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Physical Stature and its Interpretation in Nineteenth Century New Zealand

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Physical stature and its interpretation in nineteenth century New Zealand

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Abstract: During the late nineteenth century the physical stature of New Zealand-born men stagnated, despite an apparently beneficial public health environment and growth in per-capita incomes. Stature varied by social class, with professionals and men in rural occupations substantially taller than their peers. There is not enough evidence to show that the indigenous Maori population differed in height from men of European descent.

JEL codes: O56, I10, N37

Keywords: Physical stature; Height; Well-being; New Zealand
Anthropometric history; Biological standard of living

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1. Introduction

Long-term change in the health of a population is a key indicator of changing living standards. Yet there are few measures of health and living standards that are consistent over several decades. A large literature has established that the best measure of changing health and living standards over several centuries is average stature.[1] Although modern health surveys have documented changes and variation in adult stature in New Zealand, there is little historical evidence. This paper begins to fill that gap, by identifying and interpreting the evidence of physical stature among male New Zealanders born between 1868 and 1900. Consistent with the pattern observed in other countries we find that average stature declined in New Zealand in the 1890s.

Research in other Western countries finds mean stature declining in the late nineteenth century, followed by an early twentieth-century transition to increasing stature. European-descended New Zealanders shared a common genetic background with Europeans and European migrants to other 'New World' countries. Thus, New Zealand evidence on changes in height contributes to the broader question of how Europeans and their descendents responded to changes in the nutritional environment.

At first glance, late nineteenth century New Zealand was a healthy country with a beneficial nutritional environment. The New Zealand Official Yearbook for 1912, for example, claims the lowest infant mortality rates anywhere in the world.[2] It is well established that New Zealand had high real incomes, and low rates or urbanization.[3] The relationship in other countries between income, disease and height suggests that if anywhere in the world was exempt from the late-nineteenth century trend towards diminishing stature before 1900, it would be New Zealand. And yet the evidence of good health is thin, indeed there are reasons to think that New Zealand faced the same adverse pressures on health as elsewhere in the nineteenth-century world.

We provide new evidence through a consideration of the following questions:

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[1] Steckel, 'Biological Measures; Steckel, 'Heights and Human Welfare'.
[2] Dominion of New Zealand, *New Zealand Official Yearbook.*
[3] Greasley and Oxley, 'Measuring New Zealand's GDP 1865–1933'; Oxley and Greasley, 'Globalization and real wages'.

- Was there in New Zealand as elsewhere some tendency for height to diminish for those born before 1900?
- If there was a transition from stagnant or declining stature to rising heights, did it occur at roughly the same time in New Zealand as elsewhere?
- Can we identify particular groups within New Zealand who did not share equally in the experience of robust physical well-being?
- Are there socio-economic correlates that hint at the underlying causation for inequality and change over time?

As is common in the anthropometric literature for countries at low and middle levels of income our principal evidence of well-being is stature. Adult stature and body mass are proxy measures of health. Though body composition is not a complete measure of health, height and weight data from military records are the best sources for systematically understanding historical change. The rapidly growing international literature on changes in stature draws extensively on military records, making the New Zealand samples broadly similar. In New Zealand, the military records we draw on were quite representative of the male population.

New Zealand men enlisted in large numbers at the onset of war. Enthusiasm naturally waned in mid-1915 when news of the debacle at the Gallipoli landings showed that enlistment brought not just the opportunity for overseas travel, but a high risk of being wounded or dying.[4] Conscription with few exemptions was introduced for the European-descended population in 1916, and the indigenous Maori in June 1917. Throughout the war, both height and weight were recorded in the medical examinations that accompanied enlistment for both volunteers and conscripts in the New Zealand Expeditionary Forces in World War One. Body composition was consistently measured across the military records. The New Zealand military had measured men without shoes since the South African War of 1899-1902 if not before.[5] It is less clear how recruits were weighed. Photos from World War One suggest that at least in the 'main centres'—the four largest cities of Auckland, Wellington, Christchurch and Dunedin—that balance weight scales were used.

[4] Crawford and McGibbon, *New Zealand's Great War.*
[5] Attestation of William Eli Johnston, 1902. AABK/18805/W5515, Box 29, Record 2872. Archives New Zealand, Wellington.

2. Stature as a measure of health

Stature is a summary measure of the lifetime effect of nutrition, environmental conditions, the impact of disease, and workload on the body.[6] Sustained nutritional deficits while a person is growing result in individual stature falling short of maximum potential height. The human body puts calories to the immediate task of replenishing energy and fighting disease, before it can grow taller. If a growing person is persistently sick or expending more calories than they take in, growth will slow. When these nutritional deficits are widespread across the population, average stature will fall.[7] There are three main causes of nutritional deficits, which while analytically separate are not mutually exclusive: (1) declines in available calories such as famines, (2) persistent bouts of infectious disease while energy intake is constant, (3) increases in energy expended while energy intake is constant. As a summary measure subject to several influences changes in the average stature of a population do not identify the causes of change. Trends in stature must be compared with contemporaneous influences on net nutrition to identify the causes of change. Since the 1970s stature has been widely and increasingly used to measure the biological standard of living in an historical and long-term context.[8]

3. Historiographical Context

The stature of men in North America and most of Western Europe fell in the late 19th century, and only recovered in the 20th century.[9] Industrial and urban growth meant that despite rising incomes, health-related infrastructure often could not keep pace with population growth. Moreover nutrient-dense food became less affordable; protein deficient diets—especially deficient in milk protein — may have contributed to declines in stature.[10] A relevant comparison is Australia where men were taller than white men in North America and Europe, and yet Australians born in the long economic depression of

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[6] Bogin, *Patterns of human growth*; Eveleth and Tanner, *Worldwide variation.*
[7] Silventoinen, 'Determinants of variation '.
[8] Floud, Wachter and Gregory, *Height, Health and History*; Komlos, 'Shrinking in a Growing Economy'.
[9] Haines, 'Growing Incomes, Shrinking People'.
[10] Baten and Murray, 'Heights of Men and Women '; Koepke and Baten, 'Biological Standard Of Living'.

the 1880s and 1890s may have been shorter than men born in the 1870s or early 20th century.[11]

We are also particularly interested in the health and physique of the indigenous Maori population. Health disparities between Maori and the European-descended Pakeha population have been a persistent concern in New Zealand since the 1960s.[12] International comparisons of indigenous and European stature are limited. North American evidence suggests indigenous populations continued to have adequate protein in their diets because they were more rural.[13] In New Zealand there were dramatic changes in the protein and other nutrients available to Maori. At the beginning of the nineteenth century most Maori lived in settled communities of several hundred people, growing crops and obtaining their protein largely from the abundant fish stocks in New Zealand's coastal waters. European settlement meant the introduction of commercial farming, which Maori successfully adopted.[14] Following wars between Maori and European settlers in the 1860s and 1870s Maori were deprived of the best agricultural land. Most Maori continued to live largely in small rural communities, largely separate from the Pakeha population, but interacting with the commercial agricultural economy for some of their needs.[15] Reports from the 1880s and 1890s suggest Maori health was quite poor. Tuberculosis, for example, was quite common with Maori often living in damp conditions and close proximity to their neighbours.[16] The Maori population declined significantly, reaching a nadir of 42,000 in 1896, a halving of the population in 60 years according to the best estimates.[17]

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[11] de Souza, Height, Health and Living Standards; Whitwell, de Souza and Nicholas, 'Height, Health and Economic Growth'. Shlomowitz, 'A comment'.
[12] We refer to New Zealanders of European descent as Pakeha in the rest of this paper. Blakely, Tobias, Robson, Ajwanid, Bonne and Woodward, 'Widening ethnic mortality disparities'; Rose, *Maori-European Standard*; Rose, *Maori-European comparisons.*
[13] Komlos, 'Access to Food'; Prince and Steckel, 'Nutritional Success'; Steckel and Prince, 'Tallest in the World'.
[14] Petrie, *Chiefs of industry.*
[15] Belich, *New Zealand Wars.*
[16] Dow, *Maori Health.*
[17] Pool, *Te Iwi Maori.*

The decline in Maori health was dramatic. From first contact, Europeans were impressed with Maori physique in general, and stature in particular. In 1767 the English explorer, James Cook, who more than anyone put New Zealand on the European map was impressed by Maori stature, noting in his journals that Maori were 'rather above than under the common size.' Anthropologists have shown that Pacific Island and Maori populations were taller than Europeans before 1800.[18] Peter Buck's study of 424 Maori soldiers from World War I suggests Maori heights had not decreased significantly for men born before 1900.[19]

The health consequences of colonisation are not completely established. We hypothesize that the impact of colonisation on health is a cumulative disadvantage that persists over generations. A shock to the health of one generation is passed onto children, and subsequently to their children. It is well established that poor health in utero, and then through childhood and adolescence, has persistent effects on health in later life. The exact mechanisms and magnitude of the effects remain open topics of research.[20] The persistence of socio-economic inequalities in health can also be attributed to cumulative patterns of disadvantage persisting over generations.[21] Thus, to understand present patterns of socio-economic inequalities in health it is imperative to understand socio-economic inequalities in health over several generations.

Little is known about Maori health prior to and during colonisation. The decline of Maori population until 1896 is consistent with the hypothesis of deteriorating health under the impact of colonization. While early population estimates are not precise, there was a 25% decline in population between the first accurate census of Maori in 1858 and the population nadir in 1896. It is likely that the Maori population halved over the nineteenth

[18] Houghton, *First New Zealanders*; Houghton, *Great Ocean*; Houghton, Leach and Sutton, 'Estimation of stature'.
[19] Buck, 'Maori Somatology'.
[20] Barker, *Mothers, Babies, and Health*; Elo and Preston, 'Effects of Early-Life Conditions'; Fogel, 'New sources'.
[21] Halfon and Hochstein, 'Life Course'; Holland *et al.*, 'Life course '.

century.[22] The Maori population recovered rapidly in the twentieth century, with delayed declines in fertility, compared to the Pakeha population. Measured by mortality, Maori had very poor health in the nineteenth century, followed by recovery in the twentieth century. Historical research on Maori health during late population decline and early recovery has taken poor health as given, and concentrated on government policy towards Maori health. Yet, no systematic measures of the health of *living* Maori have been published for the period before 1950.[23] Government departments, and the Medical School at Otago carried out some surveys of Maori health before World War II. While some of this research was published there were no systematic comparisons of Maori and Pakeha health until the 1960s. Further complications arise because the Maori were more likely to live in rural areas than Pakeha, which should have provided a better nutrition and disease environment.[24] One possibility is that rural lifestyle allowed Maori to retain nutritious diets, but they were still susceptible to new diseases with poorer living conditions than rural Pakeha.

By contrast nineteenth-century Pakeha appeared to enjoy good health by international standards. The demographic evidence of rapid population growth led contemporaries to argue that late nineteenth century New Zealand was an unusually healthy society—healthier than North America or Australia. As the most remote destination for nineteenth century migrants, boosters of New Zealand had incentives to overstate the health and wealth that awaited the migrant. The received wisdom of New Zealand's unusual healthiness was given scholarly credence by Alfred K. Newman in 1882 whose article 'Is New Zealand a Healthy Country?—An Enquiry with Statistics' proceeded quickly to answer 'Yes'.[25] Boosters of New Zealand as a destination for the migrant emphasized the crude mortality statistics. This comparison favored New Zealand which had a young population in the 1870s and 1880s because of very high fertility rates.[26]

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[22] Pool, *Maori population*; Pool, *Te Iwi Maori.*
[23] Dow *Maori Health*; Lange, *May the People Live.*
[24] Pool, *Te Iwi Maori.*
[25] Newman, 'Healthy Country'.
[26] Pool, Dharmalingam and Sceats, *New Zealand Family.*

While the promise of good health in New Zealand may have been overstated to potential migrants, there is scholarly support for the argument. A fairer comparison of age-adjusted mortality rates shows New Zealand did have lower mortality than Britain or the United States.[27] Crafts' calculations show that in 1913 New Zealand had the world's highest level on the Human Development Index.[28] Another objective measure of good health was an early decline in Pakeha infant mortality.[29] International evidence shows that before World War II medical interventions played a relatively small role in improved longevity.[30]

New Zealand's high level of human development came not from particularly effective policy, but from inexpensive animal protein and a relatively benign public health environment. New Zealand's cities were small, with the four largest cities having metropolitan populations between 40,000 and 70,000 in 1901. Population densities were low compared with European and North American cities. Tenements and apartments were uncommon in New Zealand.[31] New Zealand cities—mostly situated on the ocean—were also lucky enough to be able to discharge some of their waste into the sea, while obtaining water upstream from rivers and reservoirs. Advantages of location and low population densities explain the good health the Pakeha population enjoyed compared to contemporaries in Australia, North America and Europe.

And yet, New Zealand cities were not especially clean or healthy. As Pamela Wood has recently shown, they just had smaller areas of poor housing than overseas.[32] In all of the 4 largest cities there were areas of cramped, damp housing that were both eyesores to the middle class and unhealthy for their inhabitants.[33] Unhealthy living conditions affected some Pakeha, but many Maori. Most Maori lived in rural areas, which conferred the public health benefits of low population density. However, in areas where Maori had lost

[27] Maddison, *World Economy.*
[28] Crafts, 'Human Development Index'.
[29] Mein Smith, 'Truby King'.
[30] McKeown, *Modern rise*; Preston, 'Changing Relation'.
[31] Ferguson, *Building.*
[32] Wood, *Dirt.*
[33] Husbands, 'Poverty'.

a lot of land to European settlers Maori often ended up living in damp, unsanitary conditions. Only a couple of generations past first contact with Europeans Maori had also not acquired immunity to diseases Europeans had grown up with, and brought with them to New Zealand. While infant and child mortality for Europeans declined quite rapidly from the 1890s, Maori mortality below the age of 15 remained very high. Children as well as infants were vulnerable to infectious diseases at rates well above those suffered by Pakeha.

In summary, then, other quantitative measures of living standards suggest that Pakeha men may well be taller than other European-descended men in Australia and North America. Exact evidence on Maori living standards is limited to mortality as evidenced by population decline. After the major wars of the 1870s, Maori population decline continued and was plausibly related to poor housing and diet, and infectious disease burdens. These factors are likely to have reduced average stature in the Maori population. However, just three to four generations earlier, early European travelers in New Zealand commented that Maori were unusually tall. These countervailing observations suggest that in the late nineteenth century Maori stature was probably declining towards Pakeha stature.

4. Preliminary Description of the Data

Our principal sources of information on adult height and weight are military recruiting records from World War I. Although World War I lasted just four years, the New Zealand-born men who served were born between 1868 and 1900, giving us information on three decades of change in living standards. Military records are widely used in international research on stature and BMI. Conscription and a wide enthusiasm for volunteering mean that we will have a nearly random sample of adult men. Although minimum physical requirements for conscription included height, it is possible to statistically adjust for sample truncation.[34] New Zealand results will be compared to the extensive international findings.[35] The main limitation of military records is that military

[34] Komlos, 'How to'.
[35] Steckel, 'Heights and Human Welfare'.

service is largely performed by men. However, the causes of declining height—nutritional deficits in utero and early childhood—are largely shared by both sexes. Indeed, international research shows that male stature is more sensitive to malnutrition and disease, suggesting the bias towards men in historical sources could even be useful.[36]

We use two samples of New Zealand soldiers in this paper, which we refer to as the 'genealogical sample' and the 'casualties sample'. We give a brief description of the sources of the samples and some of the difficulties in constructing a sample for research, before discussing their composition. The genealogical sample has been constructed from the personnel records of New Zealanders serving in World War I, which only became available to the public in 2005. Both the original paper schedules and microfilm copies of 122,357 personnel files have been transferred from the New Zealand Defence Force (NZDF) to Archives New Zealand, comprising most of the men who served in New Zealand forces in World War I. The personnel files of approximately 6000 servicemen (and women) who remained in the NZDF after 1920 have not yet been transferred to Archives New Zealand. Because of the fragile condition of some of the paper files, there is no public access to the original records. Moreover, the microfilm reels contain both publicly available World War I files, and files from World War II. Files from World War II remain restricted, as not all men who served have died. Thus, without special permission the microfilmed files are not available for public research. Instead, Archives New Zealand allows people to request paper copies of World War I records. The records are printed from the microfilm and made available to the person requesting them, and also become available for public research. Genealogists have requested most of the records that have become available although other researchers have been using the World War I files to study Pacific Island and Maori men who served in the New Zealand forces. Thus our data contains 368 indigenous Pacific Island-born men who served in New Zealand forces in World War I. The possible—yet currently unmeasurable—biases of this sample will be obvious. With further funding and access to the microfilm we are currently augmenting our data with clearer sampling procedures.

[36] Bogin.

The 'casualties sample' has been constructed from the Roll of Honour of New Zealand men who died in World War I.[37] This sample may also be biased, if the risk of being killed in action correlated for some reason with stature. Moreover, a large share of the records are not usable for even a basic analysis, missing at least one of height, birth date or birthplace. The casualties sample was transcribed from 93 bound volumes of forms that were filled out when a serviceman was killed in action. Height was meant to be transcribed on the casualty records from the enlistment records. It is understandable that during wartime transcribing information such as height and birthplace, available on other forms, and not obviously related to war service, was a low priority. Thus, of the 16,302 New Zealand servicemen killed in action we have usable information on stature for just 9,575 while only 3744 records specify both height and birthplace.[38]

To date we have collected more than 16,000 records from World War I: 9,575 in the casualties sample and 6,575 in the genealogical sample. The complete dataset includes a substantial number of men born outside New Zealand or the Pacific Islands who are not included in the analysis. For both samples we have information on the following variables: full name, place of birth, date of birth, date of enlistment, occupation at enlistment, military identification number, and height and weight. In the genealogical sample, we have collected additional information on marital status, educational achievement and religion. Other medical and health information in the World War I files was not uniformly collected. Many of the men were assessed as having 'good' health along various dimensions of health. If any aspect of a man's health was poor, further details from medical tests are sometimes given. Thus, detailed quantitative health information is available selectively for the sicker recruits, making it of limited use for analyzing overall population health. In our analysis we require birth date, birthplace, occupation, and height to be non-missing, and do not consider incomplete records. In most of our analyses we exclude men who enlisted before they reached the age of 21 years because many of them were still growing. In itself, this observation that men were

[37] Active Fatal Casualty Forms World War I, 1915-1919. 93 volumes. AABK 519, Archives New Zealand, Wellington.
[38] Carbery, *Medical Service.*

still growing in their late teens is an indicator of changing living standards. In well-nourished modern populations many men attain adult height before age 20.[39] We also exclude men older than 49 years in order to minimize any complication arising from the diminution of height at advanced ages. We restrict our sample to those born in New Zealand and in the nearby Pacific Islands (Fiji, Samoa, Tahiti, Tonga, Niue, Norfolk Island, Gilbert Islands, Society Islands, Cook Islands etc) because we wish to interpret adult height as a reflection of early-life conditions.

Immigrants to the region may have arrived at a young age but we have no basis for knowing this or of apportioning any influence from childhood into some part reflecting the experience elsewhere and another part reflecting experience in New Zealand and the islands.[40] Approximately 1 in 8 of our sample were born in Great Britain. British migration to New Zealand peaked in the early-1860s and mid-1870s.[41] Recruits in World War I, mostly born in the 1880s and 1890s, were largely New Zealand born. There are also 261 Australian-born men in the dataset. During the late 1890s and early twentieth century, there was high out-migration from Australia to New Zealand, as New Zealand's real incomes grew faster than in Australia.[42]

After exclusions for missing information, age and foreign birthplace we are left with the 3,501 observations in the genealogical sample and 2,701 in the casualties sample summarized in Tables 1 and 2. About 10% of the former sample comes from the Pacific islands; the remainder were New Zealand-born. Pacific Island and Maori men were less likely to be casualties in World War I because they served in a support unit, the Pioneer Battalion, that was not engaged in frontline service.[43] In other respects the characteristics of the two samples are broadly similar.

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[39] Bogin.
[40] Initial investigations suggest that it would be feasible to trace some of these British migrants back through their migration, and into the British civil and census records.
[41] Phillips and Hearn, *Settlers.*
[42] Borrie, *Peopling.*
[43] Cowan, *Maoris*; Pugsley, *Te Hokowhitu a Tu.*

The New Zealand-born divide equally between the North Island and the South Island, reflecting the approximately equal populations of the two main islands in the late nineteenth century. There was no appreciable difference in stature between men born in the two islands. There is no unambiguous way to distinguish men who were entirely or largely of European descent (Pakeha) from Maori population indigenous to New Zealand. Thus, we rely on Maori names, principally surnames, to indicate Maori ethnicity. This strategy is conservative, and will exclude Maori with European names. At present our Maori sample is too small to distinguish statistically between different iwi (tribes).

We have identified all men with apparently indigenous names. For convenience we refer to them as indigenous, though there are some caveats to the interpretation of these results. More than a century of interaction meant some in our sample are likely to have both European and Maori ancestry. Moreover, a genetically 'pure' Maori could adapt a European name, and a European might adopt a Maori name. We consider these possibilities relatively uncommon. By identifying Maori with European names as European, our analysis will under-estimate the difference in stature between the two groups. A further complication is that the Maori and indigenous Pacific Islanders who served in the New Zealand Expeditionary Forces hailed from a wide variety of islands, some thousands miles distant from others. Not all tropical islands are the same, and not all indigenous groups were closely related to each other. Organizing them as one category simply because they were not (apparently) of European origin creates a complex category of diverse individuals who might not have recognized themselves as having very much if anything in common.

In defence of our procedure, our analysis comes from a tradition that typically presumes environmental influences (nutrition, disease, workload) are much more influential than genetic influences on adult stature. Within this framework, the precise genetic composition of a group of an individual matters less than how she or he lived, especially as a child. The reporting of an aboriginal name probably does point to someone who lived within and identified with the indigenous community, growing up in a Maori environment. This social and environmental influence is what we wish to capture.

Men who grew up in an indigenous community and presented for enlistment with European names will be invisible to us. The proportion of such people within the European-descended but New Zealand-born community was probably small in the early twentieth century. Inter-marriage between Maori and Pakeha was accepted by both groups, but not very common. The analytical concern is whether Maori who took on European names were systematically different from those who did not. At the moment we have no way to address this concern. For all of these reasons we regard our tabulations and analysis that rely on the ethnic marker as merely indicative of very broad patterns and tendencies. Our more limited confidence in these data compounds the effect of having a relatively small sample of indigenous files.

The summary evidence in Tables 1 and 2 suggests that the Pacific Islanders—with both indigenous and European names—were younger than the New Zealanders at enlistment and by implication were born later. On average they were of comparable height but heavier. The mean and median of both height and weight was similar for all groups suggesting that the indicators of physical stature were not strongly skewed. This is unsurprising for height; most studies of late nineteenth century populations find a near-normal distribution. Evidence for weight is less commonly available but studies of late twentieth-century birth cohorts typically find mean weight is skewed to the right reflecting the presence of a small but significant number of people with large body mass. Apparently this tendency was limited or non-existent in nineteenth-century New Zealand.

The near-normality of height distribution for those born in New Zealand is clear from Figures 1 and 2. There are two principal exceptions to an otherwise remarkably normal-looking pattern. The proportion of people reporting the height of 180cm is smaller than expected. We have no explanation for this although we plan to investigate more closely and in particular re-examine our treatment of half-inch increments. The second exception is a small but noticeable under-representation of those 160cm and shorter. An obvious explanation here is the stated minimum height requirement of 162.5cm (64 inches at the time).

The coefficient of variation indicates that characteristics for Pacific Islanders as also those with an indigenous name are bunched more closely around the mean than for Pakeha. In part this would appear to arise from the more limited dispersion of age among indigenous-designated records and Pacific Islanders (the latter being disproportionately indigenous.

5. Preliminary Analysis of Patterns in Adult Height

Our goal in the analysis is to assess the extent of social differentials and change over time in stature. Because of the greater availability of additional socio-economic information, we focus our discussion on results from the genealogical sample. We must take account of the minimum height requirement of 64 inches for service in the New Zealand Expeditionary Force (NZEF). Admittedly, some men taller than the threshold were rejected for service on the basis of being unfit for reasons other than stature, just as some men shorter than 64 inches were permitted to serve. Although the truncation was inconsistent, the frequency distributions in Figures 1 and 2 make clear that it had some effect. Accordingly we discard all records of men shorter than 64 inches and estimate with a maximum-likelihood truncated regression model.

We capture change over time by partitioning the sample into men born in the 1860s and 1870s (10% of the sample), 1880s (42%) and 1890s (48%). As noted above, evidence of declining height in the late nineteenth century is reported from Australia, Canada, and the United States, the three most obvious societies for comparison with New Zealand, as well as a number of others.[44] Hence there is considerable interest to ascertain if New Zealand's exceptionality extends to this arena.

We examine the influence of socio-economic status via occupations organized into five classes: professional, managerial and clerical (17% in the genealogical sample), farmer (21%), farm labourer (12%), other labourers and servants (14%), and all other (36%).

[44] Cranfield and Inwood, 'Great transformation'; Komlos, 'Shrinking'; Steckel and Haurin, 'American Midwest'; Whitwell, de Souza and Nicholas.

The ‘other’ category is largely made up of men working in manufacturing, transport and utilities. The ‘other’ category was more likely to have been employed in cities. The soldier’s occupational class is assumed to correlate with his father’s occupational class, giving an indirect measurement of the nutritional circumstances in which the soldier grew up. Occupation is a very rough socio-economic indicator. The presumption of intergenerational persistence further reduces precision. Nevertheless, in the absence of other indicators we examine the hypothesis that these occupation-based socio-economic grouping capture the net effect of various influences on adult height.

We hypothesize that rural occupations indicate access as children to a lower relative price of food and limited exposure to infectious disease. The professional and clerical occupations suggest a higher class standing and family circumstances permitting greater spending on food and healthy housing. We anticipate that both groups will be taller, on average. Soldiers born to father with labouring occupations, especially those in urban areas and lacking in specific skills, probably grew up with lower family income in less healthy environments, and consequently were shorter as adults. Occupation correlates partially with the indigenous identity indicator discussed above. Nevertheless, to the extent that men with indigenous names report a variety of occupations, inclusion of the indigenous identity variable identifies picks up a ‘pure’ effect of being indigenous over and above any effects of ethnic clustering in particular occupations. Nearly half (45%) the Maori men in our sample were farmers or farm laborers.

The estimation results reported in Tables 3 and 4 indicate that, as expected, farmers and the professional-clerical class in New Zealand were considerably taller than the omitted category ‘all other occupations’. Farm labourers also were taller although by a smaller margin. The stature of ordinary labourers and servants, in contrast, could not be distinguished statistically from the omnibus omitted class. None of the occupational effects were significant for the Pacific Islanders possibly because of small sample size.

Those with an indigenous name in New Zealand—the Maori—were no taller than Pakeha. The two samples provide slightly different estimates, with the genealogical

sample indicating Maori were just slightly shorter than Pakeha (Table 3), and the casualties sample indicating Maori were slightly taller (Table 4). Neither result was statistically significant at conventional levels. Specification of the indigenous marker had no discernible impact on any of the other coefficients. At least in this sample there is no evidence that Maori physique was particularly impressive relative to Europeans. Whether or not it was negatively affected by colonisation depends on stature in earlier generations for which we have no systematic evidence at present. Given that many Maori were farmers or farm labourers, they would have shared with Pakeha the advantage that rural living conveyed in height. However, the overall effect was that Maori born in the late nineteenth century were not noticeably taller or shorter than Pakeha.

The decadal effects follow an intriguingly different pattern for New Zealand and the Pacific Islands. In New Zealand the genealogical sample shows that those born in the 1880s were taller than those born both earlier and later. The slight increase in stature from the 1860s and 1870s cohort to the 1880s cohort was not significant at conventional confidence levels. Declining stature from the 1880s to 1890s was marked and statistically significant. In the Pacific Islands the 1870s cohort was tallest by a large measure, and again stature diminished from the 1880s to the 1890s. Nevertheless, sample size clearly limits what can be said about the Pacific Islanders. We consider the robustness of these findings with alternate formulations; for example the 1890s effect may be exaggerated if those aged 21-25, all born in the 1890s, had not yet stopped growing. However systematically raising the minimum age threshold did not remove or reduce the evidence of stature decline in the 1890s.

The casualties sample provides a slightly different picture. The differentials associated with occupational classes are more pronounced. The 1870s effect is similar but further from significance; the 1890s effect is has a different sign but is further from significance. The indigenous effect also has the opposite sign but again it does differ significantly from zero. Differences between the casualty and genealogical samples may reflect alternate selection biases but a simpler explanation might be that the smaller casualty sample makes it impossible to precisely identify weak effects. The occupational effects are

strong and represented in both samples; the decadal and ethnic effects are weaker and therefore less easily exposed by analysis of the small casualty sample.

We cannot assess stature change before the 1870s-1880s transition with our World War I data. For this purpose we examine the files of a small number of New Zealand-born South African War soldiers. We divide them into equally sized groups of those born 1863-1878 (72 observations) and 1879-1882 (62 observations). The mean stature of both groups was 174cm. Sample size and inability to adjust for confounding factors reduces the value of this evidence but, at a minimum, we can say that the South African War records reveal no evidence of changing stature.

Regional differences in height are pronounced in some countries. For example, Cranfield and Inwood report significant differences between eastern and western Canada.[45] A dummy variable distinguishing the North Island from South Island was statistically insignificant and did not affect any of the other coefficients. The economic history literature emphasizes differences in the economic and demographic trajectories of the North and South Island but adult stature, at least, did not differ systematically. Finally, we considered if inclusion of observations for men aged 18-20 year-olds with dummy variables to capture growth effects might reduce standard errors and enhance our ability to test hypotheses. This increases sample size considerably but does not systematically affect the pattern of estimated coefficients or improve standard errors. It appears that the noise introduced by the 18-20 year olds offsets any gain from expanding the sample.

6. Conclusion

The experience of stature for men born in late nineteenth-century New Zealand was very different than that of men born a century later. Socio-economic variations in height were pronounced for those born in the 1880s and 1890s. One hundred years later the differentials were reduced (although not eliminated) by the long-term diminution of

[45] Cranfield and Inwood.

economic inequality and reduced marginal significance of income for height at high income levels.

Another point of contrast is that during the late twentieth century each generation was significantly taller than the one preceding. This does not appear to be true for nineteenth-century cohorts. As in similar jurisdictions in Europe and North America New Zealanders born during the 1890s grew up shorter than those born earlier. We do not yet have sufficient data to establish if this is a short-term, perhaps a cyclical effect or part of a longer trend. It remains clear, though, that any cohort differences were small compared with the occupational effects. This is entirely the opposite of the late twentieth century.

It is useful to situate the dip in height for the 1890s cohort in regional perspective. The 1890s marks the beginning of Australia's long slow experience of falling behind.[46] Greasley and Oxley report evidence of a degree of integration between Australia and New Zealand in the trans-Tasman labour market.[47] Not surprisingly real wages in New Zealand, as in Australia, experienced during the 1890s a significant pause in their long-term upward trajectory. Whether the 1890s decline (or, at a minimum, stasis in stature reflects the effect of real wage movements or of other factors (eg urbanization in advance of health-related infrastructure investment) is an appropriate focus for further research. The dip in stature for those born in 1890s suggest the possibility of a trans-Tasman experience although, again, further research may point to a widely-shared 1890s experience in the long-term term evolution of the global economy.[48]

We began the paper with a recognition of the importance of historical origins for Maori-Pakeha health differentials. The evidence of Tables 3 and 4 suggests that Maori stature did not differ from Pakeha stature even after controlling for generational and occupational effects. There is no evidence in this sample of a Maori advantage in

[46] Greasley and Oxley, 'Growing apart'; McLean, 'Australian'.
[47] Oxley and Greasley.
[48] Whitwell, de Souza and Nicholas.

physique that would accord with popular qualitative observations from the time. Yet nor is there evidence that colonization had made Maori significantly shorter than Pakeha.

We also compared New Zealand stature with results for Canada, as both countries were recipients of nineteenth century out-migration from Britain. In which new world environment, did men grow taller? In order to answer this question we estimate a new model comparable to that of Cranfield and Inwood using comparable military records for eastern Canada.[49] The truncation point differs (63 inches vs 64 inches) although in principle the truncated regression adjusts for this effect. We find that a non-farmer born in the 1880s in New Zealand was 171.7cm against 171.2cm in eastern Canada. The farmer effect was larger in New Zealand, and the New Zealand decline into the 1890s was smaller. The eastern Canadian height evidence is for a volunteer while the New Zealand height is for volunteers and conscripts combined. If conscripts were shorter, ceteris paribus, in New Zealand as in Canada, then the New Zealand height superiority is even greater. We conclude that while New Zealand was vulnerable to the same adverse health and nutrition pressures experienced elsewhere, New Zealanders of European descent really were taller than others.

[49] Cranfield and Inwood.

Table 1: New Zealand Expeditionary Force Data, Genealogical Sample, Summary Statistics

	N		Age (years)	Height (inches)	Weight (pounds)	Birth Year
b New Zealand	3189	median	26	68	150	1889
		mean	27.3	68	151	1888
		coeff var	.21	.04	.12	.003
b Pacific Islands	312	median	24	68	159	1892
		mean	25	68	160	1892
		coeff var	.16	.03	.12	.002
Aboriginal Name	373	median	24	68	160	1893
		mean	25	68	162	1891
		coeff var	.16	.03	.11	.002

Note: Those with an aboriginal name are included within the New Zealand and Pacific Island categories, in addition to being reported separately in the bottom line. ‘Coeff var’ is coefficient of variation (standard deviation/mean). b - born

Table 2: New Zealand Expeditionary Force Casualties Data, Summary Statistics

	N		Age (years)	Height (inches)	Weight (pounds)	Birth Year
b New Zealand	2853	median	27	67.9	150	1890
		mean	27.9	68	148	1888
		coeff var	.21	.04	.12	.003
b Pacific Islands	15	median	23	67.8	160	1892
		mean	25	67.4	159	1891
		coeff var	.15	.02	.10	.002
Aboriginal Name	144	median	22	68	160	1893
		mean	24	68	159	1891
		coeff var	.18	.03	.10	.002

Note: Those with an aboriginal name are included within the New Zealand and Pacific Island categories. ‘Coeff var’ is coefficient of variation (standard deviation/mean). b - born

Table 3: Maximum Likelihood Analysis of Stature, New Zealand Expeditionary Force Soldiers 21-49 years at Enlistment, Born in New Zealand and the Pacific Islands, Genealogical Sample

	New Zealand-born N=3051		Pacific Islanders N=298	
	Coef.	P>|z|	Coef.	P>|z|
Born 1870s	-.12	.52	2.91	.08
Born 1890s	-.27	.02	+.70	.05
Farmer	+.77	.00	+.27	.47
Labourer, farm	+.20	.25	2.09	.21
Professional-Clerical	+.51	.00	+.53	.33
Labourer, other	+.08	.68	-.15	.70
Constant	67.6	.00	67.1	.00
	Coef.	P>|z|	Coef.	P>|z|
Constant	67.6	.00	67.4	.00
Born 1870s	-.12	.51	2.84	.09
Born 1890s	-.26	.02	+.73	.04
Farmer	+.77	.00	+.70	.12
Labourer, farm	+.21	.24	2.02	.19
Professional-Clerical	+.51	.00	+.61	.27
Labourer, other	+.07	.64	+.31	.51
Indigenous Name	-.13	.60	-.73	.08

Table 4: Maximum Likelihood Analysis of Stature, New Zealand Expeditionary Force Soldiers 21-49 years at Enlistment, Born in New Zealand – Casualties Data

	New Zealand-born N=2731			
	Coef.	P>|z|	Coef.	P>|z|
Constant	67.2	.00	67.2	.00
Born 1870s	-.14	.64	-.14	.64
Born 1890s	+.03	.25	+.01	.09
Farmer	+1.05	.00	+1.05	.00
Labourer, farm	+.48	.02	+.46	.03
Professional-Clerical	+.99	.00	+1.00	.00
Labourer, other	+.42	.03	+.37	.05
Indigenous Name			+.36	.19

Figure 1: Frequency Distribution of Height for men born in New Zealand and aged 21-49 at the time of enlistment in the New Zealand Expeditionary Forces, Genealogical Sample

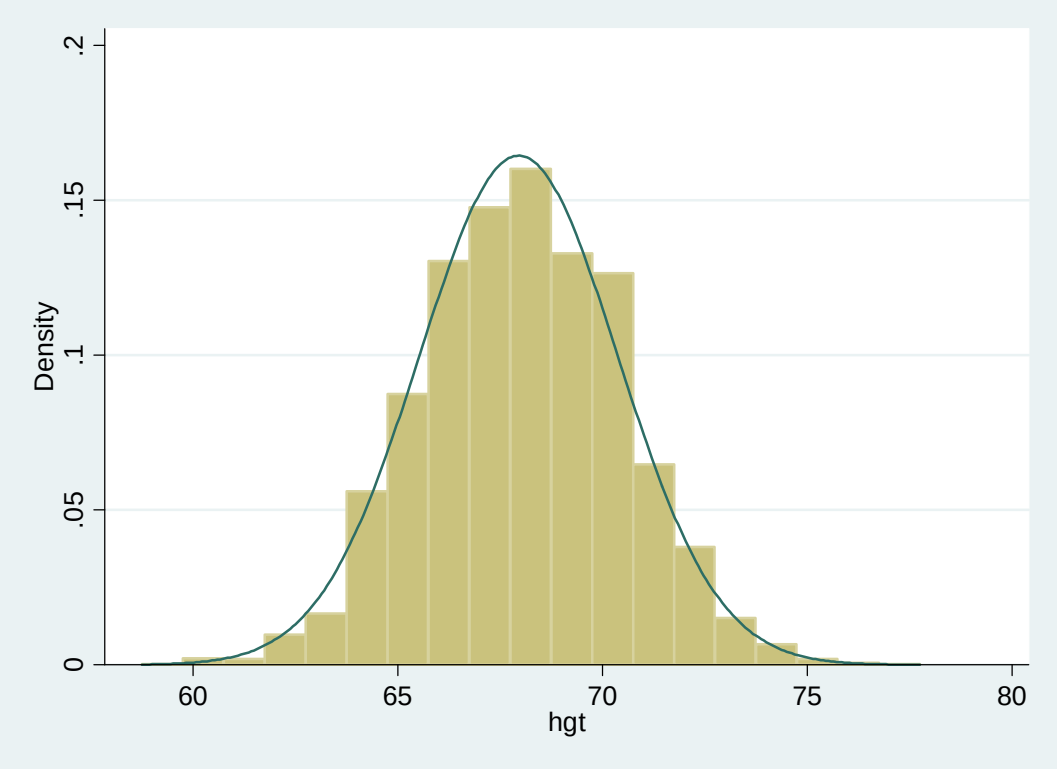
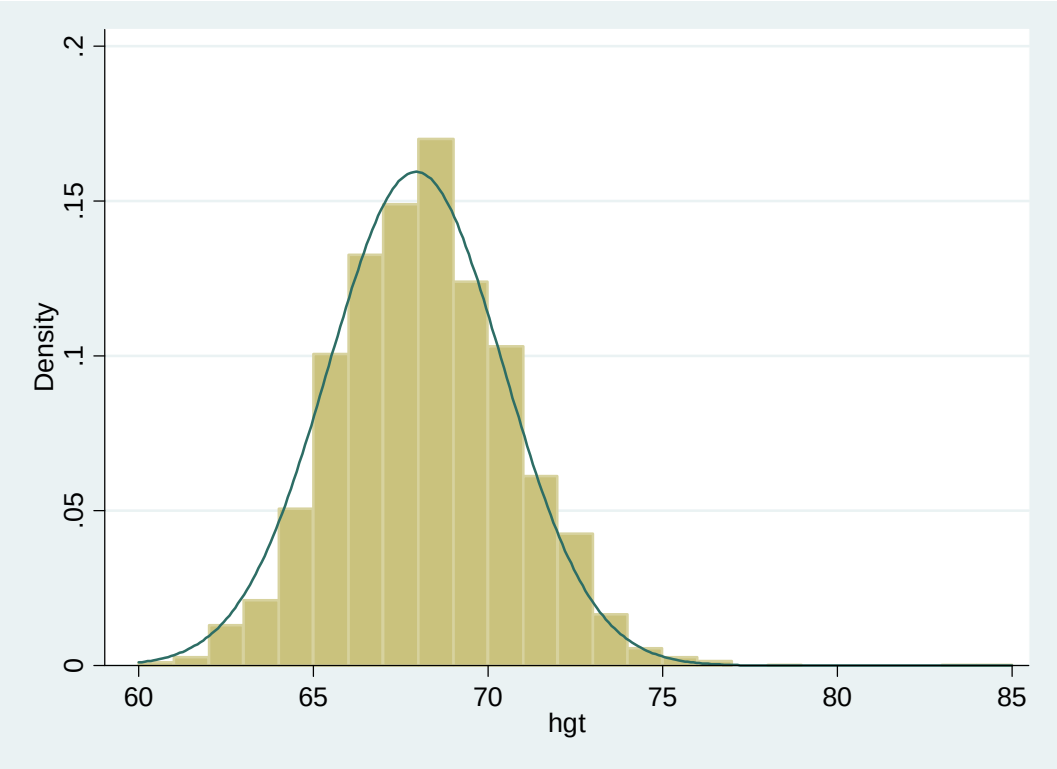


Figure 2: Frequency Distribution of Height for Those Born in New Zealand and Aged 21-49 at the Time of Enlistment in the New Zealand Expeditionary Forces, Casualties Sample



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