

Trends in colorectal cancer mortality by ethnicity and socio-economic position in New Zealand, 1981-99: one country, many stories

Abstract

Background: Ethnicity and socio-economic position are important determinants of colorectal cancer (CRC) mortality. In this paper, we determine trends in colorectal cancer mortality by ethnicity and socio-economic position in New Zealand.

Methods: Cohort studies of the entire New Zealand population for 1981-84, 1986-89, 1991-94 and 1996-99 (linking Census and mortality datasets) allowed direct determination of trends in CRC mortality by income and education. For ethnicity, we used routine unlinked Census and mortality data, but with correction factors applied for undercounting of Māori and Pacific deaths.

Results: Ethnicity: CRC mortality trends varied markedly. There were small (10-20%) decreases among non-Māori non-Pacific people, a 50% increase among Māori, and up to 10-fold increase among Pacific people. By 1996-99, all three ethnic groups had similar CRC mortality.

Socio-economic position: For females, differences in CRC mortality by education and income increased over time e.g. poor females had a 40% higher CRC mortality than rich females in 1996-99, compared with no difference in 1981-84 (p for trend 0.04). In men, increases in inequality were seen by income but not education.

Conclusion: The observed ethnic trends probably reflect differential trends in exposure to etiological risk factors. Social inequalities in colorectal cancer mortality appear to be increasing.

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New Zealand has a high rate of colorectal cancer (CRC) incidence and mortality.¹ In New Zealand, overall CRC incidence increased from the 1940s to the 1980s, but stabilised in the 1990s consistent with an observed decrease in CRC risk in younger cohorts.² CRC mortality, in contrast, has been declining for both males and females since 1975.³

New Zealand, like most developed countries, has reasonably well described longitudinal CRC mortality trends by sex and age. However, despite their importance in determining cancer incidence and mortality, the monitoring of differences by ethnic and socio-economic groups is not as accurate or extensive. Available international and local cross-sectional evidence suggests there are disparities in CRC mortality by ethnic and socio-economic groups.³⁻⁸ Existing time trend data suggest that trends in CRC mortality by socio-economic position (SEP) and ethnicity are not only dynamic, but may be different from overall CRC mortality patterns.^{4,9-12}

However, there are significant problems with the reliability of these data. The problems in ascertaining mortality trends by ethnicity and SEP, while well described in New Zealand, are not confined to this country.¹³⁻¹⁵ Trends by ethnicity are likely to be inaccurate in New Zealand because, first, Māori (the Indigenous people) and Pacific people (migrants or descendents of migrants from the Pacific islands) have tended to be

under-counted in mortality figures. Second, ethnicity has not been recorded in the same way in Census and mortality data, resulting in a numerator-denominator bias when it comes to calculating mortality rates. Third, the definitions of ethnicity have changed over time.¹⁶ These factors have distorted measures of inequality not only at one point in time, but also trends over time within ethnic groups.^{17,18} Trends by SEP are also likely to be inaccurate due the differing measures of SEP used over time and changing numerator-denominator bias (particularly around measures of occupational class).¹⁹

This paper uses data from the New Zealand Census Mortality Study (NZCMS), which linked Census and mortality data, allowing an accurate determination of trends in colorectal cancer by both ethnic and socio-economic factors. The objective of this paper is to accurately measure trends in ethnic and socio-economic CRC mortality in New Zealand between 1981 and 1999. In so doing, it will not only generate useful information for New Zealand, but also be of international significance as this work can, accurately, elucidate the dynamic nature of the social causes of disease.

Methods

Linkage of Census and mortality data

As described previously in this journal, record linkage was conducted between Census records and mortality data.²⁰ Briefly,

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mortality data grouped into four periods (1981-84, 1986-89, 1991-94 and 1996-99) were anonymously and probabilistically linked to the preceding Census (1981, 1986, 1991, 1996).²⁰ (That is, we used sex, date of birth, ethnicity, country of birth and, most importantly, geocoded address data as matching variables within a probabilistic record linkage process.) The percentage of eligible mortality records linked to a Census record ranged from 71% in the 1981-84 cohort to 78% in the 1996-99 cohort. More than 96% of links were estimated to be true links.²¹

Ethnic trends

While having linked Census and mortality data would make it possible to calculate ethnic mortality rates directly from the linked Census-mortality data, we used an alternative method that involved all CRC deaths from 1980-99 (not just deaths in each of the three years of mortality data linked to each of the Censuses). This increased the power of the analyses. But we still needed to use the linked Census-mortality data to determine how much undercounting of Māori and Pacific deaths occurred during each of the four periods during the 1980s and 1990s, and then use these correction ratios to correct the complete routine mortality dataset. The method used to calculate the adjustment factors is described in detail elsewhere.¹⁸ Briefly, we determined the number of Māori and Pacific deaths according to the 'gold-standard' Census data ethnicity variable, and divided this by the number identified by mortality data. For example, if 300 decedents self-identified as Māori at the Census before their death, but only 200 of them were identified as Māori on the mortality file, we have to correct the counts of Māori deaths from routine mortality data by multiplying by 1.5 (i.e., the correction factor or ratio of 300 to 200).

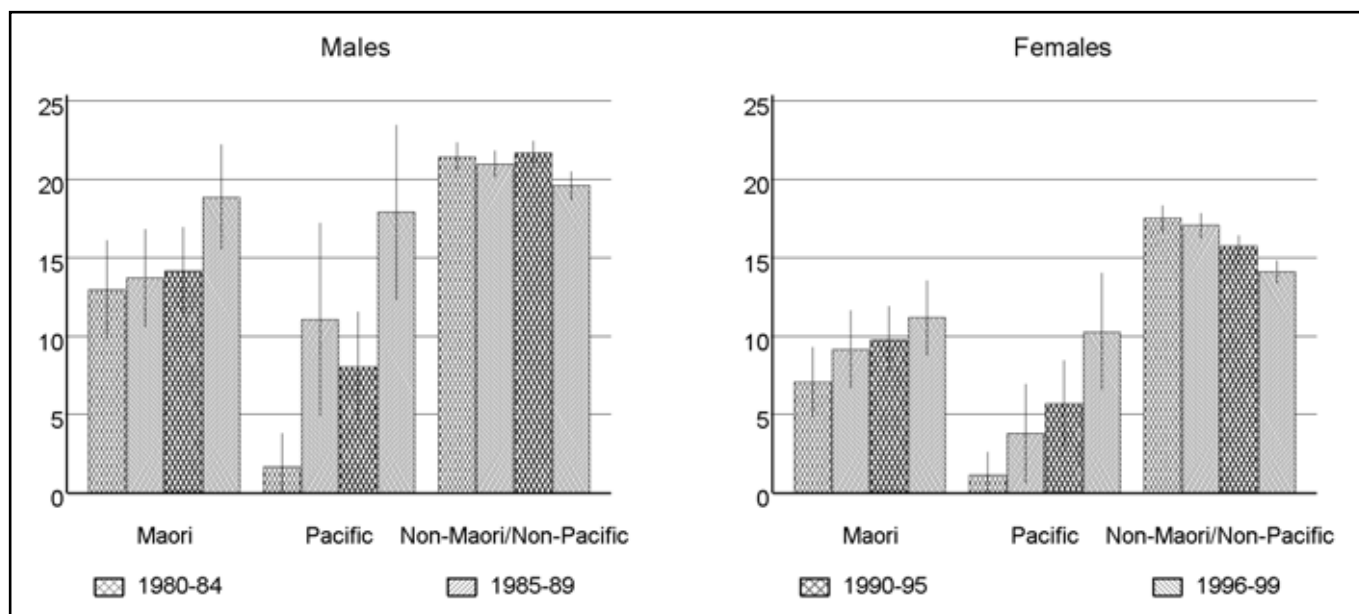
The routine mortality data was grouped into four periods: 1980-84, 1985-89, 1990-1995, and 1996-99. The number of deaths in these periods were corrected for under-counting (Māori and

Pacific) or over-counting (non-Māori non-Pacific) as described above, by strata of age and sex. Sex-specific, age-standardised mortality rates (and 95% confidence intervals) for each ethnic group and time period were calculated,²² using 1981, 1986, 1991 and 1996 Census data as the denominator and the WHO standard population as the standard population.²³

Note that the third period (1980-1985) is of six years' duration and the fourth period (1996-99) is of four years' duration to reflect the major change in the collection of ethnicity in mortality data that occurred in September 1995. (Prior to September 1995, each decedent could be identified only as either Māori or Pacific or non-Māori/non-Pacific, based on blood quantum. After this date, a question equivalent to the 1996 Census ethnicity question was incorporated into mortality data, allowing multiple ethnic identification.)

This paper uses the prioritised concept of ethnicity. In the 'prioritised' concept, ethnicity was assigned as Māori if one of the up to three possible self-identified ethnicity responses on the 1986, 1991 or 1996 Census was Māori or, in 1981, those who recorded any degree of Māori ethnic origin. For those not allocated as Māori, the prioritised ethnic group was assigned as Pacific if one of the self-identified ethnic groups was Pacific or, in 1981, any degree of Pacific ethnic origin was noted. The remaining records were assigned as non-Māori non-Pacific, of which the majority were of NZ European ethnicity. The use of prioritised ethnicity is a common practice in New Zealand epidemiological studies, because it means that each individual is counted just once. For example, analyses of all people identifying at least one ethnic group as Māori, all people identifying at least one ethnic group as Pacific, and so on, will lead to many people being included in at least two categories of the ethnic group variable. Although it is known that, for example, people only reporting one ethnic group (i.e. sole Māori) tended to have a lower socio-economic position

Figure 1: Colorectal cancer mortality rates (per 100,000) by prioritised ethnic group among 1-74 year-olds (using NZCMS adjusters applied to routine data).



and higher mortality rates, analyses published elsewhere demonstrated that the interpretation of trends over time in mortality (i.e. the purpose of this paper) does not substantially vary between 'sole' or 'prioritised' time series.²⁴

Socio-economic trends

In the absence of reliable socio-economic factors on mortality data, we were obliged to directly use the actual linked Census-mortality cohort data to calculate socio-economic trends (as compared with the correction methodology above for ethnic trends).

All individuals aged 25-77 at follow-up (either three years after Census or at death within those three years) with income or education information were analysed. Information regarding education was obtained from Census forms of individuals aged 25-77, although no information was available for 5-11% of individuals. An intercensal classification of educational qualifications was used to standardise educational categories across Censuses.²⁵ Individuals were then divided into groups of no qualifications, school qualifications and post-school qualifications. Income was summed at a household level for adults in the household (ages 25-77) and equivalised for household size using the Jensen equivalisation index.²⁶ The equivalisation process adjusts for the number of adults and children in each household, recognising that larger families require more income to have the same standard of living. Incomes were consumer price index adjusted to 1996, then divided into three roughly equivalent-sized income groups. The household income variable was unable to be calculated for between 15-21% of individuals due to one or more adults in the household being absent on Census night or declining to report an income.

Mortality rates (and 95% confidence intervals) were calculated after direct standardisation of the cohorts to the age (and ethnic) structure of the 1991 NZCMS cohort.²² Weighted data were used in these calculations, to allow for variation in the proportion of mortality records linked to a Census record by strata of age, rurality, ethnicity and small area deprivation.²⁵ For example, if there were 20 out of 30 eligible mortality records for 45-64 year-old Māori males living in moderately deprived areas in the north of New Zealand, then each of the 20 linked records were assigned a weight of 1.5 (i.e. 30/20), and likewise for hundreds of other strata.²⁵ Sensitivity analyses published elsewhere suggest the weights are

reliable at adjusting for any residual linkage bias when determining the mortality differences by socio-economic factors.²⁵

To overcome the problem of changing group size over time, the relative and slope index of inequality (RII and SII, respectively) were used to calculate population inequality in relative and absolute terms, respectively, in each cohort.¹⁴ The RII is equivalent to a relative risk measure for the poorest compared with the richest (or people with lowest compared with highest educational qualification), but utilises mortality rates across all levels of income (and education) using regression. The SII is the absolute difference in mortality rates between the two extreme ends of the socio-economic continuum. Mortality rates by quintile of income, and five levels of education, were used in the calculation of SIIs and RIIs.

Results

Figure 1 and Table 1 illustrate the changes in colorectal cancer by ethnic group in New Zealand. In the earliest period, Māori and Pacific males had CRC mortality rates that were 39% and 90% lower than non-Māori/non-Pacific males; however, there was an increase in CRC mortality of 46% and ninefold for Māori and Pacific males respectively (*p* value for trend 0.15 and 0.08). In contrast, non-Māori/non-Pacific males showed little, if any, change in mortality rates. In 1981-84, Māori and Pacific females had CRC mortality rates 62% and 95% lower than non-Māori/non-Pacific females. By 1996-99, Māori and Pacific females had increases in mortality of 57% and tenfold respectively whereas non-Māori/non-Pacific females had a 29% decline in mortality (all *p* values for trend <0.05).

Figure 2 and Table 2 show CRC mortality rates by education and income. Among females, mortality rates declined in all educational groups between 1981 and 1999, with larger decreases among females with post-school and school qualifications (27% and 25% respectively) compared with those with no qualifications (11%). By income, there were declines in CRC mortality rates in high and low-income females (27% and 18%), but a mortality decline of only 6% in medium income females. Considering the actual socio-economic differences in CRC mortality, there was evidence of an increase in both relative and absolute inequalities among females (see Table 3). For example, by income the RII increased from 1.00 (95% CI 0.70-1.41) in 1981-84 to 1.41 (95% CI 1.0-1.98) in 1996-99 (*p* for trend 0.02). This trend was also

Table 1: Colorectal cancer mortality rates, per 100,000, by ethnic group (and 95% confidence intervals).

	1980-84	1985-89	1990-95	1996-99	<i>p</i> trend
Ethnic group, 1-74 year-olds (using NZCMS adjusters applied to routine data)					
Females					
Māori	7 (5-9)	9 (7-12)	10 (8-12)	11 (9-14)	0.02
Pacific	1 (0-3)	4 (1-7)	6 (3-8)	10 (7-14)	0.01
Non-Māori/non-Pacific	18 (17-19)	17 (16-18)	16 (15-17)	14 (13-15)	0.03
Males					
Māori	13 (10-16)	14 (11-17)	14 (11-17)	19 (16-22)	0.15
Pacific	2 (0-4)	11 (5-17)	8 (5-12)	18 (12-24)	0.08
Non-Māori/non-Pacific	21 (20-22)	21 (20-22)	22 (21-23)	20 (19-21)	0.38

seen by education in females, although there is overlap of the confidence intervals.

For males there was also evidence of socio-economic differences in CRC mortality, with higher CRC mortality among males with lower incomes and educational qualifications. By income, the RII increased from 1.19 (95% CI 0.85-1.67) in 1981-84 to 1.72 (95% CI 1.27-2.33) in 1996-96 (*p* for trend 0.04) (see Table 3). However, there was no clear trend in the magnitude of educational differences in male CRC mortality – although inequalities always existed (see Table 2 and Figure 2).

Discussion

There were startling changes in colorectal cancer mortality rates by ethnicity in New Zealand between 1981 and 1999. Māori and Pacific people both had increasing rates of CRC mortality, dramatically so among Pacific people. By the end of the 1990s, all three ethnic groups had roughly comparable mortality rates. By socio-economic position there was evidence of increasing inequalities in CRC mortality among females by both education and income, and by income among males.

While the linkage of Census and mortality data in New Zealand is a major step forward in our ability to understand mortality trends by ethnicity and socio-economic position, the linkage is not perfect.

Therefore, we have invested considerable effort in developing methods that ensure both calculations of under- (over-) counting of mortality data by ethnicity and analyses directly on the linked cohort data for socio-economic differences mortality are robust. This developmental work, and sensitivity analyses about it, are published in detail elsewhere.^{18,25} Although we cannot say that the results reported in this paper are exactly correct, we are confident that they are close and, more importantly, that the consequent interpretation of trends are reliable.

Variability of trends in CRC mortality by ethnic group within one country has been noted previously, but not as dramatically as those reported here. For example, black Americans showed an increase in CRC mortality from 31/100,000 in 1975 peaking at 38/100,000 in 1990 and then declining to 33/100,000 in 2000, whereas white Americans had consistently declining mortality from 33/100,000 in 1975 to 24/100,000 in 2000.¹¹ More recent US data looking at multiple ethnic groups showed differential rates of decline in CRC mortality over the 1990s between black, Hispanic and non-Hispanic white groups, and (non significant) increases in CRC mortality among American Indians and Alaskan Indigenous people.²⁷

The increase in CRC mortality in Māori and Pacific people in New Zealand is likely to represent an underlying increase in CRC

Figure 2: Age-standardised colorectal cancer mortality rates among 25-77 year-olds 1981-99 (per 100,000) (using analyses directly on linked Census-mortality data).

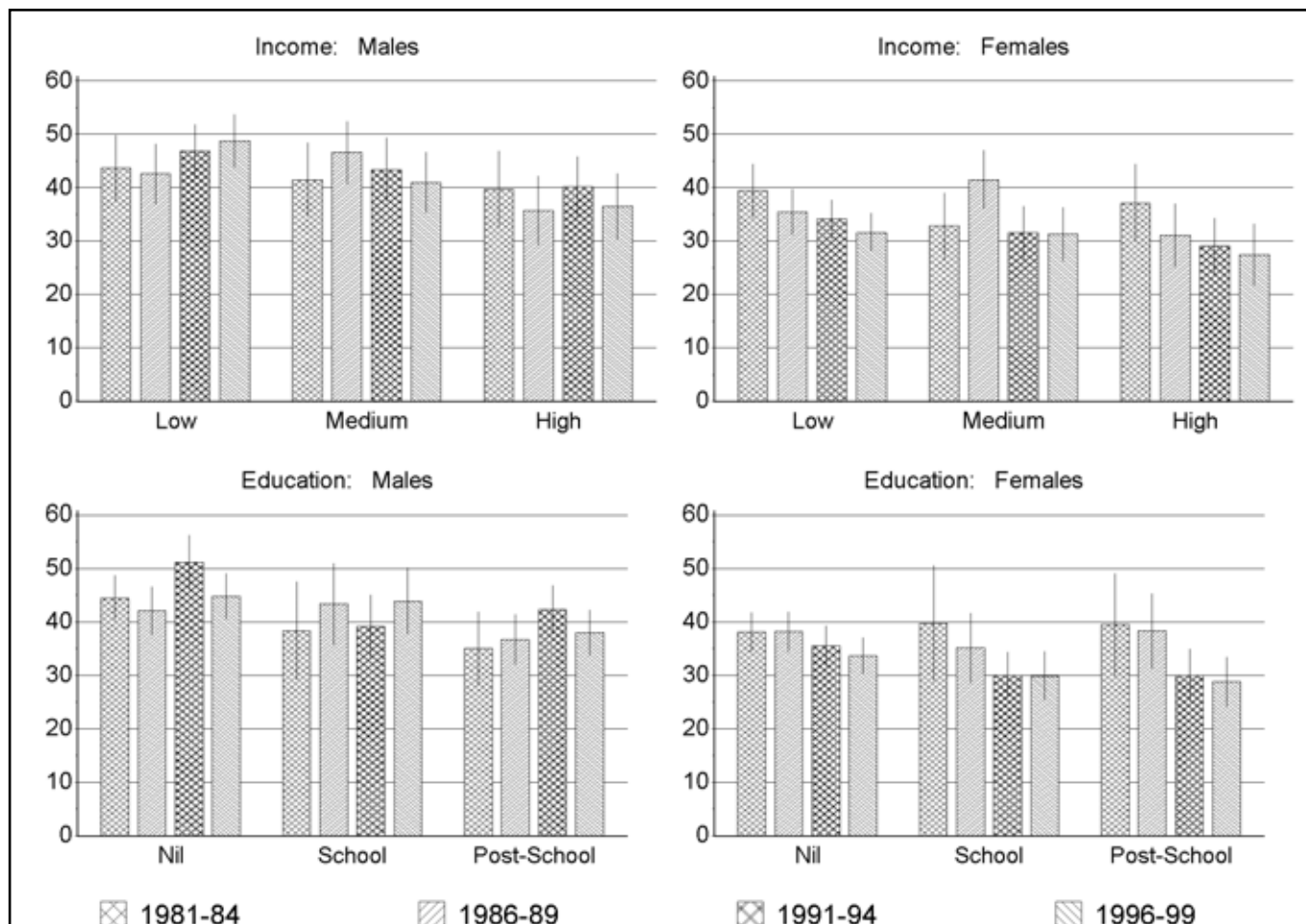


Table 2: Colorectal cancer mortality rates, per 100,000, by socio-economic position (and 95% confidence intervals).

	1981-84	1986-89	1991-94	1996-99	<i>p</i> trend
Income, 25-77 year-olds (using analyses directly on linked Census mortality data)					
Females					
Low	39 (34-44)	35 (31-40)	34 (30-38)	32 (28-35)	0.02
Medium	33 (27-39)	42 (36-47)	32 (27-37)	31 (26-36)	0.53
High	37 (30-43)	29 (24-34)	29 (24-34)	27 (22-33)	0.06
Males					
Low	44 (38-50)	43 (37-48)	47 (42-52)	49 (44-54)	0.10
Medium	42 (35-48)	47 (41-52)	43 (37-49)	41 (35-47)	0.63
High	40 (33-47)	36 (29-42)	40 (34-46)	37 (30-43)	0.76
Education, 25-77 year-olds (using analyses directly on linked Census mortality data)					
Females					
Nil	38 (35-42)	38 (35-42)	36 (32-39)	34 (30-37)	0.05
School	40 (29-51)	35 (29-42)	30 (26-34)	30 (25-34)	0.13
Post-school	40 (30-49)	38 (31-45)	30 (25-35)	29 (24-33)	0.08
Males					
Nil	45 (40-49)	42 (38-47)	51 (46-56)	45 (41-49)	0.70
School	38 (29-48)	43 (36-51)	39 (33-45)	44 (38-50)	0.50
Post-school	35 (28-42)	37 (32-41)	42 (38-47)	38 (34-42)	0.56

incidence. Although more advanced CRC stage at diagnosis among Māori and Pacific people, and worse survival among Māori, have been found in New Zealand,^{28,29} it is unlikely that divergent trends in survival for Māori and non-Māori/non-Pacific could solely (or even mostly) explain the divergent mortality trends observed in this paper, and implausible that worsening survival for Pacific people could explain an approximately tenfold increase in mortality.

There is some evidence from elsewhere supporting an increase in Māori CRC incidence over the 1970s and 1980s.^{29,30} However, the scale of the increase reported is likely to be underestimated due to poor recording of ethnicity data on hospitalisation and cancer registration data.¹⁶ In addition, there is evidence that ethnicity under-reporting in national datasets was inconsistent over time, making trend data extremely suspect.^{17,18} For Pacific people in New Zealand, there is no data on incidence of CRC over time. However, during the 1980s CRC incidence was considerably lower

in Pacific people compared with non-Māori/non-Pacific people in New Zealand.³¹

Risk factors for CRC incidence include smoking, physical inactivity, red meat intake and, possibly, specific cooking methods. While the protective role of fibre, fruit and vegetable and associated micronutrient intake remains controversial, the role of diet overall appears to be important.^{32,33} In the absence of some other constellation of unrecognised risk factors of overwhelming importance, it must be presumed that there has been a change in diet over time among Māori and an even more dramatic change among Pacific people.

Choice of diet is shaped by a constellation of social factors. Migration is one such factor, which may result in changing CRC incidence through altered diet.³⁴⁻³⁶ The three ethnic groups presented in this paper have vastly different migration patterns. Post World War II, massive internal migration of Māori occurred. In 1946, 74% of Māori were rural dwellers, but by 1976 76% of

Table 3: Relative and absolute inequality measures by socio-economic position 25-77 year-olds, 1981-99.

	1981-84	1985-89	1991-94	1996-99	<i>p</i> trend
Education 25-77 year-olds (using analyses directly on linked Census mortality data)					
Females					
RII	0.89 (0.23-3.48)	1.02 (0.56-1.82)	1.24 (0.70-2.20)	1.28 (0.95-1.74)	0.04
SII	-5 (-39-29)	1 (-13-14)	7 (-4-18)	8 (2-13)	0.07
Males					
RII	1.51 (1.26-1.82)	1.33 (0.84-2.11)	1.33 (0.75-2.36)	1.39 (0.94-2.06)	0.64
SII	17 (12-21)	11 (0-22)	13 (-3-28)	14 (4-23)	0.33
Income, 25-77 year-olds (using analyses directly on linked Census mortality data)					
Females					
RII	1.00 (0.70-1.41)	1.13 (0.83-1.52)	1.19 (0.87-1.52)	1.41 (1.0-1.98)	0.02
SII	0 (-15-14)	4 (-8-16)	5 (-4-15)	10 (-1-21)	0.04
Males					
RII	1.19 (0.85-1.67)	1.23 (0.89-1.72)	1.42 (1.08-1.87)	1.72 (1.27-2.33)	0.04
SII	7 (-2-16)	9 (1-17)	15 (3-27)	22 (14-29)	0.02

Māori lived in urban areas, having moved there for employment.³⁷ In contrast, European settlers had become predominantly city dwellers by 1911.³⁸ Employment-related migration of Pacific peoples to New Zealand occurred predominantly in the 1970s, but had largely ceased by 1980.³⁹

There is solid evidence of a change in diet among Pacific people following migration, with an increase in alcohol and tobacco consumption, meat, cereals, dairy and simple sugars.⁴⁰⁻⁴³ It should be noted that these changes are not uniformly towards a greater CRC risk, e.g. increasing fibre. These changes in diet were reflected in increases in body mass index, diabetes prevalence, blood pressure and cholesterol.^{44,45} In contrast, there is no direct evidence of difference in diets between urban and rural New Zealand post-World War II, and temporal data on diet by ethnicity do not allow accurate comparisons on specific dietary risk factor differences to be made.⁴⁶⁻⁴⁸

However, our findings are strongly supportive of the overwhelming importance of environmental factors to CRC incidence. A time lag of approximately 15 years between exposure to CRC risk factors and incidence of CRC has also been noted in other studies.³⁵ The rapid and sharp increase in Pacific CRC mortality in the 1980s and 1990s following peak migration in the 1970s is highly consistent with this hypothesised time lag. The number of Pacific CRC deaths was too sparse to disaggregate for age, period and cohort analyses, so we were unable to examine the effects of age at migration.

CRC mortality trends by socio-economic position in New Zealand suggest emergent and increasing socio-economic inequalities. There is some evidence from the United States that inequalities in CRC mortality have reversed over time: in the 1950s, CRC mortality was higher in more affluent counties, but by 1998 CRC mortality was higher in more deprived counties.¹⁰ Data from the UK similarly find that socio-economic gradients in both rectal and colon cancer changed over the last half of the 20th century. For rectal cancer, a gradient of increasing mortality with decreasing social class emerged after World War II in males, and in colon cancer the gradient of higher mortality seen in higher social classes post-World War II seems to have diminished slightly in later periods.^{4,9} Our study is both consistent with this prior international evidence of a changing socio-economic patterning of CRC mortality over time, and also strengthens this evidence base as we used individual-level socio-economic data for both education and income.

Whether there are also socio-economic gradients in CRC incidence in New Zealand is unclear. Area-level data from 1996/97 in New Zealand suggest that incidence is lower for males living in less deprived neighbourhoods, but no relationship was seen in females.³ Therefore, we must consider differential survival from CRC as a possible explanation for the (emerging) socio-economic gradient in CRC mortality in New Zealand. Socio-economic differences in survival have been found in other countries,^{49,50} and lower socio-economic groups in New Zealand have more unmet need in terms of health care services generally.⁵¹ One theory to understand these survival differences is the inverse equity theory,

which suggests that as mortality declines due to technological advances, relative inequality will increase as individuals with higher SEP claim the benefits of new technologies or interventions prior to those with lower SEP.⁵² As CRC treatments steadily improve over time, it is not implausible that higher socio-economic groups are initially more advantaged.

The finding of no changes in educational inequalities over time among males (but still widening income inequalities) is not consistent with the above generalisation of widening socio-economic gaps in CRC mortality. Why might that be? First, it may just be a null finding for males by education due to chance. Second, it is possible that the trend of widening gaps by income among males was due to increasing health selection over time. That is, the negative impact of being diagnosed with CRC on one's household income increased over time, thereby spuriously causing an apparent trend of increasing income inequalities in CRC over time. However, the removal of the first six months of follow-up (when health selection effects would be maximal) did not alter the results, although this may be too short a period to be able to entirely eliminate the effects of health selection. Also, while it seems likely that health selection does induce some association of income with mortality for chronic conditions such as cancer and cardiovascular disease in the NZCMS,⁵³ we do not have strong evidence that the amount of health selection varies over time.

In conclusion, CRC mortality trends during the 1980s and 1990s vary by ethnicity and socio-economic position in New Zealand. Changing CRC incidence is almost certainly the main explanation for varying mortality trends by ethnicity – although trends in stage at diagnosis and survival by ethnicity may also contribute to varying trends in CRC mortality by ethnicity. The less pronounced variation in CRC mortality trends by socio-economic position, and associated widening of socio-economic inequalities in CRC mortality, may be explained by more even contributions of incidence, stage at presentation and survival. These trends need to be monitored and researched further, particularly if screening for colorectal cancer is implemented which – unless implemented carefully – is likely to increase social and ethnic inequalities in colorectal cancer mortality.

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Ethical statement

The program of work of the New Zealand Census Mortality Study has approval from the Wellington Ethics Committee (Reference number 98/7).

Summary statistics New Zealand security statement

The New Zealand Census Mortality Study (NZCMS) is a study of the relationship between socio-economic factors and mortality in New Zealand, based on the integration of anonymised population Census data from Statistics New Zealand and mortality data from the New Zealand Health Information Service. The project was approved by Statistics New Zealand as a Data Laboratory project under the Microdata Access Protocols in 1997. The datasets created by the integration process are covered by the Statistics Act and can be used for statistical purposes only. Only approved researchers who have signed Statistics New Zealand's declaration of secrecy can access the integrated data in the Data Laboratory. (A full security statement is in a technical report at <http://www.wnmeds.ac.nz/nzcms-info.html>) For further information about confidentiality matters in regard to this study please contact Statistics New Zealand.

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