a body weight of 10 stone, or 140lb, and very few soldiers in our sample weigh less than 140 lb. While there is no evidence of truncation in heights, possibly because all recruits exceeded the minimum threshold, there is evidence of truncation in weights. Other than truncation in weights and heaping around integer values for height and weight, the distributions appear mostly normal. The distribution on chest circumference seems slightly negatively skewed. The distribution of the BMI's is very smooth and symmetric.

Figure 2: Distribution of height and weight for contingents 1-7, and 8-10.



We explore the differences between the first seven and last three contingents further with the overlaid height and weight density plots shown in figure 2. The differences are clear for heights. The height distribution for the first seven and last three contingents have very similar shapes, but the distribution of heights for the last three contingents is shifted to the left. The majority of the soldiers shorter than 66 inches served in the last three contingents, while the majority of soldier who were taller than 70 inches served in the first seven contingents. The differences are less marked for weight. There is evidence of truncation at a minimum weight of 140 lb for both groups, although a greater proportion of soldiers in the last three contingents were below that weight than the first seven in the first seven contingents. The differences are clearer at the heavier weights. More than 20% of the soldiers from the first seven contingents weighed more than 170 lb while less than 3% of the last three contingents weighed more than 170 lb. These differences suggest that recruiting standards fell during the war.

4.1 Matching historic birth records

Studies of the heights of soldiers recruited for wars typically use minimum and maximum age restrictions to ensure that they include in their analysis only soldiers who have reached their adult height but who have not yet started shrinking from old age. Three studies that we cite in the next section for comparison purposes use an age range of 21 to 49. The fourth study uses a minimum age of 22 for Boer War soldiers and 21 for WW1 soldiers. In some cases the minimum age is determined from the data, in others it is assumed. While the cost of setting the minimum age too low is obvious—including young men who are still growing will bias the height estimates downwards—there is a cost in data to setting minimum age too high, because a large proportion of all recruits are between the ages of 19 and 23. In addition, the studies that we cite, in common with the literature, use ages reported by the recruit at enlistment, that are not subsequently verified. We examine the implications of using reported ages by determining the actual ages of 53% of the soldiers in our sample.

We match the soldiers in our sample to records at New Zealand Births, Deaths, and Marriages Online (BDM).[48] The birth records provide information on family name, given name or initials, year of birth, and the given names and/or initials of both parents. The name match is based on each soldier's given and last names. We verify the match with three additional pieces of information from the personnel files: (i) the soldier's middle name or initial, (ii) either parent's given name(s) or initial(s), (iii) the soldier's reported age. We allow for slight variations in the spelling of names, such as "Edmund" vs. "Edmond", "Frederick" vs. "Frederic", "Fredric", and "Fredrick", and "Louis" vs. "Lewis". We also allow for the possibility that soldiers have not reported any middle names at enlistment. Information on the parents comes from the name of the next-of-kin as reported on the attestation form. Although this may bias our matching in favour of younger men who are less likely to be married, the majority of the soldiers in our sample give a parent as their next-of-kin, including those in their thirties.[49] The year of birth

[48] `https://www.bdmhistoricalrecords.dia.govt.nz/`

[49] Although there were exceptions, the rules for enlistment required that non-officers be single. See Hall, 'New Zealanders in South Africa', p. 9.

match is based on the possible years of birth derived from their reported age at enlistment. We match to a birth record within four years either side of the possible birth years. Because most soldiers reported their age in years only, we need to allow for the possibility that they enlisted before or after their birthday, hence there is more than one possible birth year. In all cases a match is rejected if there is any conflicting information.

Table 2: Tabulation of Matching Results

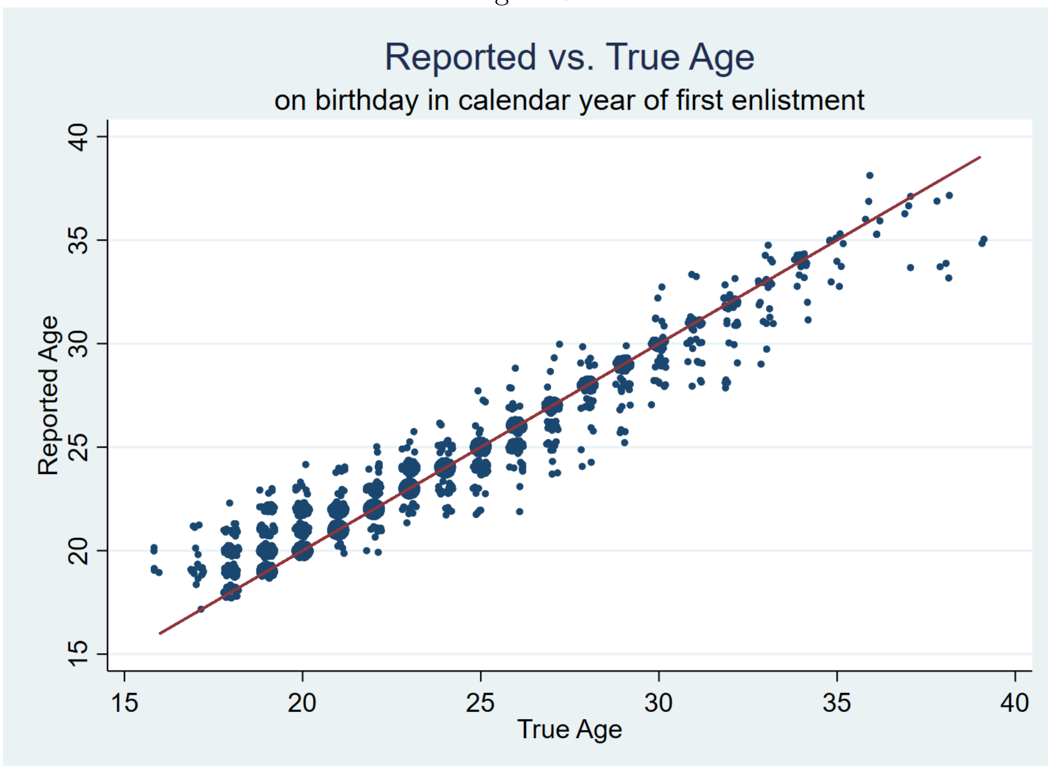
	obs.	%
Total number of military records	4921	100%
No matches: first-last name combination does not exist in birth records	996	20.2%
No matches: conflict(s) in (i)-(iii)	921	18.7%
Possible matches with multiple search results	402	8.2%
Linked to unique birth registration number	2602	52.9%
All three (i)-(iii) present and matching	1399	28.4%
Two out of three (i)-(iii) present and matching; the other absent	1117	22.7%
One out of three (i)-(iii) present and matching; others absent	86	1.7%

Note: The matching criteria are: (i) soldier's middle name; (ii) either parent's given name(s) or initial(s); (iii) year of birth implied by soldier's reported age at enlistment.

The results of the matching process are shown in table 2. Of the 4,921 soldiers in our full sample: we are not able to find first name-last name matches for 996 soldiers; possible matches contained conflicts for 921 soldiers; and there were multiple possible matches for 402 soldiers. Those with multiple possible matches were typically men with a common first and last name, no middle name, and no uniquely identifiable next-of-kin. We are able to match 2,602 soldiers to a birth record. We deem matches to be "confident" when all three of name, year of birth within the allowable window, and next-of-kin, are present and corroborating, and "probable" when two out of three are present and corroborating, with the last one absent. Of the 2,602 matches, 1,399 are confident and 1,117 are probable.

We check the accuracy of our matching process by comparing our matches to the self-reported country of birth from the Certificate of Discharge. The place of birth field was typically left blank and only 1,454 soldiers in our sample (29.5%) reported a country of birth. Of the 1,454 soldiers who reported a country of birth: 786 reported being born in New Zealand and we had matched them to the BDM; 409 reported being born in New Zealand and we had not matched them to the BDM; 21 reported being born other than in New Zealand and had we matched them in the BDM; and 238 reported being born other than in New Zealand and we had not matched them to the BDM. This check gives us some confidence in our matching process, particularly as the rate of false positives, those that report being born outside New Zealand but who we match in the BDM, is very low (1.4%).

Figure 3:



We then compare the reported ages to the real ages as derived from the BDM matching process. The comparison requires some further assumptions as the BDM only provides a year of birth and approximately half of the soldiers gave their age in years only, leaving in question whether they enlisted before or after their birthday. Because we are interested in the difference between the actual and reported age, to be conservative we take the minimum possible difference between them. The true age is always the age that the soldier will reach on their birthday in their year of enlistment. For example, if a soldier enlisted in February 1900 and is linked to a birth registration number in 1880, his true age is 20. Where soldiers report only a year of birth, we cannot tell whether they are enlisting before or after their birthday, and so allow for both possibilities and choose a reported age closest to the true age. Continuing the example, if the soldier in question reported his age to be 22 when he enlisted, he can either intend that he had already turned 22 in 1900, or that he was 22 at the start of the year and will turn 23 in 1900. In this case we record the soldier's reported age as 22, because it is closest to his true age of 20.

For the soldiers who do reported their age in years and months, the reported age is based on whether the enlistment month is before or after the birth month.

Figure 3 shows a scatter plot of reported versus real ages, with jittered markers to show density. Dishonest reporting of age is prevalent. Young soldiers, those with a true age of 21 or below, frequently exaggerated their age. Most of the exaggeration was a matter of one or two years, but for each of the true ages from 18 to 20 there were soldiers who reported an age four years older than they were. There is also evidence of exaggeration by older soldiers, but in the opposite direction. Soldiers aged 25 years and older tended to under-report their age.

Table table 3 shows the proportion of young soldiers of each reported age from 19 to 22 whose true age is less than their reported age. The proportion is highest for the very youngest soldiers—for the confident and probable matches, more than 35% of those who reported their age as either 19 or 20 were younger than that age. The proportion drops to 27% for those reporting an age of 21 and 22. If we focus on those with a reported age of 21 to 25 (a commonly used five-year birth cohort for adult heights), the proportion whose true age is less than 21 is 11.2%. We explore the significance of these findings in the next section.

Table 3: True Age versus Reported Age for Young Soldiers

	total obs.	obs. with true age < reported age	%
"Confident" matches only			
Reporting to be 19 years old	54	16	29.6%
Reporting to be 20 years old	159	57	35.8%
Reporting to be 21 years old	214	63	29.4%
Reporting to be 22 years old	234	75	32.1%
"Confident" and "probable" matches			
Reporting to be 19 years old	98	38	38.8%
Reporting to be 20 years old	280	99	35.4%
Reporting to be 21 years old	371	102	27.5%
Reporting to be 22 years old	421	117	27.8%

5 Results

In this section we explore birth-cohort trends in the soldiers' physical measurements, and their correlation with occupation and rank. We divide the occupations into five categories, similar to those used by Cranfield and Inwood (2015): farmer (31%); white collar (8%); skilled (23%);

unskilled (15%); labour (19%), and other (4%). The "farmer" category includes jobs such as farmer, shepherd, station hand, and farm hand. The "white collar" category includes jobs such as clerk, chemist, and surveyor. The "skilled" category includes jobs such as carpenter, farrier, blacksmith, saddler, and engineer. The "unskilled" category includes jobs such as butcher, groom, bushman, storeman, and stockman. The "labour" category includes both general labourers and miners. The "other" category includes men who were students, travellers, gentlemen, or those who leave their occupation blank. In addition to occupations, we create an "officer" indicator variable for the ranks of lieutenant, major, and captain. Officers account for about 3% of our total observations, and only half of them were born in New Zealand.

Table 4 shows the results of the regressions on height. We only include those born in New Zealand, who we identify as those linked to a unique or multiple registrations in the BDM plus those who declare to be born in New Zealand on their Certificate of Discharge. We further limit our sample to those aged 21 or older. Column (1) shows the regression results for soldiers with a *true* age of 21 years or older. Column (2) shows the regression results for soldiers with a *reported* age of 21 years or older. Lastly, column (3) shows the results of regressing the sample from the column (1) regressions on the their reported age rather than their true age. The purpose of this regression is to ascertain whether the differences in the significance of the results between columns (1) and (2) are due to differences in the sample sizes. All regressions are truncated regressions, with lower limit of 64 inches.[50]

The results on occupations are consistent across the regression specifications. In common with the literature, farmers (the base category) are tall compared to skilled workers, unskilled workers, and labourers. The differences are statistically significant, around 0.3 inches. The small difference (in inches) between farmers and white collar workers is not statistically significant. Also consistent with the literature, officers were taller than non-officers, by 0.76 to 0.82 inches, and the difference is highly significant.

Turning to the birth cohorts, we see important differences between the regression specifications. We use 1865 to 1869 as the base birth cohort, as it is the earliest category that is reasonably populated. Starting with the results in column (2), for the regression using *reported* ages, we find that the youngest soldiers, those born between 1880 and 1884, are 0.4 inches shorter than the base cohort, and the difference is highly statistically significant. This is the only cohort

[50]Komlos (2004) discusses the various approaches for handling truncation in heights data.

that is significantly different from the base category for this regression specification. When we repeat the regression using *true* ages, as shown in column (1), the difference between the base category and the 1880 to 1884 birth cohort is not statistically significant, even at the 10% level. The difference between these results suggests that the finding that the youngest soldiers are shorter is entirely due to the inclusion of soldiers who lied about their age to enlist, and who are not yet 21. When we repeat the regression with reported ages using the true age sample, the results, shown in column (3), are very similar to those shown in column (2). The results shown in column (3) suggest that this finding is robust, and is not purely due to a larger sample size. Our results show that there is no evidence for a decline in stature in New Zealand in the late nineteenth century at least up to the 1880 to 1884 birth cohort, when soldiers' true ages are used. The only cohort significantly different from the base cohort are those born between 1870 and 1874, who are a statistically significant 0.4 inches taller. We also show that age exaggeration at enlistment can affect height estimation for young soldiers.

We repeat regressions in columns (1) and (2) for weight, chest circumference, and BMI. The results are shown in table 5. These regressions are less sensitive to the use of true versus reported ages, although in all cases the differences between the youngest cohort and the base cohort are larger when the true age is used. Younger soldiers, regardless of the sample used, are lighter, have a smaller chest measurement, and are lighter for their height, than older soldiers. The differences are statistically and physically significant. Using the true age regression results, the youngest soldiers are 5.75 lb lighter, have chest measurements 0.73 inches smaller, and have BMI 0.68 smaller than those in the base category. The difference between the use of true and reported ages suggests that while those who lied about being 21 were shorter than those who actually were 21, they were heavier, had a larger chest measurement, and a higher BMI. This raises the possibility that being more physically developed in other respects was a substitute for height at enlistment.

The occupational differences are similar for the officers, who were heavier, had larger chest measurements, and were heavier relative to their height than farmers. Other differences reflect occupational demands. While white collar workers are as tall as farmers, they are lighter, have smaller chest measurements, and are lighter for their height. Conversely, while skilled workers, unskilled workers, and labourers are shorter than farmers, they are as heavy, have similar chest measurements, and are as heavy for their height.

5.1 Cross-country comparison

Figure 4 shows a comparison of the heights of soldiers from Australia, Canada, and New Zealand who served in either the Second Boer War or in WW1. The Australian and Canadian data are the average heights of a sample of Australian- and Canadian-born men who enlisted to serve. The Australian heights are from Shlomowitz, for a sample of 3,069 Australian-born out of a total of the approximately 16,000 men who served in the Australian contingents (many of that total were foreign born, including approximately 1,500 New Zealand-born men).[51] The Boer War data for Canada are from Cranfield and Inwood, and are the birth-cohort averages for a sample of 2,629 Canadian-born men out of the approximately 7,000 men who served in the Canadian contingents.[52] The New Zealand data for the Boer War are from the regression results in column 1, Table 4, with farmer as the base occupation.

The WW1 data for Australia and Canada are from Cranfield and Inwood's height regressions.[53] They include the region or state of origin and religious denomination in their regressions. None of the regional differences are significant in Australia. There are some religious differences, as Catholics (the base category) are taller than the Methodists, Baptists, and members of the Church of England. The series shown in figure 4 is uses Western Australia as the base region, farmer as the base occupation, and Catholic as the base religious denomination. Unlike Australia, there are significant regional differences in heights in Canada. Western Canadians are 0.6 inches taller, Maritimes are 0.3 inches taller, and Quebecois are 0.5 inches shorter. Catholics in Canada are shorter than members of the other denominations. The differences are substantial—ranging from 0.5 to 1 inch—and statistically significant. For the purposes of comparison we use the coefficient on "Church of England". The base region is Ontario and the base occupation is farmer. The WW1 data for New Zealand are derived from regression results in Inwood, Oxley,

[51] Shlomowitz, 'Did the mean height' p. 486, Table 1. Shlomowitz's data are from Whitwell, de Souza, and Nicholas 'Health, height, and economic growth'. Whitwell et al pool height data from Boer War and WW1 soldiers, a decision that Shlomowitz criticizes on the grounds that the soldiers were recruited differently, and so are not easily comparable. Shlomowitz reproduces their results with the Boer War soldiers separate from the WW1 soldiers.

[52] Cranfield and Inwood, 'The great transformation', p. 6, Table 1.

[53] Cranfield and Inwood 'A tale of two armies', p. 219, table 4, column 3 and p. 221, table 5, column 3. Although Shlomowitz reports on the heights of Australian-born men who served in WW1, we prefer Cranfield and Inwood's data because they have a much larger sample.

and Roberts.[54] The coefficient for farmer is used to make their results comparable to ours, and more directly comparable to those for Australia and Canada.[55]

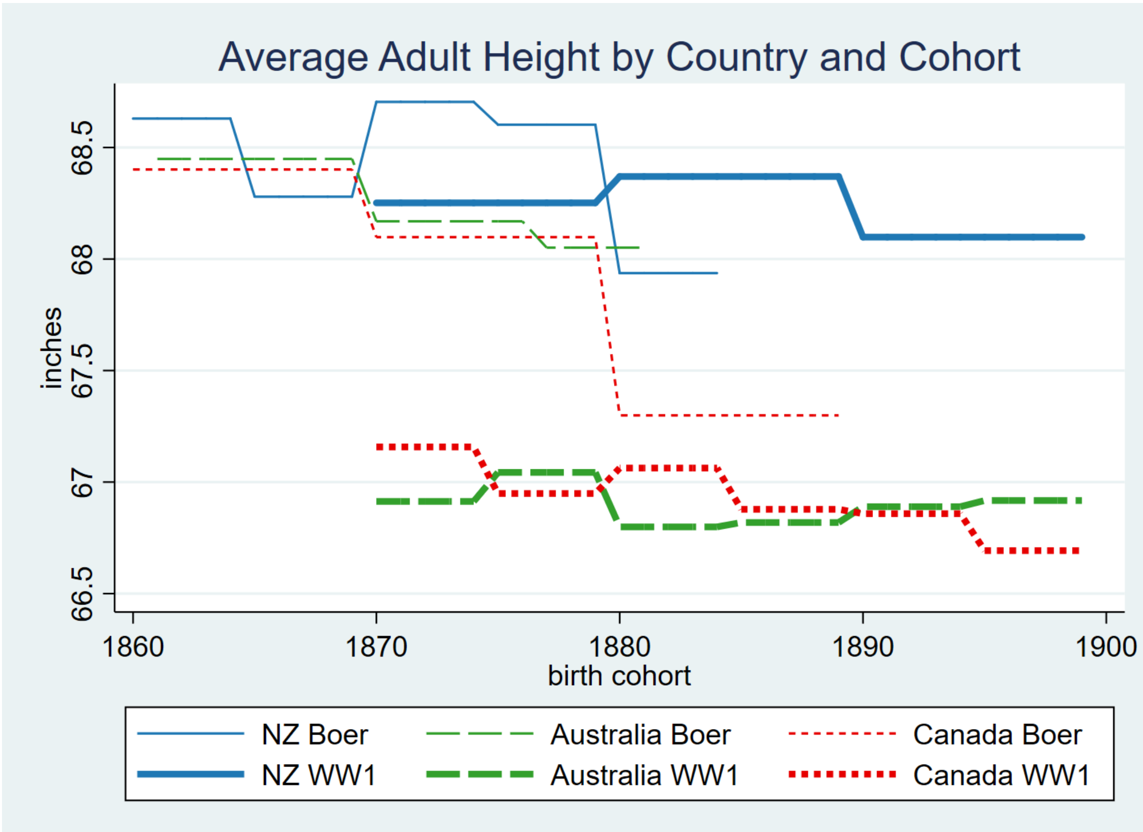


Figure 4: The Boer War data are sample means reported in Shlomowitz (2007, Table 1) for Australia and Cranfield and Inwood (2007, Table 1) for Canada. The Boer War heights for New Zealand are from column 1 in Table 4. The WW1 data are derived from regression results in Cranfield and Inwood (2015) for Australia (Table 4) and Canada (Table 5) and Inwood, Oxley, and Roberts (2010, Table 4) for New Zealand. Details of the use of the regression results are in the text.

The soldiers who served in the Boer War and who were born before 1880 are tall. For all three countries the average height of this group is above 68 inches. There are some differences. For example, the soldiers born in New Zealand in the 1870s are taller than those born in Australia

[54] Inwood, Oxley, and Roberts, Physical Stature, table 4, p. 278

[55] While neither we nor Inwood, Oxley, and Roberts include denominational differences, according to the 1896 census 40% of New Zealanders were members of the Church of England, 23% were Presbyterians, and 14% were Roman Catholics.

and Canada in that decade. There are also similarities. In particular, the youngest cohort is the shortest for all three armies. For the reasons discussed above, we treat this apparent shortness with caution. In the case of New Zealand, the difference in height between the 1880-1884 the 1865-1869 cohorts is not statistically significant.

The difference between the heights of the Boer War and WW1 soldiers from Australia and Canada is marked. Where the average height for Boer War soldiers is between 68 and 68.5 inches (excluding the youngest Canadian cohort), the tallest WW1 cohorts are only slightly taller than 67 inches. For the 1870s, a decade in which the birth cohorts of the Boer War and WW1 soldiers overlap, the Boer War soldiers are around an inch taller. Part of this difference comes from the use of actual means for the Boer War heights and truncated regressions for the WW1 heights. This will result in the heights of the Boer War soldiers being overstated relative to those who served in WW1. However, the differences in heights are also consistent differences in the recruiting standards and the strictness with which they were enforced.

The most striking feature of figure 4 is tallness of the New Zealand soldiers who served in WW1 and the absence of any difference between their heights and those of the New Zealand Boer War soldiers. The average height of New Zealand WW1 soldiers, including those born in the 1890s, is over 68 inches. This is more than an inch taller than the equivalent soldiers from Australia and Canada. The absence of any difference in heights between the Boer War and WW1 soldiers is particulary notable given the large (and expected) differences found for Australia and Canada.[56] This calls into question Inwood, Oxley, and Robert's claim that there was a decline in adult heights for those born in the 1890s in New Zealand. If we accept the hypothesis that the differences in selection criteria between the Boer War and WW1 were binding, and that young soldiers lied about their age in sufficient numbers to push mean heights downwards, then the evidence in figure 4 is consistent with average male heights in New Zealand rising in the last decades of the nineteenth century, including for those born in the 1890s. Finally, the results for all cohorts, but particularly for those born in the 1870s, suggest that the depression of the late 1800s had no impact on adult heights. This finding is consistent with Depauw and Oxley's contention that stunting in both childhood and adolescence is needed to produce stunted adults.

[56]While the comparison of heights for New Zealand is based on truncated regressions for both wars, the use of raw means for the Boer War makes no difference to this finding.

6 Conclusion

In this paper, as our first contribution, we present empirical evidence on the heights of New Zealand soldiers who served in the Boer War. Our evidence lends further support to the claim that the standard of living in nineteenth century New Zealand was generally very high. The New Zealand soldiers were, on average, as tall as soldiers from Australia and Canada, two other countries with an historically high standard of living. A comparison of heights across countries and wars yields a surprising finding: while the Australian- and Canadian-born soldiers who served in the Boer War were taller than those who served in WW1, this was not the case in New Zealand. Soldiers who served in the Boer War were subject to more stringent recruitment standards than those who served in WW1, and so the differences in heights found for Australia and Canada are consistent with our expectations. By contrast, the New Zealand-born soldiers who served in WW1 were as tall, to within half an inch, as those who served in the Boer War. While we are wary of direct inference on population heights from the heights of soldiers, our findings are suggestive. If the recruitment standards were similar across all three countries for each of the two wars, then our findings would support the hypothesis that adult heights were rising in late nineteenth century New Zealand.

Our second contribution is the use of actual rather than reported ages in the analysis of birth-cohort height trends. We obtain the actual age of about half the soldiers in our sample by matching their personal information against the New Zealand birth records. Using these actual and reported ages, we document the extent to which young soldiers over-state their age in order to enlist. Our findings have direct implications for studies that use reported ages for determining whether a soldier has reached their adult height. A common finding in the literature, including in some of the studies we cite for comparison purposes, is that the youngest soldiers are also the shortest. We show that for our sample when we use the actual age, rather than the reported age, the apparent short stature of the youngest soldiers disappears. Therefore, we caution against interpreting the short stature of the youngest cohort of soldiers as evidence of declining adult height in that birth cohort.

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A Data Appendix

A.1 Introduction

Military personnel files contain some number of the following:

A.1.1 New Zealand Military Forces South African War Form R.31

Form R. 31 is a summary sheet that appears at the front of the file, and includes fields for name, rank, and contingent(s). Although it is not a field on the form, the regimental number, a unique identifier given to each soldier on a per-enlistment/contingent basis, is typically included. Only a very small number of files, typically those for officers transferring from elsewhere in the Empire to the New Zealand Contingents, do not contain a regimental number.

A.1.2 Attestation form for volunteers

The Attestation Form is the enlistment form, and contains the following fields of interest: name, regimental number, rank, occupation, age, height, weight, chest measurement, name of next-of-kin, address of next-of-kin, the nature of their relationship with their next-of-kin, and the enlistment date. The printed form includes the contingent number.

A.1.3 New Zealand S.A. Contingent Preliminary Medical Examination form

The preliminary medical examination includes fields for height, weight and chest circumference. The date on medical examination is typically within a few days of the date on the attestation form.

A.1.4 Certificate of Discharge

The relevant fields in the certificate are: name, age, occupation, place of birth, and height and weight. The place of birth is typically left blank.

A.1.5 Department of Internal Affairs Notification of Death

A small number of files include a Department of Internal Affairs Notification of Death, form L.A.-61. The majority of the notifications are for deaths that took place after 1950. The relevant fields in the Notification of Death are name, regimental number, rank, year of birth, and place of birth. These fields are completed by the New Zealand Defence Force (and then returned to the Department of Internal Affairs) and so typically only contain information that are available elsewhere in the file.

Table 4: Cohort Regressions on Height

	(1)	(2)	(3)
True Cohort			
1860-1864	0.349		
	(0.467)		
1865-1869	omitted		
	—		
1870-1874	0.422**		
	(0.215)		
1875-1879	0.323		
	(0.201)		
1880-1884	−0.344		
	(0.237)		
Reported Cohort			
1860-1864		0.293	0.360
		(0.406)	(0.590)
1865-1869		omitted	omitted
		—	—
1870-1874		0.195	0.323
		(0.166)	(0.213)
1875-1879		0.171	0.197
		(0.154)	(0.200)
1880-1884		−0.463***	−0.527**
		(0.176)	(0.260)
Occupation			
Farmer	omitted	omitted	omitted
	—	—	—
White Collar	0.042	0.213	0.048
	(0.179)	(0.143)	(0.180)
Skilled	−0.290**	−0.257***	−0.281**
	(0.121)	(0.093)	(0.122)
Unskilled	−0.317**	−0.322***	−0.300**
	(0.135)	(0.105)	(0.136)
Labour	−0.319**	−0.362***	−0.304**
	(0.132)	(0.101)	(0.133)
Other	0.008	0.034	−0.065
	(0.283)	(0.212)	(0.287)
Officer	0.818***	0.760***	0.814***
	(0.235)	(0.209)	(0.239)
constant	68.281***	68.426***	68.367***
	(0.204)	(0.156)	(0.202)
N	1582	2597	1572
log likelihood	−3063.7	−5004.1	−3046.8

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Note: Truncated regressions, with lower bound 64 inches. All regressions limit observations to those born in New Zealand only. Regression (1) further limits observations to those with true age 21 or above. Regressions (2) and (3) further limit observations to those with reported age 21 or above.

Table 5: Cohort Regressions on Weight, Chest Circumference, and BMI

Regressor:	(1) Weight	(2) Chest	(3) BMI	(4) Weight	(5) Chest	(6) BMI
True Cohort						
1860-1864	1.104	−0.713*	−0.182			
	(3.171)	(0.412)	(0.413)			
1865-1869	omitted	omitted	omitted			
	—	—	—			
1870-1874	0.233	−0.324*	−0.299			
	(1.467)	(0.179)	(0.191)			
1875-1879	−1.942	−0.564***	−0.527***			
	(1.375)	(0.167)	(0.179)			
1880-1884	−5.763***	−0.734***	−0.676***			
	(1.604)	(0.193)	(0.209)			
Reported Cohort						
1860-1864				4.276	0.413	0.414
				(2.770)	(0.380)	(0.367)
1865-1869				omitted	omitted	omitted
				—	—	—
1870-1874				1.109	−0.090	0.042
				(1.132)	(0.144)	(0.150)
1875-1879				−1.216	−0.342**	−0.286**
				(1.055)	(0.134)	(0.140)
1880-1884				−5.280***	−0.686***	−0.487***
				(1.190)	(0.149)	(0.158)
Occupation						
Farmer	omitted	omitted	omitted	omitted	omitted	omitted
	—	—	—	—	—	—
White Collar	−4.764***	−0.486***	−0.659***	−3.662***	−0.436***	−0.624***
	(1.219)	(0.147)	(0.159)	(0.973)	(0.119)	(0.129)
Skilled	−1.943**	0.063	−0.061	−1.813***	0.014	−0.083
	(0.815)	(0.100)	(0.106)	(0.629)	(0.078)	(0.083)
Unskilled	−1.316	0.119	0.020	−1.947***	0.041	−0.076
	(0.914)	(0.111)	(0.119)	(0.708)	(0.087)	(0.094)
Labour	0.206	0.130	0.293**	0.118	0.179**	0.314***
	(0.891)	(0.109)	(0.116)	(0.679)	(0.084)	(0.090)
Other	1.190	0.055	0.153	−0.739	−0.292	−0.147
	(2.009)	(0.235)	(0.262)	(1.477)	(0.181)	(0.196)
Officer	6.868***	0.394*	0.426**	6.354***	0.544***	0.392**
	(1.617)	(0.202)	(0.211)	(1.438)	(0.183)	(0.190)
constant	155.889***	37.549***	23.515***	155.145***	37.313***	23.279***
	(1.389)	(0.170)	(0.181)	(1.062)	(0.136)	(0.141)
N	1577	1508	1577	2594	2467	2594
R^2	.04493	.02728	.03111	.04479	.03223	.03291

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Note: OLS regressions. All regressions limit observations to those born in New Zealand only. Regressions (1)-(3) further limit observations to those with true age 21 or above. Regressions (4)-(6) further limit observations to those with reported age 21 or above.