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Social inequalities or inequities in cancer incidence? Repeated census-cancer cohort studies, New Zealand 1981–1986 to 2001–2004

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Abstract
Background We examine incidence trends for 18 adult cancers, by ethnicity and socioeconomic position in New Zealand.
Methods The 1981 to 2001 censuses were linked to subsequent cancer registrations, giving 47.5 million person-years of follow-up.
Results *Ethnicity:* Pooled over time, differences were marked: Pacific and Māori rates of cervical, endometrial, stomach and pancreatic cancers were 1.5–2.5 times European/Other rates; Māori, Pacific and Asian rates of liver cancer were 5 times European/Other; European/Other rates of colorectal, bladder and brain cancers were 1.5–2 times the rates of other groups and melanoma rates 5–10 times higher; Pacific and Asian kidney cancer rates were half those of Māori and European/Other.
Over time, Māori and Pacific rates of cervical cancer fell faster and Māori rates of colorectal and breast cancer increased faster, than European/Other rates. Male lung cancer rates decreased for European/Other, were stable for Māori and increased for Pacific. Female lung cancer rates increased for all ethnic groups.
Income: Other than lung (rate ratio 1.35 men, 1.56 women), cervical (1.35) and stomach cancer (1.23), differences in incidence by income were modest or absent.
Conclusions Tobacco explains many of the social group trends and differences and constitutes an inequity. Cervical cancer trends are plausibly explained by screening and sexual practices. Faster increases of colorectal and breast cancer among Māori are presumably due to changes in dietary and reproductive behaviour, but the higher Māori breast cancer rate is unexplained.
Ethnic differences in bladder, brain, endometrial and kidney cancer cannot be fully explained.

Keywords Cancer incidence · Inequity · Inequality · Trends · Socioeconomic position · Ethnicity · New Zealand

Introduction

Cancer incidence varies by time, place and person. Within countries, there are documented variations in cancer incidence by social groups such as ethnicity and socioeconomic position [1, 2], including in New Zealand [3]. Differences in cancer incidence between social groups are largely driven by underlying differences in exposure to known (and unknown) risk factors. At least some of these social group differences in cancer incidence can be considered inequitable [4]. Health inequities have been defined as systematic differences in health that are 'unnecessary, avoidable, unfair and unjust' [5] or 'judged to be avoidable by reasonable action' [6] (Panel). Consequently, some social group differences in cancer incidence are not inequities. For example, a higher melanoma rate among white-skinned people is a biological difference between ethnic or racial groups that cannot be called inequitable. There are also some social group differences that cannot be explained by known biological or environmental causes and hence cannot be categorised as inequities. For example, testicular cancer incidence is higher among Māori compared with non-Māori in New Zealand and conversely is lower among

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blacks compared with whites in the United States, with both patterns being unexplained [7]. Finally, cultural norms in behaviour that vary between social groups, for example diet, and lead to differing cancer incidence may be inequities (in part at least) depending on how freedom of choice is judged. For example, New Zealand exports surplus saturated fat in the form of mutton flaps and lard to Pacific Islands which may impact on their risk of some cancers. Thus, a clear assignation of what is a cancer inequity is often difficult and a matter of judgement (Panel).

In this paper, we use linked New Zealand census-cancer data for 1981 to 2004 to explore ethnic and socioeconomic trends in cancer incidence. Specifically, we

- determine which cancers have social group differences and whether differences vary over 1981–2004
- interpret which differences and trends can be (partially) explained by trends in known risk factors or prevention activities and which might be considered *inequities* in cancer incidence
- identify differences and trends that need further understanding and research.

Panel: Judging when inequalities in cancer incidence are inequities

Not all social group differences or inequalities in health, and cancer incidence in particular, can be called *inequities*. Whitehead (1992) defines health inequities as:

'… differences which are *unnecessary* and *avoidable*, but in addition are considered *unfair* and *unjust*. So, in order to describe a certain situation as inequitable the *cause* has to be examined and *judged* to be unfair in the *context* of what is going on in the rest of society.' [Emphases in original] [5]

This means that cancer incidence inequalities whose causation we do not understand cannot be classified as inequities. It also implies that judgement is required in determining what is *unnecessary, avoidable, unfair* and *unjust.* (Subsequent authors have argued that 'unnecessary' and 'avoidable' may not be required in defining health equity [6, 8].) Regarding judging fairness and justice, Whitehead identified seven main determinants of health differences:

1. Natural, biological variation.
2. Health-damaging behaviour if freely chosen (e.g. risky sports).
3. Transient health advantage of one group over another, due to one group adopting healthier practises earlier.
4. Health-damaging behaviour where the choice of lifestyles is severely limited.
5. Exposure to unhealthy, stressful living and working conditions.
6. Inadequate access to essential health and other public services.
7. Natural selection of health-related social mobility, involving the tendency for sick people to move down the social scale.

The first three do not constitute an inequity, whereas 4–6 do when the degree of choice is limited. (The seventh example is unlikely to apply often to cancer incidence.) The issue of 'choice' is central and is often tied back to a fair distribution of opportunities. For example, a Rawlsian perspective identifies underlying inequities in the distribution of 'primary goods', namely the social determinants of health, power, income and the social bases of self-respect [9]. However, health equity is not completely determined by underlying social inequality [10]. Further, as some social inequality is often ethically justified due to competing ethical principles, some health inequalities may be a necessary trade-off with other societal goals [9].

New Zealand provides an interesting context in which to explore the above objectives. It is an ethnically diverse country with four main groups: Māori, the indigenous people who settled via a series of migrations from Polynesia from c.700–1000 AD; those of European origin who commenced migration in the 1800s; people from Pacific Islands who largely migrated post-World War II; and immigrants from Asia, some of whom arrived in 1880s and others as part of a more recent wave commencing in 1986. By the 2006 census, the New Zealand population was just over 4 million, with 14% Māori, 7% Pacific and 9% Asian.

Inequalities between the different ethnic groups in New Zealand have been documented in a number of social domains, including health [11, 12]. Māori tend to have the worst health statistics, followed by Pacific, European and then Asian (although the Asian advantage compared with European appears to be due to healthy migrant effect [13]). Knowledge on *trends* in ethnic and socioeconomic inequalities in cancer incidence in New Zealand is limited. This is largely due to variable recording of ethnicity on cancer registry and census data [14] causing numerator–denominator bias (varying over time) in the routine calculation of cancer incidence rates by ethnicity and a lack of a socioeconomic measure on cancer data that are compatible with census data. The data used here are linked census-cancer registry data, allowing the calculation of cancer incidence since 1981 free of numerator–denominator bias.

Methods

Datasets and linkage

The New Zealand Cancer Registry collected cancer registrations from 1948 to 1994 on a voluntary basis, with high compliance excepting melanoma. The 1993 Cancer Registry Act made notification mandatory for all malignant tumours, except basal and squamous cell carcinomas of the skin.

Five closed cohorts were created by anonymous probabilistic record linkage of the 1981, 1986, 1991, 1996, 2001 censuses to incident cancer(s) until the subsequent census or in the case of the 2001 cohort until 31 December 2004 (the most recent data available). The methods are described in detail elsewhere [15, 16]. Briefly, 73.2% (1981–1986) to 81.7% (2001–2004) of eligible cancer registrations were linked to census data using sex, age, ethnicity, country of birth and date of birth as matching variables and geocodes as blocking variables. We calculated inverse probability of linkage weights for strata based on age, sex, ethnicity, time since census, neighbourhood deprivation and mobility, cancer diagnosis and region. All data used in this paper are weighted, i.e. actual linked census-cancer records are weighted up to be representative of all eligible incident cancers, with the weights adjusting for varying linkage success by the above sociodemographic variables.

Data used in this paper

Data were restricted to adult person-years (25+), for census respondents who were at their usual residence on census night. Observations were censored upon the occurrence of the first cancer, e.g. any cancer for 'first cancer' and first occurrence of breast cancer (i.e. any C53 code). We could not censor for non-cancer mortality (due to privacy concerns) or migration (data not linked to census).

If individuals indicated any/all of Māori, Pacific and/or Asian ethnic affiliation, they were placed in any/all of total Māori, total Pacific and total Asian ethnic groups. The residual people who did not indicate any of the above ethnic affiliations were placed in the non-Māori/Pacific/Asian group (hereafter called European/Other). The 1981 census question was based on ethnic origin (rather than affiliation); in order to be consistent with later census years, we classified someone as Māori if they recorded any fraction as Māori (likewise for Pacific and Asian).

Equivalised household income was calculated by summing personal income for all adults in the household, adjusting for inflation and equivalising for the number of adults and children in the household. Household income was missing if any usually resident adult was absent on census night or any adult refused to provide their personal income. We also analysed cancer incidence by highest educational qualification, but only report pooled rate ratios over time (Fig. 1) as patterns were similar to household income (full results available on request from authors).

We selected cancers that were among the top ten for each sex in each ethnic group when rates were pooled over time (excluding lip/oral which was only elevated among Asian), namely lung (C33–34), female breast (C53),

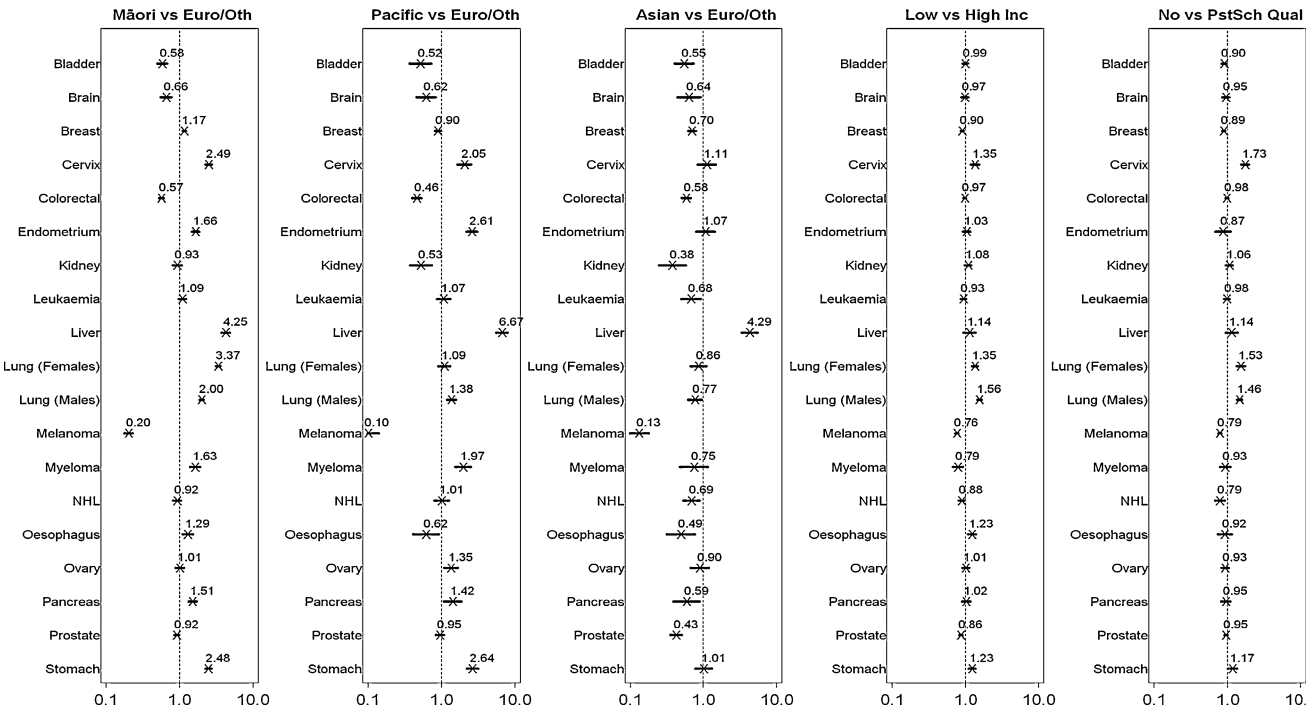

Fig. 1 Forest plot of SRRs (log scale) by cancer for Māori, Pacific and Asian compared with European/Other, low compared with high household income, and nil compared with post-school qualifications, pooled over cohorts. Age standardised to WHO World standard population. Actual rate ratios available in Supplementary Materials Table 1

prostate (C61), colorectal (C18–20), melanoma (C43), stomach (C16), leukaemia (C91–95), non-Hodgkin's lymphoma (C82-85), cervix (C53), bladder (C67), kidney (C64) and liver (C22); endometrial (C54-55), oesophageal (C15), ovary (C56), myeloma (C90) and pancreas (C25). We also included brain (C71), giving 18 cancers in total.

Supplementary Materials, Table 1 shows the number of (weighted) first cancers and person time in each of the ethnic and income groups in each cohort.

Analysis

A range of measures of inequality are available, with varying implicit values and interpretation [17]. The focus on ethnicity (nominal variable) limits the choice of measure, and New Zealand precedents suggest treating European/Other as the reference group. Accordingly, we present standardised incidence rates, rate ratios (SRR) and rate differences (SRD), using the WHO world population as the standard. Sexes were combined (except for sex-specific and lung cancers). Statistical tests of increasing or decreasing linear trend were calculated on rates and rate differences and on the logarithm of rate ratios.

Results

Total cancer incidence was highest for Māori, lowest for Asian and slightly higher for the low- compared with high-income group (Supplementary Materials, Fig. 1). Lung cancer was the principal reason for higher rates among Māori and low-income groups.

We first orientate the reader to the tables and figures and give high-level overviews of social group differences both *pooled* across time and for *trends over time*. We then briefly describe notable findings (largely those by ethnicity) by cancer.

Overview of social group differences pooled over time

Figure 1 shows cancer-specific SRRs pooled over time by ethnicity, income and education. Three cancers had substantively elevated SRRs for low- compared with high-income tertiles: lung (men 1.56 (95% CI 1.47–1.66), women 1.35 (1.24–1.48)); cervical cancer 1.35 (1.19–1.54); and stomach cancer 1.23 (1.11–1.37). Four cancers had a 10–24% lower SRR among the low-income tertile: breast 0.90 (95% CI 0.87–0.93), melanoma 0.76 (0.73–0.79), NHL 0.88 (0.81–0.96) and prostate 0.86 (0.83–0.90). The only notable difference between education and income results was a higher SRR for cervical cancer 1.73 (95% CI 1.55–1.94) for education. Ethnic differences were larger and more complex and are described by cancer below.

Overview of trends over time in social group differences

Cervical and lung cancers (by sex) demonstrated noteworthy trends over time that varied by both ethnicity and socioeconomic position (Fig. 2). For nine other cancers (Fig. 3), there was enough stability to allow substantive interpretations of ethnic trends over time. The remaining cancers had unstable ethnic rates by time, or little socioeconomic difference (including little variation over time), and are not represented graphically (but are available elsewhere [16]). Standardised rate ratios and rate differences, by time, are shown in Tables 1 and 2 for all instances and plotted in Figs. 2 and 3 where there was evidence of variation in absolute or relative inequality over time.

Bladder

Rates doubled over time for Māori and increased by a third for European/Other (Fig. 3). Pooled over time, Māori, Pacific and Asian rates were 52–58% of European/Other rates (Fig. 1).

Brain

Pooled over time, Māori, Pacific and Asian rates were 62–66% of European/Other rates (Fig. 1). There were no obvious trends over time.

Breast

Breast cancer incidence increased by 71% for Māori (p for trend < 0.01), 25% for Pacific ($p = 0.38$), 49% for European/Other ($p < 0.01$) and 80% for Asian ($p = 0.04$). While Māori rates were similar to European/Other in 1981–1986, by 2001–2004 they were 23% higher than European/Other (Fig. 3, Table 1). Absolute inequalities between Māori and European/Other widened from 8.4 per 100,000 in 1981–1986 to 39 per 100,000 in 2001–2004 ($p = 0.06$; Table 1), but relative inequalities did not change significantly over time. Breast cancer incidence increased by about half in all socioeconomic groups.

Cervical cancer

There were decreases in cervical cancer incidence of 58% for Māori, 64% for Pacific and 40% for European/Other (p for trend all < 0.05). Asian rates were similar over time. Relative and absolute inequalities between Māori and European/Other women declined (e.g. SRD decreased from 38 to 12 per 100,000, $p = 0.01$) and likewise for Pacific women. Conversely, Asian cervical cancer rates increased relative to European/Other over time, although confidence

Table 1 Relative and absolute inequalities by ethnicity over time, for selected cancers

Cancer	Cohort	Relative inequality: SRR (95% CI)			Absolute inequality: SRD (95% CI)		
		Total Māori SRR (95% CI)	Total Pacific SRR (95% CI)	Total Asian SRR (95% CI)	Total Māori SRD (95% CI)	Total Pacific SRD (95% CI)	Total Asian SRD (95% CI)
Breast (Females)	1981–1986	1.07 (0.93–1.24)	0.98 (0.73–1.32)	0.61 (0.40–0.93)	8.4 (−9.2–26)	−2.0(−35–31)	−44 (−74–15)
	1986–1991	1.02 (0.91–1.14)	1.05 (0.84–1.30)	0.79 (0.58–1.08)	2.2 (−14–18)	6.6 (−25–38)	−29 (−64–5.1)
	1991–1996	1.25 (1.13–1.37)	0.74 (0.62–0.89)	0.63 (0.49–0.80)	35 (18–52)	−37 (−57–17)	−53 (−76–31)
	1996–2001	1.23 (1.14–1.33)	0.90 (0.79–1.04)	0.73 (0.63–0.86)	38 (23–52)	−15 (−35–4.7)	−43 (−62–25)
	2001–2004	1.23 (1.14–1.33)	0.83 (0.72–0.95)	0.74 (0.65–0.84)	39 (23–56)	−29 (−50–9.2)	−44 (−61–27)
	P (Trend)	*0.15*	*0.39*	*0.45*	*0.06*	*0.37*	*0.89*
	Pooled	1.17 (1.11–1.22)	0.90 (0.82–0.98)	0.70 (0.63–0.79)	24 (16–31)	−15 (−26–3.0)	−43 (−54–31)
Cervix (Females)	1981–1986	3.04 (2.48–3.71)	2.22 (1.41–3.49)	0.92 (0.41–2.06)	38 (28–48)	23 (4.2–41)	−1.4 (−15–12)
	1986–1991	2.28 (1.87–2.78)	2.79 (1.82–4.28)	1.11 (0.57–2.13)	24 (16–32)	33 (11–55)	2.0 (−12–15)
	1991–1996	2.51 (2.09–3.02)	2.10 (1.51–2.94)	0.90 (0.46–1.77)	24 (18–31)	18 (6.8–29)	−1.6 (−12–8.2)
	1996–2001	2.28 (1.89–2.74)	1.27 (0.85–1.90)	1.32 (0.88–1.98)	18 (13–24)	3.9 (−3.4–11)	4.6 (−3.0–12)
	2001–2004	2.11 (1.62–2.74)	1.34 (0.88–2.06)	1.60 (1.12–2.28)	12 (6.9–18)	3.8 (−2.4–10)	6.7 (0.6–13)
	P (Trend)	*0.11*	*0.09*	*0.04*	*0.01*	*0.06*	*0.06*
	Pooled	2.49 (2.27–2.73)	2.05 (1.67–2.52)	1.11 (0.84–1.46)	24 (20–27)	17 (10–24)	1.8 (−3.1–6.7)
Colorectal	1981–1986	0.46 (0.38–0.56)	0.49 (0.33–0.74)	0.59 (0.39–0.90)	−46 (−53–38)	−43 (−60–26)	−34 (−55–14)
	1986–1991	0.50 (0.42–0.58)	0.36 (0.23–0.56)	0.54 (0.38–0.77)	−44 (−52–37)	−56 (−70–42)	−40 (−57–23)
	1991–1996	0.58 (0.51–0.67)	0.52 (0.40–0.66)	0.59 (0.44–0.79)	−39 (−46–31)	−45 (−57–33)	−38 (−54–22)
	1996–2001	0.66 (0.59–0.74)	0.50 (0.41–0.61)	0.66 (0.55–0.80)	−32 (−39–25)	−46 (−56–37)	−32 (−43–20)
	2001–2004	0.63 (0.56–0.71)	0.42 (0.34–0.53)	0.52 (0.43–0.62)	−34 (−41–27)	−54 (−63–45)	−45 (−54–36)
	P (Trend)	*0.04*	*0.72*	*0.73*	*0.03*	*0.57*	*0.40*
	Pooled	0.57 (0.53–0.60)	0.46 (0.40–0.53)	0.58 (0.51–0.67)	−39 (−42–36)	−49 (−54–43)	−37 (−45–30)
Lung (Females)	1981–1986	2.99 (2.44–3.65)	0.66 (0.33–1.35)	0.90 (0.42–1.91)	50 (36–65)	−8.5 (−20–3.5)	−2.5 (−20–15)
	1986–1991	3.58 (3.09–4.15)	1.25 (0.76–2.06)	1.14 (0.64–2.04)	79 (64–94)	7.7 (−11–27)	4.4 (−16–25)
	1991–1996	3.44 (3.02–3.92)	0.86 (0.56–1.32)	0.85 (0.52–1.38)	88 (73–104)	−5.0 (−18–8.4)	−5.5 (−21–9.4)
	1996–2001	3.33 (2.99–3.71)	1.17 (0.88–1.55)	0.62 (0.41–0.94)	85 (73–96)	6.1 (−5.7–18)	−14 (−23–4.3)
	2001–2004	3.42 (3.05–3.82)	1.48 (1.15–1.91)	0.84 (0.62–1.14)	94 (81–108)	19 (4.4–33)	−6.2 (−16–3.8)
	P (Trend)	*0.74*	*0.11*	*0.44*	*0.05*	*0.08*	*0.40*
	Pooled	3.37 (3.17–3.58)	1.09 (0.91–1.31)	0.86 (0.68–1.09)	78 (72–85)	3.1 (−3.4–9.5)	−4.6 (−11–2.2)
Lung (Males)	1981–1986	1.73 (1.50–2.00)	0.78 (0.48–1.26)	0.65 (0.37–1.13)	69 (46–91)	−21 (−57–15)	−33 (−67–0.9)
	1986–1991	1.84 (1.61–2.11)	1.64 (1.22–2.19)	1.05 (0.68–1.64)	72 (51–92)	54 (14–94)	4.6 (−35–44)
	1991–1996	2.14 (1.91–2.40)	1.40 (1.08–1.81)	0.57 (0.36–0.91)	93 (73–112)	32 (3.1–61)	−35 (−56–13)
	1996–2001	2.19 (1.97–2.44)	1.79 (1.48–2.16)	0.83 (0.61–1.12)	82 (67–98)	54 (31–77)	−12 (−30–5.7)
	2001–2004	2.30 (2.05–2.58)	1.45 (1.16–1.82)	0.75 (0.56–1.02)	83 (67–99)	29 (8.1–49)	−16 (−30–0.9)
	P (Trend)	*<.01*	*0.56*	*0.85*	*0.30*	*0.45*	*0.52*
	Pooled	2.00 (1.89–2.12)	1.38 (1.21–1.57)	0.77 (0.63–0.95)	79 (71–88)	30 (16–44)	−18 (−31–5.6)

Results for all cancers are available in Supplementary Materials Table 1

Reference group European/Other. Age standardised to WHO World standard population

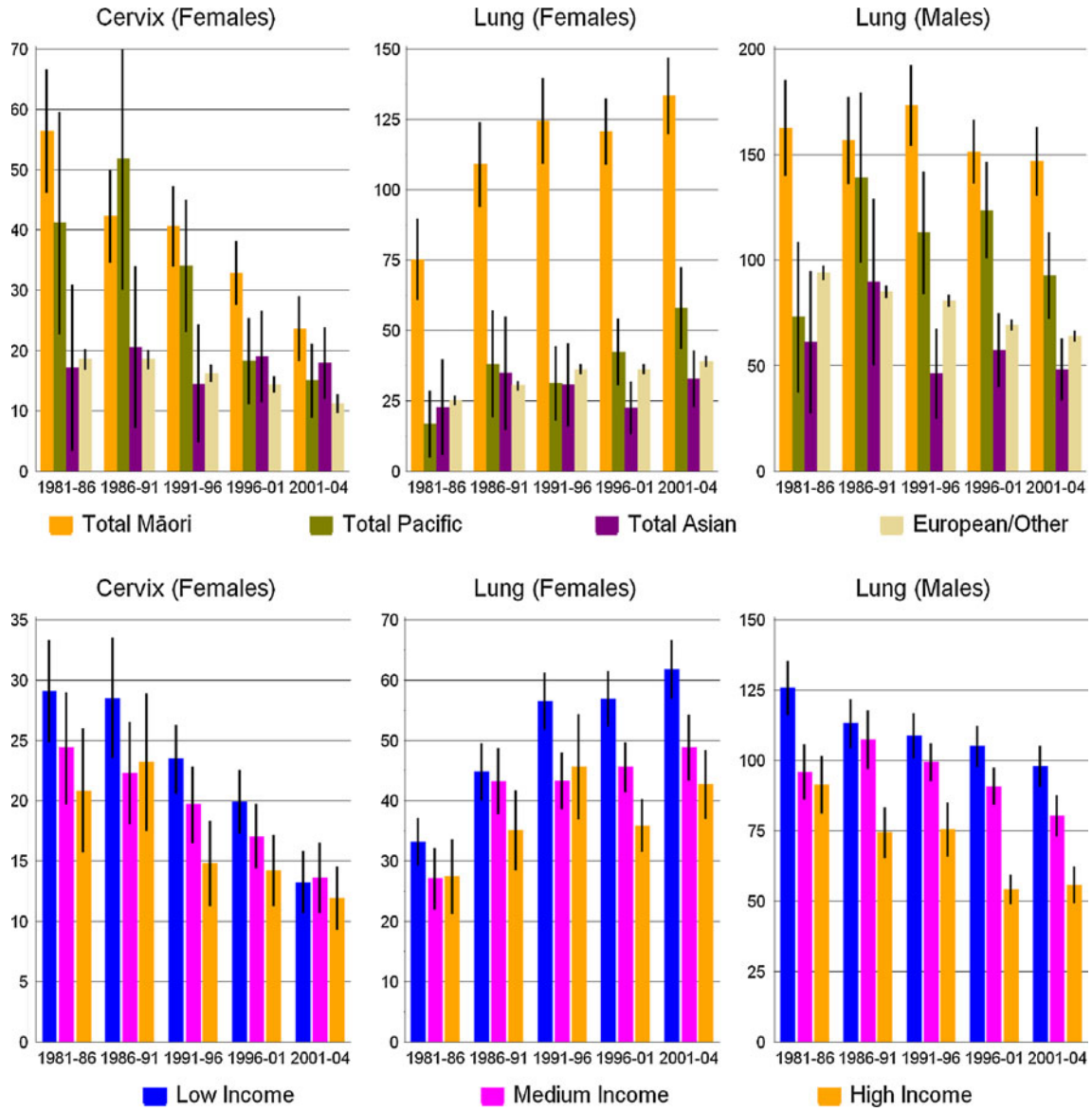

Fig. 2 Rates of lung (males and females separately) and cervical cancer by ethnic and income groups. Age standardised to WHO World standard population. Actual rates available in Supplementary Materials Table 1

intervals are wide. By 2001–2004, Māori rates were approximately twice European/Other, Pacific a third higher and Asian two-thirds higher (Table 1).

Colorectal

Pooled over time, Māori, Pacific and Asian rates were 46–58% of European/Other rates (Fig. 1). Over time, rates increased by 53% for Māori ($p = 0.02$) but were stable for other ethnic groups, such that the SRR for Māori compared with European/Other increased from 0.46 to 0.63 ($p = 0.06$; Table 1).

Endometrial

Pooled over time, Māori had 1.66 (1.49–1.85) and Pacific 2.61 (2.22–3.05) times the rate of European/Other.

Kidney

Rates increased by two-thirds for both Māori and European/Other and were similar at each point in time. Pooled over time, Pacific and Asian rates were 0.53 (95% CI 0.38–0.73) and 0.38 (0.25–0.57) of the European/Other rate.

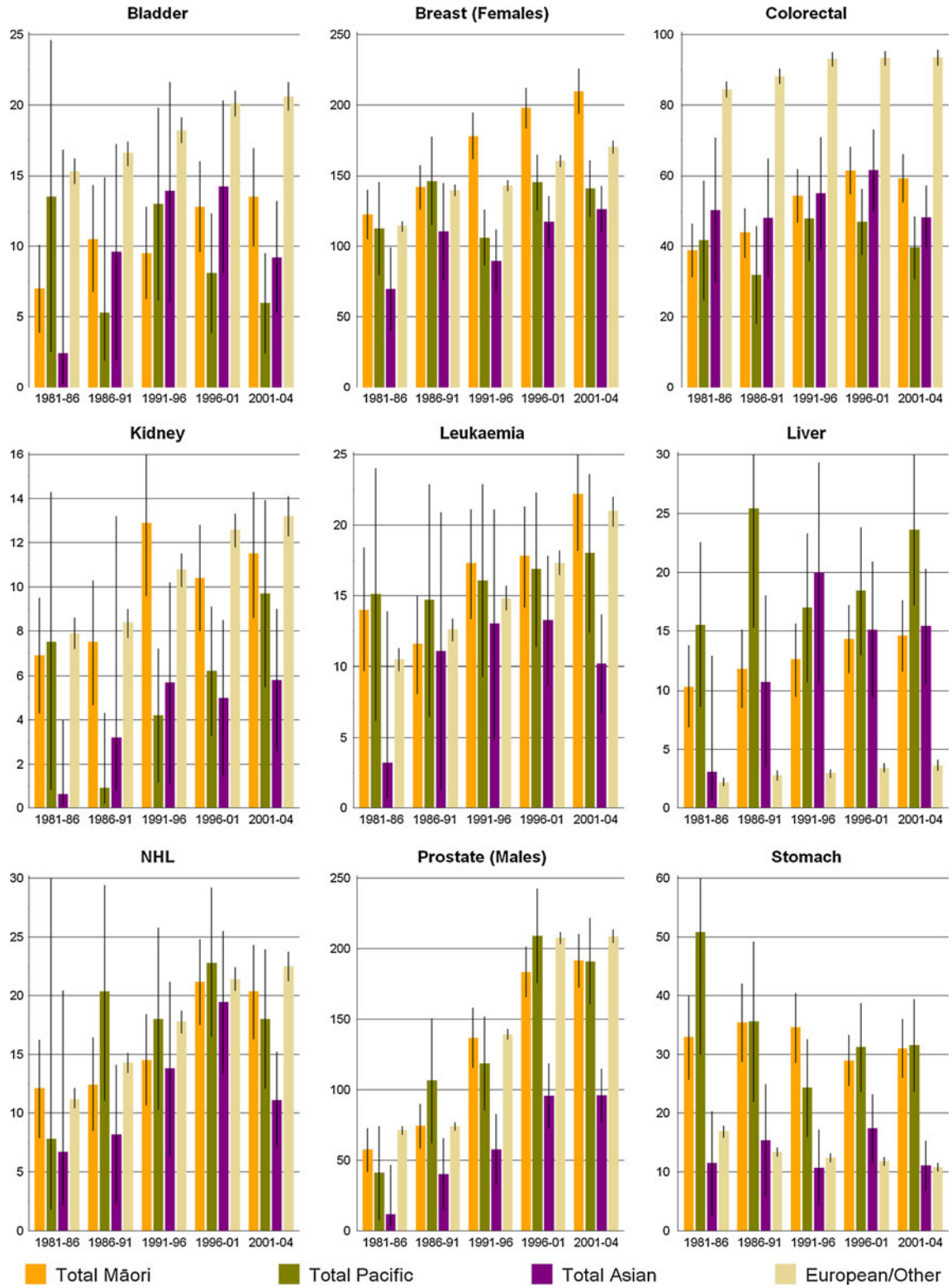

Fig. 3 Cancer-specific incidence rates by ethnicity and cohort for adults (25 + years, sexes combined unless otherwise stated) 1981–1986 to 2001–2004. Age standardised to WHO World standard population. Actual rates available in Supplementary Materials Table 1. Some cancers included elsewhere in the paper are not plotted in this figure for the following reasons: endometrium, brain, myeloma, oesophageal and ovary—data to sparse and imprecise by time; Melanoma—much higher rates for European/Other render Māori, Pacific and Asian trends difficult to visualise; cervix and lung—plotted in Fig. 2

Table 2 Relative and absolute inequalities by household income over time, for lung (by sex) and cervical cancer

Cancer	Cohort	Relative inequality: SRR (95% CI)		Absolute inequality: SRD (95% CI)	
		Low income SRR (95% CI)	Medium income SRR (95% CI)	Low income SRD (95% CI)	Medium income SRD (95% CI)
Cervix (Females)	1981–1986	1.40 (1.05–1.86)	1.17 (0.85–1.60)	8.3 (1.6–15)	3.5 (−3.4–11)
	1986–1991	1.23 (0.91–1.66)	0.96 (0.70–1.31)	5.3 (−2.2–13)	−0.9 (−8.0–6.1)
	1991–1996	1.59 (1.22–2.07)	1.33 (1.00–1.77)	8.7 (4.2–13)	4.9 (0.2–9.6)
	1996–2001	1.40 (1.10–1.78)	1.20 (0.93–1.55)	5.7 (1.8–9.6)	2.8 (−1.1–6.7)
	2001–2004	1.11 (0.83–1.49)	1.14 (0.84–1.55)	1.3 (−2.3–5.0)	1.7 (−2.2–5.6)
	P (Trend)	*0.60*	*0.72*	*0.11*	*0.78*
	Pooled	1.35 (1.19–1.54)	1.14 (0.99–1.31)	6.1 (3.6–8.6)	2.5 (−0.1–5.0)
Lung (Females)	1981–1986	1.21 (0.94–1.56)	0.99 (0.74–1.32)	5.8 (−1.5–13)	−0.4 (−8.4–7.5)
	1986–1991	1.28 (1.03–1.58)	1.23 (0.98–1.54)	9.7 (1.6–18)	8.1 (−0.4–17)
	1991–1996	1.24 (1.01–1.53)	0.95 (0.76–1.18)	11 (1.0–21)	−2.3 (−12–7.6)
	1996–2001	1.59 (1.37–1.84)	1.27 (1.09–1.48)	21 (15–27)	9.7 (3.8–16)
	2001–2004	1.45 (1.24–1.69)	1.14 (0.96–1.36)	19 (12–27)	6.1 (−1.7–14)
	P (Trend)	*0.17*	*0.59*	*0.02*	*0.35*
	Pooled	1.35 (1.24–1.48)	1.11 (1.01–1.22)	13 (9.4–17)	4.2 (0.5–7.8)
Lung (Males)	1981–1986	1.38 (1.20–1.58)	1.05 (0.90–1.22)	35 (21–48)	4.5 (−9.4–19)
	1986-1991	1.52 (1.32–1.76)	1.45 (1.24–1.69)	39 (27–51)	33 (20–47)
	1991–1996	1.44 (1.25–1.67)	1.32 (1.14–1.52)	33 (21–46)	24 (12–36)
	1996–2001	1.94 (1.72–2.18)	1.68 (1.49–1.89)	51 (42–60)	37 (28–45)
	2001–2004	1.76 (1.53–2.01)	1.44 (1.25–1.67)	42 (33–52)	25 (15–34)
	P (Trend)	*0.11*	*0.18*	*0.31*	*0.39*
	Pooled	1.56 (1.47–1.66)	1.35 (1.26–1.44)	40 (35–45)	25 (19–30)

Reference group European/Other. Age standardised to WHO World standard population

Leukaemia

European/Other rates doubled over time; other ethnic groups showed lesser increases and more instability (Fig. 3). Pooled over time, Asian rates were 0.68 (0.50–0.92) of European/Other, but the three other ethnic groups were similar.

Liver

Māori, Pacific and European/Other rates increased by about half over time. Pooled over time, SRRs for Māori 4.25 (3.75–4.82), Pacific 6.67 (5.60–7.94) and Asian 4.29 (3.36–5.47) were all markedly elevated.

Lung cancer: males

European/Other rates decreased by 32% (p for trend $<$ 0.01), Māori rates were stable or perhaps decreasing, and Asian and Pacific rates were unstable over time. Māori rates were double those of European/Other pooled over time, but the SRR increased from 1.73 in 1981–1986 to 2.30 in 2001–2004 (p for trend $<$ 0.01; Table 1). Pacific rates were 38% greater and Asian rates 23% less, pooled over time. By income, rates decreased most among the high-income group meaning that relative inequalities increased (Table 2).

Lung cancer: females

European/Other rates increased by 55% ($p = 0.01$), Māori rates by 77% ($p = 0.04$) and Pacific rates by three and half times ($p = 0.02$). Māori rates were 3.37 times European/Other rates pooled over time, with no obvious trend in relative inequalities; absolute inequalities increased from 50 to 94 per 100,000 ($p = 0.05$; Table 1). Pacific rates were initially less than European/Other, but exceeded European/Other by 48% in 2001–2004. Asian rates tended to track European/Other rates. By income, rates increased by 55% (high-income) to 86% (low-income), with consequent increases in relative and absolute inequalities (Table 2).

Melanoma

Rates doubled among European/Other (in part a consequence of increased completeness of registrations from the mid-1990s). Over time, European/Other rates were five times Māori rates and ten times Pacific rates.

Myeloma

Rates increased by a third for European/Other over time, with similar (although unstable) trends in the other ethnic groups. Pooled over time, Māori rates were two-thirds greater than European/Other and Pacific rates twice as high.

Non-Hodgkin's Lymphoma

Rates approximately doubled in all ethnic groups, tracking each other except for Asian with a third lower rates.

Oesophageal

Māori rates were 1.29 (1.10–1.51), Pacific rates 0.62 (0.42–0.92) and Asian rates 0.47 (0.30–0.72) those of European/Other.

Ovary

There were no clear trends in ethnic-specific rates over time. Pooled over time, Pacific had a 1.35 times greater rate than European/Other (95% CI 1.10–1.66), and the remaining ethnic groups had similar rates.

Pancreas

There were no clear trends in ethnic-specific rates over time. Pooled over time, Māori and Pacific rates were 1.51 (1.34–1.70) and 1.42 (1.09–1.86) times European/Other rates.

Prostate

Prostate cancer rates increased profoundly over time (and in unison except for Asian), largely due to PSA testing. Pooled over time, Māori rates were 0.92 European/Other rates (95% CI 0.86–0.98), Pacific rates were similar to European/Other and Asian rates were less than half.

Stomach

Rates fell by 36% for European/Other ($p = 0.02$), but were unstable over time for other ethnic groups. Pooled over time, Māori had 2.48 (2.27–2.70) and Pacific 2.64 (2.23–3.14) times the rates of European/Other.

Discussion

Our results show marked differences in cancer incidence by ethnicity, which varied over time for some cancers, particularly colorectal, breast, cervical and lung. Differences across socioeconomic groups were considerably smaller, absent for many cancers, and tending not to vary over time. We summarise the trends under three subheadings: largely explicable social group differences, partially explicable social group differences and unexplained differences. We then attempt some judgement of which inequalities can be regarded (in part at least) as inequities.

Largely explicable social group inequalities

Social group differences in lung cancer, and their increase over time, fit reasonably well with what we know about the histories of smoking. Māori have had much higher rates of smoking for decades and Pacific more recently. Phased tobacco epidemics that affect women after men and concentrate among lower socioeconomic groups are well theorised [18] and are demonstrated in New Zealand [19]. Lung cancer rates among female Māori are very high, reflecting 50% or greater smoking prevalence in the past. Female Pacific smoking rates have increased over recent decades, and their lung cancer rates are tracking up. The last 10–20 years has seen concerted tobacco control efforts tailored for Māori, Pacific and lower socioeconomic groups, and momentum is now building among tobacco control leaders and politicians (especially Māori politicians) to phase tobacco out of New Zealand. For example, the New Zealand Parliament has recently agreed to a goal of making New Zealand 'essentially a smoke-free nation by 2025' [20]. This action would result in a major reduction in health inequalities [21].

Tobacco is a contributory factor to inequalities in liver, stomach and cervical cancer, but not the main driver. Elevated liver cancer rates are almost entirely due to endemic chronic hepatitis B infection among children, fuelled by higher levels of household crowding among non-European populations [22]. Inequalities in liver cancer are expected to diminish in the future, as vaccination was added to the childhood national immunisation schedule in 1988.

Helicobacter Pylori is a risk factor for stomach cancer, which is concentrated among lower socioeconomic and crowded settings. Pacific adults have been found to have twice the prevalence of H. pylori seropositivity of European and Māori 1.6 times [23]. Additionally, there are at least three large Māori kindreds with a strong genetic susceptibility to stomach cancer [24] that, in the context of a relatively uncommon cancer, may impact on incidence rates for the total Māori population.

Inequalities in cervical cancer incidence between social groups have historically been driven by differences in sexual behaviour and varying screening coverage. The New Zealand decreases in cancer incidence occurred

despite escalating risk in cohorts born after the 1930s, related to changes in sexual behaviour [25]. Cervical screening was well established in opportunistic form in the 1980s and as a population-based screening programme from 1991. While coverage rates for Māori, Pacific and lower socioeconomic women remain lower than for European women, it would appear that enough women are being screened to bring about large reductions in rates and reduce inequalities on an absolute scale. HPV vaccination programmes have recently commenced. Concerted effort will be required to ensure equal and high uptake among Māori and Pacific to further reduce inequalities.

Partially explicable social group differences

Endometrial cancer incidence has been found to increase by 50% for a five-point increase in BMI. [26] Pacific and Māori women have higher prevalence of obesity (48% and 27%, respectively) compared with European (22%), but this still seems insufficient to explain the 66% (Māori) to 161% (Pacific) excess in cancer rates [27]. Indeed, higher fertility among Pacific and Māori would be expected to be protective. Further research as to causes of the elevated Māori and Pacific rates of endometrial cancer is justified. Similarly, elevated pancreatic cancer among Māori and Pacific fits with tobacco consumption, although a 50% higher rate cannot be explained by smoking alone.

Unexplained social group differences

This paper finds some puzzling and inexplicable inequalities, sometimes the converse of expected. Kidney cancer is an example of the latter. The two most established risk factors are obesity and smoking—yet, despite Pacific people having higher rates of both these risk factors, their rates are half those of European/Other. Furthermore, end-stage renal disease considerably increases the risk of kidney cancer, and Pacific people have high rates of renal disease (diabetes being an important contributory factor). Research as to why kidney cancer rates are low among Pacific people is warranted.

Myeloma is another oddity with respect to ethnic patterning. Internationally, there is some evidence that increasing socioeconomic position is associated with increased risk of myeloma [28], and variable incidence by ethnicity/race has been found elsewhere. The two-thirds greater rates for Māori, double for Pacific and similar Asian and European/Other rates warrant further research.

We have analysed and discussed social group differences in breast cancer incidence in detail elsewhere [29]. Briefly, the patterns are interesting and not understood. Most known risk factors (e.g. age at menarche, parity) suggest Māori should have a lower incidence than European/Other, yet their rates are higher. Total alcohol consumption is little different between Maori and non-Māori and actually less among Pacific [30]. High fertility rates are associated with lower risk of breast cancer, so more rapidly reducing fertility rates among Māori may explain the faster increase among Māori in the last 25 years. However, Māori fertility still remains higher begging the question as to why their breast cancer rates are higher than European/Other at all points in time.

Which inequalities are inequities?

Assignation of the label 'inequity' is a matter of judgement (Panel). Nevertheless, a common policy goal in many countries is to reduce inequities, requiring some idea of which differences are, in fact, inequities. We contend that the differences due to tobacco smoking are largely inequities. It is clear that non-European and lower socioeconomic populations have higher smoking rates because of underlying social inequities including the legacy of tobacco as an tool of land acquisition in early colonisation [31]; social marginalisation that leads to greater difficulty in quitting; generational patterning; deliberate targeting by tobacco companies; and differential impact of past tobacco control programmes. Accordingly, tobacco control (and indeed eradication) is the highest cancer control priority to not only reduce overall cancer burden but also redress inequities in that burden.

Obesity is related to some cancers, and differences in incidence of these may be framed in a similar way to the tobacco argument. However, obesity is considerably less strongly related to cancer than smoking, and there are culturally driven and 'choice' differences in diet that, arguably, render obesity-related differences in cancer incidence less of an inequity than tobacco-related inequities—especially noting the addictiveness of tobacco. However, in so much as obesity is determined by Whitehead's (1992) [5] fourth (health-damaging behaviour where the choice of lifestyles is severely limited) and fifth (exposure to unhealthy, stressful living and working conditions; Panel) determinants of health differences, elements of inequity are also at play. For example, Pacific people tend to undertake more shift work.

Stomach and liver cancers may also be partially viewed as inequitable, through mechanisms of household crowding. Higher incidence of cervical cancer among Māori and Pacific women is likely to be due to a combination of differences in exposure to HPV and lower screening coverage. We can confidently judge the latter to be an inequity, but it is more difficult to make a judgement on the former. Regardless, the profound reduction of rates and in absolute inequalities in the last 25 years should be lauded as an

example of what can be achieved through (even imperfect) population-based screening.

This paper examines cancer *incidence*. It would be remiss, however, not to point out the larger inequalities in cancer survival [3, 32], often played out through varying levels and quality of access to and through health services and much more easily judged as inequitable.

Strengths and limitations

A strength of this study is the inclusion of the total population and the linkage of census and cancer registration data to overcome potential numerator–denominator biases. This study is deliberately 'high level', surveying the social patterning of many cancers without drilling down to subtypes. Detailed cancer-specific studies are also needed. Finally, we have deliberately focused on environmental and lifestyle risk factors, driven by social determinants, in this paper. In the absence, however, of direct evidence on the role of genetics and biology (melanoma and partial exceptions such as stomach cancer noted above), we believe it is erroneous to assume that unexplained ethnic differences are necessarily due to genetics and biology. We look forward to further research that explicitly examines both biological and environmental explanations for ethnic differences in cancer and in particular interactions of the two.

Conclusion

This paper describes, and attempts to partially explain and interpret, striking ethnic group differences in cancer incidence since 1981 in New Zealand. Also, striking is how much smaller socioeconomic differences in cancer incidence are. Some of these differences may be categorised as inequities, particularly those that can be traced back to the long-standing manifestations of colonisation and racism, through mechanisms such as tobacco and living conditions. However, much of the social group inequalities in cancer incidence in New Zealand remain unexplained.

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Conflict of Interest Nil

Ethics Approval was granted for this project under the Statistics New Zealand Data Integration Policy and the Wellington Ethics Committee granted ethics approval for CancerTrends (Ref 04/10/093).

Statistics NZ Security Statement Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the author, not Statistics New Zealand.

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