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Varying evolution of the New Zealand lung cancer epidemic by ethnicity and socioeconomic position (1981–1999)

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Abstract

Aim Tobacco use and resultant health effects have been described as an epidemic that progresses through the population. This paper aims to describe and explain trends in lung cancer mortality by ethnicity and socioeconomic position in New Zealand between 1981–1999.

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 lung mortality by income and education. For ethnicity, we used unlinked census and mortality data—but with correction factors applied for undercounting of Maori and Pacific deaths.

Results Lung cancer mortality decreased in males and increased in females over the time period studied. In males, socioeconomic inequality persisted despite a decline in mortality in all socioeconomic groups. In females, a disproportionate increase in the mortality of lower socioeconomic groups compared to higher socioeconomic groups resulted in an increase in inequality. Divergent trends by ethnic group resulted in an increase in ethnic inequalities between 1981 and 1996 in both males and females.

Conclusions There are significant and growing ethnic and socioeconomic inequalities in lung cancer mortality in New Zealand. In the current absence of concerted public health action these inequalities will probably widen in future decades.

Background

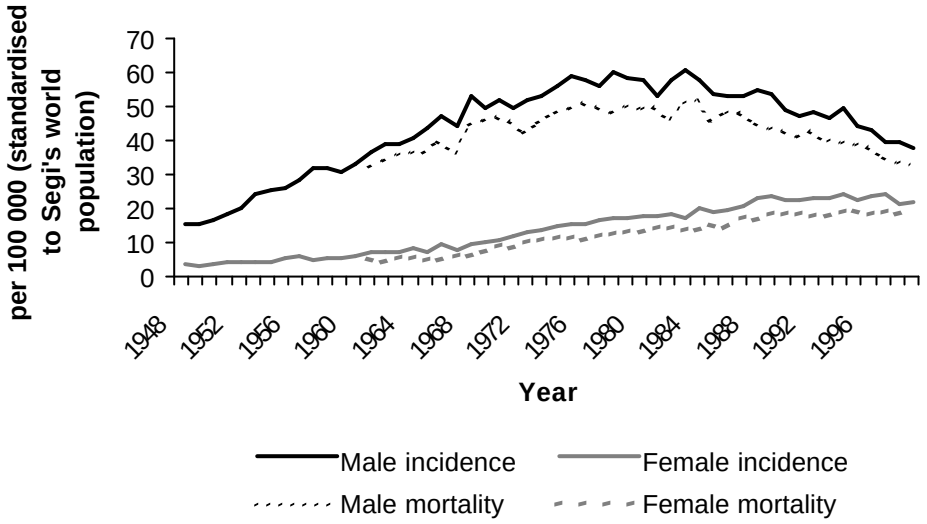
New Zealand has relatively high lung cancer incidence and mortality, particularly among Maori.[1,2] Lung cancer incidence and mortality trends largely reflect historical cigarette use and tobacco control efforts—although the role of occupational exposures is probably underestimated.[3]

In 1994, Lopez, using historical data from a number of developed countries, proposed a model describing trends in tobacco-use and the resultant health effects. He showed that tobacco-use tends to progress through the population in a predictable way, like an ‘epidemic’, which differs by sex and, possibly, socioeconomic group. He noted that males tend to take up smoking initially and suffer the health consequences first, while females take up smoking later, and at a lower rate than males, resulting in fewer health consequences.[4]

The Lopez model also describes the transition in population distribution of tobacco use from initially being equally distributed among socioeconomic groups (or possibly concentrated in the higher socioeconomic groups), to being concentrated among the lower socioeconomic groups as the higher socioeconomic groups abandon smoking.[4]

Temporal trends in lung cancer incidence and mortality in New Zealand demonstrate this epidemic pattern by sex (see Figure 1). These patterns by sex are similar to trends seen in seen in Australia, the UK, Ireland, and the USA.[5–7]

Figure 1 Age-standardised lung cancer incidence and mortality New Zealand (all ages; 1948–1999)



Source: New Zealand Health Information Service

According to the Lopez model, one would anticipate that lung cancer mortality would evolve from being an 'egalitarian' cause of death to one that is progressively confined to the lower socioeconomic groups over time (i.e. an increase in both relative and absolute inequalities).[8]

Data on lung cancer mortality by socioeconomic position (SEP) is not available in New Zealand prior to the 1970s. Data available for males show higher rates of lung cancer mortality in lower socioeconomic groups in 1974–78, 1984–87, and 1996–97; and for females in 1996–97.[9–11] Unfortunately, these studies do not allow us to evaluate whether inequalities are increasing or decreasing over time, as different measures of socioeconomic position were used in each study.

Ethnic disparities in lung cancer are not described in the Lopez model. Given the importance of ethnicity on health, and the diverse ethnic makeup of New Zealand's population, it is important to explore the effects of the lung cancer epidemic on the different ethnic groups in New Zealand. Lung cancer incidence was higher for Maori compared with non-Maori in 1996–97,[11] and incidence was higher in Pacific people compared to non-Maori/non-Pacific in the 1980s.[12]

Systematic undercounting of Maori and Pacific people in routine cancer incidence and mortality statistics means that these data are likely to have underestimated the excess burden of lung cancer among Maori and Pacific people.[13,14]

The New Zealand Census Mortality Study, through the anonymous record linkage of census and mortality records, allows an accurate description of ethnic and socioeconomic trends in lung cancer mortality in New Zealand. To inform tobacco policy in New Zealand, these trends (particularly the resultant future projections) need to be described. We hypothesise that, given the current epidemic staging; socioeconomic inequalities in lung cancer will have increased for females between 1981 and 1999. The tobacco epidemic peaked earlier in men than in women, hence trends for males are less easy to predict. We also hypothesise that there are likely to be divergent trends in lung cancer mortality between ethnic groups.

Methods

Background—The methodology of the NZCMS is discussed in detail in other publications.[15–17] A brief summary of methods relevant to this paper is included. We used direct analyses on NZCMS data to determine socioeconomic trends. For ethnic trends, we applied adjustment ratios (derived from the NZCMS) to routine mortality and census data in order to compensate for undercounting of deaths in some ethnic groups in historical mortality data.

Data—Four population cohorts were constructed, by anonymously and probabilistically linking individual census and mortality records over four time periods from 1981–1996. New Zealand Health Information Service (NZHIS) provided mortality data for 0–74 year olds for the periods 1981–84,1986–89, 1991–94, and 1996–99.

The percentage of records linked ranged from 71–78%, with positive predictive value of the linkage in excess of 96%.[15,16] Linkage varied by age, rurality, ethnicity, and small-area deprivation so linkage weights were applied to overcome any potential misclassification bias of the mortality outcome caused by differential success of linkage.[18] Deaths from lung cancer (ICD 162) were identified from the ICD code for underlying cause of death from the mortality data.

Socioeconomic trends—All individuals aged 25–77 at follow-up (either 3 years after census or at death within those 3 years) with valid income or education information were included in analyses. Information regarding education was obtained from individual census forms, however this data was missing for between 2–11% of census respondents.

An intercensal classification of educational qualifications was used to harmonise educational categories across censuses.[16] Individuals were then divided into three groups: those with no qualifications, school qualifications, and post-school qualifications. Income was collated at a household level for individuals aged 25–77 and equivalised for household size using the Jensen equivalisation index.[19]

Incomes were consumer price index adjusted for inflation to 1996 dollars, then divided into three income groups with cut points of low (<$26 010), medium (>$26 010 to <$43 020), and high (>$43 020). 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 [CI]) were calculated with direct standardisation to the age and ethnic structure of the 1991 cohort.[20] 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.[21]

The RII is a regression based equivalent to a relative risk measure for the poorest compared to the richest (or people with lowest compared to highest educational qualification), but utilises mortality rates across all levels of income (and education). The SII is the absolute difference in mortality rates between the two extreme ends of the socioeconomic continuum.

Ethnic trends—Mortality data was provided by the New Zealand Health Information Services (NZHIS) for the years 1980–1999 by year of registration of death. Years were grouped into four periods: 1980–84, 1985–89, 1990–1995, and 1996–99. For each of the four periods, 1981, 1986, 1991, and 1996 census data by strata of sex, age, and ethnicity were used as denominator data in the calculation of mortality rates.

To adjust for the undercounting of Maori and Pacific deaths on mortality records, adjustment factors were used to estimate correct mortality counts. The method used to estimate the adjustment factors is described elsewhere.[14] These corrected mortality counts and the census population counts were then

used to calculate direct age-standardised mortality rates (and 95% confidence intervals),[20] using the WHO standard population as the standard population.[22]

This paper uses the prioritised concept of ethnicity. In the 'prioritised' concept, ethnicity was assigned as Maori if one of the up to three possible self-identified ethnicity responses on the 1986, 1991, or 1996 censuses was Maori or, in 1981, those who recorded any degree of Maori ethnic origin.

For those not allocated as Maori, 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-Maori non-Pacific, of whom the majority were of NZ European ethnicity.

Results

Socioeconomic trends

Males—Between 1981 and 1999, a decline in lung cancer mortality in all education and income groups was observed among males. The rate of decline differed by socioeconomic group, with the greatest decline being seen in the high-income group (52%, p for trend 0.04) and the least in the post-school education group (12%, p for trend 0.23) (See Table 1 and Figure 2). Male mortality remained higher than female mortality despite these substantial declines.

At all points in time there was a socioeconomic gradient in male lung cancer mortality. That is, males in lower education and income groups had higher mortality than those in higher income and education groups. For example, the RII relative risk-type measure for education in 1981–84 was 2.30 (95% CI: 1.50–3.53), and the absolute difference counterpart (the SII) was 66 per 100 000 (95% CI: 38–94). There was some evidence of increasing relative inequality by income (i.e. RII increased from 1.80 in 1981–84 to 4.54 in 1996–99; p for trend 0.15), but little evidence of changing relative inequality by education. There was no consistent trend towards increasing or decreasing absolute inequalities by either income or education (see Table 2).

Females—Lung cancer mortality trends diverged between the different socioeconomic groups from 1981 to 1999. The low-income group had a 70% increase in mortality from 27/100 000 to 46/100 000 (p for trend 0.01); and similarly, mortality in the no qualifications group increased from 29/100 000 in 1981 to 48/100 000 in 1999, a 66% increase (p for trend 0.02). The medium and high SEP groups showed no significant change in mortality rates, although there was some indication that mortality in high income groups may be falling over time (see Table 1 and Figure 2).

Table 1 Lung cancer mortality rates, per 100,000 population, by socioeconomic position (and 95% confidence intervals)

		1981–84	1986–89	1991–94	1996–99	P trend
Income, 25–77 year olds *(using analyses directly on linked census-mortality data)*						
Females	Low	27 (23–32)	36 (32–40)	40 (36–45)	46 (42–50)	0.01
	Medium	29 (23–35)	31 (26–36)	32 (26–37)	31 (26–36)	0.25
	High	27 (20–34)	24 (18–30)	25 (19–31)	21 (16–26)	0.10
Males	Low	102 (93–112)	102 (93–110)	87 (81–94)	79 (73–86)	0.03
	Medium	82 (73–92)	75 (68–82)	65 (58–73)	59 (52–66)	<0.01
	High	71 (61–81)	50 (43–58)	49 (41–58)	34 (28–40)	0.04
Education, 25–77 year olds *(using analyses directly on linked census-mortality data)*						
Females	Nil	29 (26–33)	34 (31–38)	44 (40–49)	48 (44–52)	0.02
	School	23 (15–31)	37 (30–44)	30 (25–35)	33 (28–38)	0.52
	Post-School	16 (10–23)	21 (15–26)	23 (18–29)	22 (18–26)	0.19
Males	Nil	98 (92–104)	95 (88–101)	84 (77–90)	78 (73–84)	0.01
	School	77 (62–91)	67 (58–77)	70 (62–78)	54 (47–61)	0.14
	Post-School	57 (46–68)	67 (59–74)	61 (54–67)	50 (45–55)	0.23

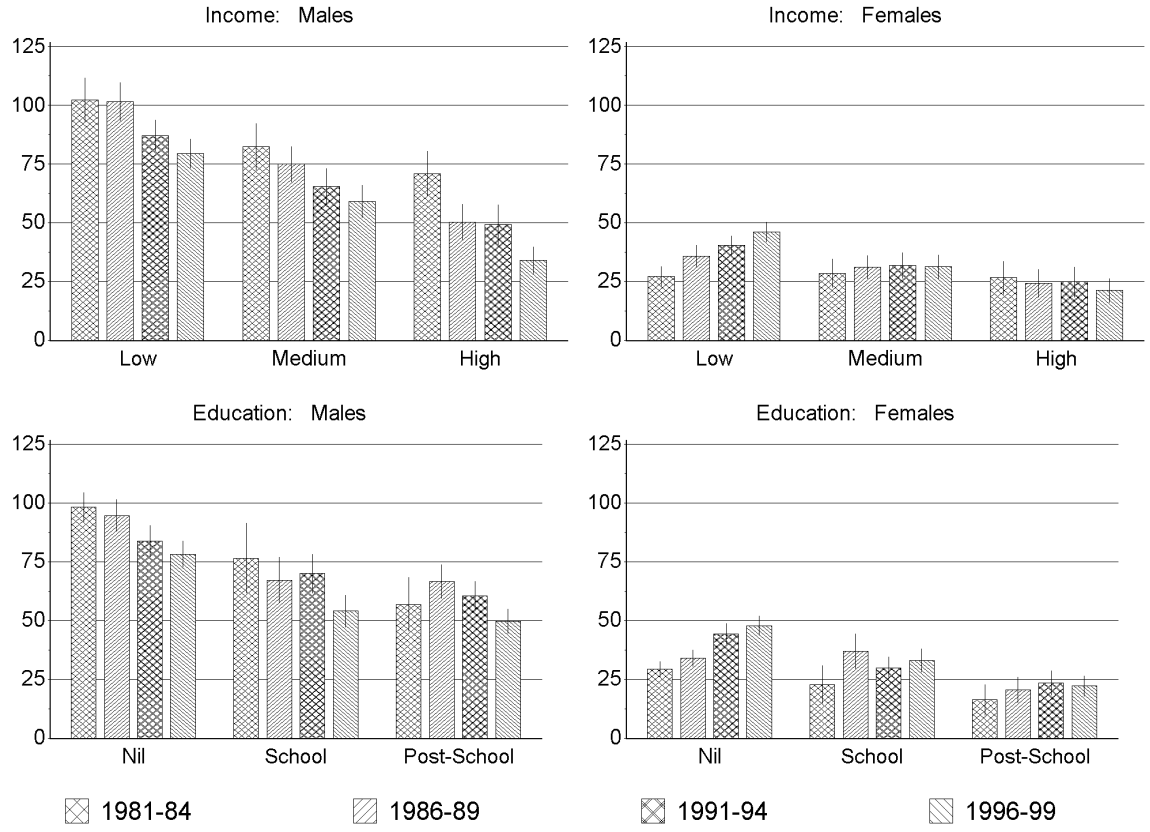
Table 2 Relative and absolute inequality measures by socioeconomic position (25–77 year olds; 1981–1999)

		1981–84	1985–89	1991–94	1996–99	P trend
Income, 25–77 year olds ***(using analyses directly on linked census-mortality data)***						
Females	RII	1.14 (0.74–1.76)	1.83 (1.25–2.68)	2.09 (1.37–3.19)	4.09 (2.51–6.67)	0.03
	SII	4 (-9–16)	18 (9–26)	23 (20–26)	40 (20–60)	0.06
Males	RII	1.80 (1.39–2.33)	3.36 (2.44–4.61)	2.72 (1.97–3.74)	4.54 (2.99–6.89)	0.15
	SII	47 (30–64)	80 (68–91)	60 (47–74)	69 (53–85)	0.82
Education 25–77 year olds ***(using analyses directly on linked census-mortality data)***						
Females	RII	2.53 (1.42–4.52)	2.03 (1.35–3.05)	3.18 (2.08–4.86)	4.15 (2.53–6.80)	0.18
	SII	22 (10–34)	21 (1–40)	34 (24–44)	42 (34–49)	0.03
Males	RII	2.30 (1.50–3.53)	1.97 (1.55–2.50)	1.99 (1.55–2.56)	2.72 (2.11–3.52)	0.42
	SII	66 (38–94)	51 (20–82)	45 (28–62)	54 (21–87)	0.29

Table 3 Lung cancer mortality rates, per 100,000 population, by ethnic group (and 95% confidence intervals)

		1980–84	1985–89	1990–95	1996–99	P trend
Ethnic group, 1–74 year olds *(using NZCMS adjusters applied to routine data)*						
Females	Maori	49 (43–55)	54 (48–60)	60 (54–65)	69 (63–75)	0.01
	Pacific	5 (1–9)	18 (11–25)	14 (10–19)	20 (15–26)	0.10
	Non-Maori/non-Pacific	12 (11–13)	14 (13–15)	15 (14–16)	14 (13–15)	0.22
Males	Maori	84 (76–92)	76 (69–84)	87 (80–94)	86 (79–93)	0.54
	Pacific	55 (38–72)	56 (43–69)	59 (49–69)	64 (53–75)	0.05
	Non-Maori/non-Pacific	41 (39–42)	36 (35–38)	32 (31–33)	25 (24–26)	0.01

Figure 2 Age standardised lung cancer mortality rates among 25–77 year olds 1981–1999 (per 100 000) (using analyses directly on linked census-mortality data).



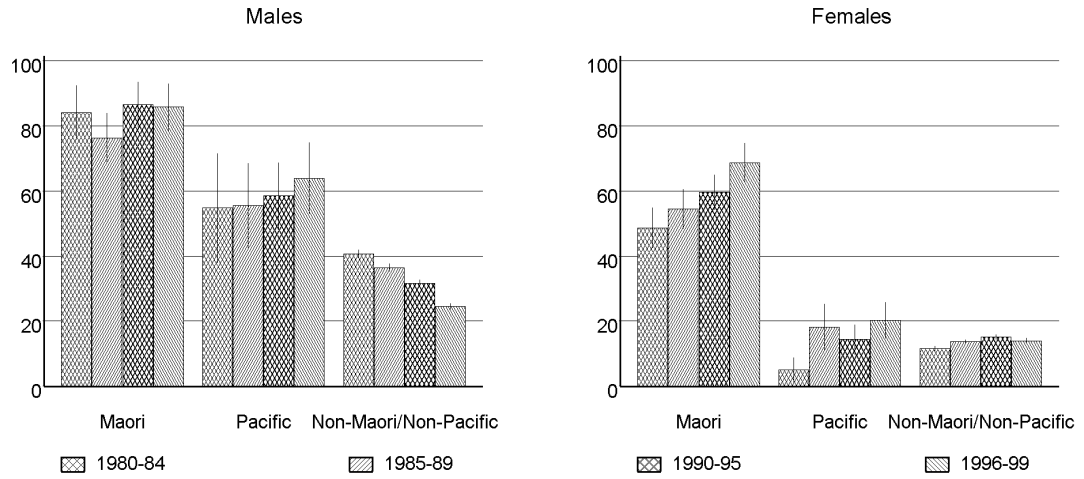
The divergent trends in mortality rates in the socioeconomic groups in females are reflected in the population measures of inequality (see Table 2). By income, there was little relative inequality in the 1981 cohort, RII 1.14 (95% CI: 0.74–1.76); but by 1999, the RII had increased to 4.09 (95% CI: 2.51–6.67) (p for trend=0.03). Absolute inequality increased by income from 4 per 100,000 (95% CI: -9–16) to 40 per 100 000 (95% CI: 20–60) (p for trend=0.06). Relative and absolute inequality also increased by education.

Ethnic trends

Males—Maori males had no decline in lung cancer mortality between 1980 and 1999, but there was a 16% increase in Pacific male mortality and, by contrast, a 24% decline in mortality for non-Maori/non-Pacific males (see Figure 3 and Table 3).

As a result of these different trends, ethnic inequalities in lung cancer increased over the time period studied with Maori men being 3.50 times (95% CI: 3.19–3.84) more likely to die of lung cancer in 1999 compared to 2.07 times (95% CI: 1.87–2.29) in 1981. Pacific men were 1.35 times (95% CI: 0.99–1.83) more likely to die in 1981; but by 1999, this had increased to 2.61 times (95% CI: 2.19–3.10).

Figure 3 Lung cancer mortality rates (per 100 000) by prioritised ethnic group among 1–74 year olds (using NZCMS adjusters applied to routine data)



Females—Non-Maori/non-Pacific females had no change in mortality between 1980–1999 from 12/100,000 to 14/100,000. Pacific female lung cancer mortality was initially the lowest of all ethnic groups at 5/100 000 in 1981, but increased to 20/100 000 by 1999. Lung cancer mortality in Maori females was already about four times higher than non-Maori/non-Pacific females in 1981, and subsequently increased 41% over the time period, from 49/100 000 to 69/100 000 (p trend=0.01). By 1996, Maori females were 4.92 (95% CI: 4.45–5.45) times more likely to die of lung cancer than non-Maori/non-Pacific females (see Table 3).

Discussion

This study shows that socioeconomic and ethnic *inequalities* in lung cancer mortality remained static or increased in New Zealand from 1981 to 1999. While lung cancer mortality declined in males, there was no decrease in socioeconomic inequalities, and there was a substantial increase in ethnic inequalities. For females, there was not only an increase in overall mortality, but also an increase in both ethnic and socioeconomic inequalities.

Overall trends in lung cancer incidence and mortality suggest that New Zealand is in Stage 4 of the tobacco epidemic,[4] which along with Ireland and UK is among the most advanced in the world.[6] During Stage 4, smoking prevalence in both sexes declines, as does male lung cancer mortality, while female lung cancer rapidly rises to a peak and then starts to wane. Findings around inequalities are of interest both domestically (in order to plan local services) and internationally as a guide to what may be anticipated if action to avoid inequalities is not taken.

Socioeconomic Trends

This study shows that, despite the peak in the male lung cancer epidemic 20 years ago and decreases in mortality rates in all socioeconomic groups, inequality has not reduced. Similar findings have been noted in the USA, UK, and Australia where relative and absolute inequality do not appear to have decreased.[23–25] In contrast, findings in Canada show that relative and absolute inequality have decreased among males since the epidemic peaked.[26]

Interestingly, there was no evidence of the epidemic in Canada being staged by socioeconomic position as lung cancer mortality in all SEP groups (measured by area average income) peaked at the same time. This is in contrast to findings in the UK and US.[23,24]

In females, relative and absolute inequality has increased despite a slowing of the rate of increase in the lung cancer mortality since the 1990s (rates are forecast to increase slightly during the next decade).[11] The increase in inequality is due to the disproportionate increase in mortality among lower SEP groups. Comparable patterns have been seen in the US, UK, and Australia, but not Canada where only absolute inequality between the SEP groups increased as the epidemic increased to a peak.[23–26]

Changes in lung cancer mortality reflect the historical patterns in cigarette use by socioeconomic position and the staged nature of smoking through the population (although other causes of lung cancer, such as life course deprivation and occupational exposures, are important among lower SEP groups).[27,28]

In New Zealand, population tobacco use has been monitored only since 1976, when socioeconomic patterning of tobacco use was already present in males and females.[29] Subsequent monitoring of these differences shows that, despite an overall decline in smoking prevalence, socioeconomic inequalities in tobacco use have increased in relative terms.[30]

Ethnic trends

The ethnic trends in mortality in New Zealand are extremely concerning. These findings suggest that lung cancer is an increasing source of health inequality between ethnic groups in New Zealand. There is evidence of differential survival from lung cancer by ethnic group, related to stage and, possibly, healthcare differences.[11,31] Nevertheless, because of the high fatality of lung cancer, changes in ethnic inequalities are largely due to changes in underlying incidence.

The increase in Pacific lung cancer mortality is probably due in part to the increasing prevalence of tobacco use in this group following migration to New Zealand in the 1970s[32] (although the lag period suggests that tobacco use may have increased prior to migration). The mortality pattern in Pacific males is particularly interesting given that it is in the opposite direction to other ethnic groups. It suggests that migrant groups may not have the same overall trends in lung cancer as other ethnic groups in the population.

The different lung cancer mortality trends among Maori compared to non-Maori/non-Pacific may reflect Maori being in an earlier stage of the tobacco epidemic. Alternatively, the influence of other factors may make the Lopez model inadequate to describe the effects of tobacco use in Maori.

Exposure to tobacco commenced by the late 19th century among Maori,[33] although we have no data on how it dispersed through the population. However there is some evidence to suggest that smoking prevalence in Maori women has historically been more akin to Maori male smoking prevalence, rather than non-Maori/non-Pacific female tobacco use.[33]

Contemporary data showing the extremely high rates of tobacco use and lung cancer among Maori females, and the persistence of these patterns over time provide further evidence that the Lopez model is insufficient to describe the tobacco epidemic in this group.[1,34–36]

The legacy of colonisation on indigenous people (which has included social marginalisation, cultural alienation, and the disproportionate representation of the colonised population in lower socioeconomic groups) needs to be considered as an explanation for the differing tobacco epidemic in Maori.

Current inequities of tobacco impact on Maori are likely to be exacerbated in the future since ethnic inequalities in tobacco use widened between 1981 and 1999, reflecting the failure of tobacco control efforts at that time to engage sufficiently with Maori.[30] Postulated reasons for this failure include the monocultural nature of anti-smoking messages, financial barriers to smoking cessation, and the uneven impact of tobacco control legislation during this period (for example, the 1990 smokefree environments legislation resulted in differential exposure to second hand smoke in workplaces by ethnicity).[30,37]

On the other hand, recent tobacco-control initiatives (such as the Quit Programme) have been increasingly designed for Maori and low socioeconomic groups, and the recent Smokefree Environment amendments prohibiting smoking in all workplaces and bars and cafes may help to reduce smoking inequalities in the near future.

Where to from here? What can we expect in lung cancer mortality inequalities in the future? Expected patterns of lung cancer mortality and inequalities in the next 20–30 years are described in Table 4. These are based on the epidemic patterns, the known time lag between population tobacco use and changes in lung cancer mortality (20–30 years between population changes in tobacco prevalence and lung cancer mortality changes, and a 30–40 year lag between maximal tobacco prevalence and the peak of the lung cancer epidemic) and available time trend data on tobacco prevalence by ethnicity and SEP in New Zealand.[4,30]

This study suggests that lung cancer inequalities seen in New Zealand by ethnic group and SEP are likely to persist, or increase over time. However these are not inevitable, as mortality risk both at an individual and a population level can be averted or diminished by tobacco cessation, even at a late age.[38] While New Zealand has historically had a relatively comprehensive tobacco control programme (compared to other countries),[39] innovative interventions (such as the Aukati Kai Paipa programme) that are focused on groups with the highest need are now required to reduce inequalities in lung cancer mortality.

Table 4 Predictions for mortality rates and inequalities in lung cancer mortality for the next 20–30 years in New Zealand

	Socioeconomic position		Ethnic group	
	Mortality rates	Inequality	Mortality rates	Inequality
Males	• All income and education groups will continue to decline. • Absolute rates differences between the socioeconomic groups will be preserved.	• Absolute inequality will remain stable • Relative inequality will increase	• Maori should start to decline within the next 5–10 years. • Pacific men will peak within next 10–20 years • nMnP will continue to decrease.	• Absolute and relative inequality will increase until Maori mortality starts to decline • Then absolute inequality will decrease, but relative inequality may continue to increase. • Absolute and relative inequality between Pacific and nMnP men will increase until Pacific mortality peak.
Females	• Lung cancer will decline in high-income group and rate of decline will increase. • Medium income group decline will become more apparent. • Low-income peak will occur and decline will start within next 20 years. • The no education group will have a sustained peak of lung cancer mortality.	• An increase in both absolute and relative inequalities by income will be seen for the next 10–15 years. • By education we expect a sustained increase in relative and absolute inequality as there has been no decrease in smoking prevalence in the no education group between 1981 and 1996.	• Maori will peak within next 15 years and start to decline. • BUT low income Maori group will remain high for a prolonged period. • Pacific will continue to increase to a lower peak than Maori – peak in lung cancer may occur in about 30 years. • nMnP will continue to decline.	• Ethnic inequalities will increase in absolute and relative terms until Maori and Pacific women reach lung cancer epidemic peaks. • Following peaks absolute inequalities will decline but relative in equalities may continue to increase or perhaps to decrease.

nMnP= non-Maori/non-Pacific

Summary Statistics New Zealand Security Statement—The New Zealand Census Mortality Study (NZCMS) is a study of the relationship between socioeconomic 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.htm) For further information about confidentiality matters in regard to this study please contact Statistics New Zealand.

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

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