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Cancer in Pacific people in New Zealand

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Abstract

Purpose To describe cancer incidence rates among Pacific people living in New Zealand from 1981 to 2004.

Methods Linked census-cancer registration data were used to calculate age-standardized cancer incidence rates for Pacific people. Both trends over time within Pacific people and differences in rates between Pacific and European/Other people in New Zealand were assessed.

Results Pacific rates were higher for cancers of the cervix, endometrium, gallbladder, lip, mouth and pharynx, liver, lung, ovary, pancreas, stomach, and thyroid, and lower for colorectal, bladder, and testicular cancers and melanoma. Differences were large, ranging from a 90 % lower rate of melanoma to over seven times higher rate of liver cancer compared to European/Other. Breast and prostate cancers were the commonest malignancies for Pacific women and men, respectively. Important changes for Pacific women over time include a 64 % decrease in cervical cancer incidence ($p$trend = 0.02) and a 245 % increase for lung cancer ($p$trend = 0.02), while men had a 366 % increase in prostate cancer ($p$trend = 0.02).

Conclusions Pacific people in New Zealand have a disproportionate cancer burden related to infectious diseases such as HPV and Hepatitis B. However, with escalating evidence for causal associations between diabetes, obesity, and physical inactivity with various cancers, the challenge will be to prevent these cancers from rising in Pacific people who have the highest rates of these conditions in New Zealand. Disparities for tobacco-related cancers support tobacco consumption as another important cause of cancer incidence disparity. Continued efforts are needed to reduce infectious disease and improve screening program uptake among Pacific people.

Introduction

Ethnic diversification in New Zealand has continued to grow since a demand for labor in the 1950s and 1960s saw the ongoing migration of British and Northern European people, and a large increase in migration of Pacific Island people to New Zealand. Today, Pacific people make up 6.9 % of the New Zealand population with 38 % of this population under 15 years of age (compared with 22 % of the total New Zealand population) [1]. With the adoption of Westernized lifestyles and, notably, changes in nutrition and physical activity, we have seen the increase in non-communicable diseases such as diabetes mellitus, cardiovascular disease, strokes, and obesity as a major source of morbidity and mortality among Pacific people in New Zealand [2, 3]. However, it is now recognized that cancer is also a major public health problem among this population too. Pacific people in New Zealand have experienced the least mortality improvement in the last 25 years compared to any other ethnic group [4]. Cardiovascular disease and "other" causes

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(including diabetes) contribute over 70 % to the all-cause mortality gap between Pacific and Europeans, but cancer mortality is now increasing among Pacific females with 25 % of this gap due to malignancy by 2001–2004 [5].

Up until recently, there has been little information on cancer incidence rates among Pacific people in New Zealand. This is because (1) there are often small numbers for a given health outcome among Pacific people so it can be difficult to get a statistically robust measure of disease or outcome, and (2) in relation to cancer specifically, there has been misclassification of ethnicity on the Cancer Registry [6] and therefore numerator–denominator bias when incidence rates have been calculated from the cancer registry and census estimates.

Asian–Pacific Island groups are the fastest growing minority populations in the United States [7]. Cancer incidence and mortality data for Pacific populations residing in the United States from 1998 to 2002 revealed that Native Hawaiian, Samoan, and Tongan women had the highest incidence rates among Asian–Pacific Island groups for all cancers and that they even exceeded the rate seen in non-Hispanic white women (referent group) [8]. For Samoan and Tongan women, while breast cancer was the most commonly diagnosed malignancy, incidence rates of endometrial cancer were 2.5–3.5 times the rate seen in non-Hispanic white women. Both Samoan men and women had the highest mortality rates, which again exceeded that of non-Hispanic white men and women. In the Pacific Islands, gynaecological malignancies such as cervical, endometrial, and ovarian cancers are the most common female cancers while liver, lung, and stomach cancers are predominant in males [9].

Recent analyses on linked New Zealand census-cancer data from 1981 to 2004 demonstrated marked differences in cancer incidence between ethnic groups and highlighted the need for research in areas where these disparities are unexplained, in particular, endometrial cancer for Pacific women [10].

The aim of this paper is to describe age-standardized cancer incidence rates and rate ratios (compared with NZ Europeans) for Pacific people in New Zealand from 1981 to 2004 and provide more depth of interpretation of the Pacific cancer rates than was possible in an earlier overview paper [8]. Where there are differences in cancer incidence, we have conjectured as to whether these are explained by differences in occurrence of cancer risk factors or uptake of prevention programs.

Materials and methods

The dataset was created by linking New Zealand Cancer Registry (NZCR) records to the 5-yearly New Zealand census of population and dwellings (the census) data, and is published in detail elsewhere [11, 12]. Briefly, five closed cohorts were created of the New Zealand usual resident population (all ages) on census night 1981, 1986, 1991, 1996, 2001, followed up for incident cancer(s) until the subsequent census or in the case of the 2001 cohort, until 31 December 2004 (the most recent data available at the time of the study's record linkage). Linkage was not possible between censuses. Also, we did not have information in the linked datasets regarding any migration out of New Zealand or non-cancer death after census, meaning that we were unable to censor observations. (Any resultant bias, however, would be modest or negligible.)

The New Zealand Cancer Registry is a population-based register of all primary malignancies in New Zealand (excluding non-melanotic skin cancers). Laboratories are the primary source of data and since 1993 are required by law to report any new diagnosis of cancer.

For any census period, between 18.3 and 26.8 % of records were unable to be linked. This linkage varied by sociodemographics, with 19–33 % of Pacific cancer records unable to be linked (partly due to younger age of Pacific cancer registrants, but also due to a direct "ethnic effect"). To avoid underestimation of rates due to linkage bias, weights were calculated for strata based on age, sex, ethnicity, and small-area deprivation. For example, if 20 out of 30 cancer registrations for Pacific males aged 45–64 living in moderately deprived areas were linked, each of the 20 linked records was assigned a weight of $30/20 = 1.5$, making the 20 records representative of the 30 eligible records. All analyses used these weights.

A modified total ethnicity approach was used for this work. Total ethnicity places an individual in all ethnic groups that they identify with. If individuals indicated any/all of Māori, Pacific, and/or Asian ethnic affiliation, they were placed in any/all of Total Māori, Total Pacific, Total Asian ethnic groups. The residual people who did not indicate any of the above ethnic affiliations were placed in the residual non-Māori/Pacific/Asian (referred to as European/Other hereafter).

Incidence rates and rate ratios (and 95 % confidence intervals) were calculated after direct standardization of the cohorts to the age structure of the 2001 WHO world standard population. Statistical tests of trend were conducted for rates and of the log transformed rate ratios. All measures were also calculated for all five cohorts pooled. All these analyses were conducted in SAS v9.

To obtain a smoothed change in rates over time, inverse-variance weighted regression was used to calculate annual percentage change (APC) for all cancers in Pacific people. Standardized rates (SR) and standard errors were obtained for each cancer by cohort and sex. Point estimates and standard error bars were plotted at 5-year intervals. A linear regression line was fitted with y = point estimate,

$x =$ time where 1981–1986 was set as zero and each subsequent cohort (1986–1991, 1991–1996, 1996–2001, 2001–2004) was a multiple of five on the x-axis (except the last cohort which was 19 because it only consisted of four years). The resulting regression line had a slope that was equivalent to the APC, and the intercept was the predicted SR at the initial year (1981). Inverse-variance weights (i.e., weight = 1/variance) were used to fit the regression line because of the unequal number of observations per 5-year group. Each slope and intercept had an estimate and standard error with p values denoting their significance. These analyses were conducted in R 2.13.0 (R Foundation, Vienna, Austria) [13].

Ethical approval was granted for CancerTrends by the Central Regional Ethics Committee (Ref 04/10/093).

Results

Table 1 shows incidence rates for cancers for Pacific, European/Other, and Māori by sex, pooled over time. Figure 1 shows a forest plot of standardized rate ratios (SRR) for cancers comparing Pacific with European/Other rates for women (Fig. 1a) and men (Fig. 1b). Figure 2 shows the annual percentage change in incidence rates for selected cancers for Pacific women and men between 1981 and 2004.

We found that a number of cancers occurred at higher incidence rates among Pacific compared to European/Other people, averaged across the 25 years. We grouped these into four broad categories:

1. Gynaecological cancers
2. Smoking-related cancers
3. Gastrointestinal and hepatobiliary cancers
4. Other (including breast, thyroid, myeloma)

We also comment below on cancers for which Pacific people were found to have lower incidence rates, and those with lower or similar rates, but for which rates were changing markedly over time.

Gynaecological cancers

Pacific women had higher rates of endometrial, cervical, and ovarian cancers than European/Other women in New Zealand. There was a particularly high rate of endometrial cancer among Pacific women with a pooled age-standardized incidence rate of 46.7/100,000 (95 % CI, 39.4–53.9) for Pacific women compared to 17.9/100,000 (95 % CI, 17.3–18.5) for European/other (Table 1). This gave a pooled SRR for Pacific compared to European/Other women of 2.61 (95 % CI, 2.22–3.05). Among all Pacific women, the incidence of endometrial cancer increased from 37.5/100,000 (95 % CI, 17.3–57.6) in 1981–1986 to 69.7/100,000 (95 %

CI, 55.1–84.2) in 2001–2004 but this was not statistically significant (Fig. 2; annual percentage change 1.5, *p for linear trend* = 0.175). The incidence rate of cervical cancers among Pacific women was 32.9/100,000 (95 % CI, 26.3–39.6) compared to 16.0/100,000 (95 % CI, 15.4–16.7) for European/Other women, with a pooled SRR of 2.05 (95 % CI, 1.67–2.52). Table 2 shows SRRs for these cancers by age group. For endometrial cancer, the association was considerably stronger for younger women (for women aged 25–44 years SRR = 6.36 (95 % CI, 4.39–9.22) compared with 2.85(95 % CI, 2.26–3.60) and 2.22 (95 % CI, 1.61–3.05) for women aged 45–64 years and 65+ years). In regard to cervical cancer, SRRs compared to European/Other appear to increase with increasing age (SRR = 1.21 (95 % CI, 0.90–1.64), 2.92 (95 % CI, 2.12–4.02), and 3.23 (95 % CI, 1.97–5.29) for women aged 25–44 years, 45–64, and 65+ years, respectively). Over time, rates of cervical cancer for all Pacific women aged 25+ years decreased (41.2/100,000 (95 % CI, 22.8–59.5) in 1981–1986 to 15.0/100,000 (95 % CI, 8.9–21.1) in 2001–2004, APC −1.8, $p = 0.02$). By age, there were significant reductions in cervical cancer incidence over time for all Pacific and European/Other age groups, except for Pacific women aged 65 years and over (4 % decrease ($p$trend = 0.62) versus 51 % decrease ($p$trend = 0.02) for their European/Other counterparts). Ovarian cancer was also highest for Pacific women with an age-standardized rate of 25.4/100,000 (95 % CI, 20.2–30.5) compared to 18.7/100,000 (95 % CI, 18.1–19.4) for European/Other women.

Smoking-related cancers

Lung cancer is the most important of this group, but cancers of the head and neck (including larynx, pharynx, nasal sinuses), bladder, pancreas, stomach, and cervix are also related to tobacco consumption [14]. Lung cancer is the second most common cancer for Pacific men with a rate 38 % greater than that of European/Other men (SRR, 1.38; 95 % CI, 1.21–1.57). Respective age-standardized incidence rates are 109/100,000 (95 % CI, 95–123) and 79.3/100,000 (95 % CI, 78.0–80.5). The rate for Pacific women was much lower at 36.2/100,000 (95 % CI, 29.8–42.6) compared to 33.1/100,000 (95 % CI, 32.4–33.9) for European/Other women, SRR = 1.09 (95 % CI, 0.91–1.31). Nonetheless, lung cancer rates among Pacific women have increased rapidly over time, from 16.8/100,000 (95 % CI, 4.9–28.6) in 1981–1986 to 57.9/100,000 (95 % CI, 43.5–72.3) in 2001–2004, APC 1.9, $p = 0.02$. There were no significant trends for Pacific men (APC 0.11, $p = 0.96$). Pacific men had higher rates of oral cancers (lip, mouth, and pharynx) than European/Other consistent with patterns of tobacco use (SRR, 1.49; 95 % CI, 1.13–1.98), but over time, rates have decreased (APC −1.05, $p = 0.04$). Rates for

Table 1 Age-standardized incidence rates (2001 WHO world standard population) for total cancers in Pacific and European/Other men and women (25+ years), pooled for 1981–2004 and standardized rate ratios (SRR) and rate differences (SRD) for all cancers in Pacific compared to European/Other men and women with 95 % confidence intervals

Site	Males				Females			
	Pacific	European/Other	SRR	SRD	Pacific	European/Other	SRR	SRD
Bladder	16.8 (9.7–24.0)	29.6 (28.8–30.4)	0.57 (0.37–0.87)	−13 (−20–5.5)	3.8 (1.5–6.1)	8.8 (8.4–9.2)	0.45 (0.24–0.81)	−4.7 (−7–2.4)
Brain	7.1 (4.5–9.7)	10.5 (10.0–11.1)	0.67 (0.46–0.98)	−3.4 (−6.1–0.8)	4.8 (2.7–6.9)	7.1 (6.6–7.5)	0.66 (0.43–1.03)	−2.5 (−4.6–0.3)
Breast					129 (118–141)	144 (142–146)	0.90 (0.82–0.98)	−15 (−26–3)
Cervix					32.9 (26.3–39.6)	16.0 (15.4–16.7)	2.05 (1.67–2.52)	17 (10–24.0)
Colorectal	43.7 (35.0–52.4)	99.1 (97.6–101)	0.44 (0.36–0.54)	−55 (−64–47)	38.6 (31.2–45.9)	82.7 (81.4–83.9)	0.42 (0.31–0.58)	−44 (−52–37)
Endometrium					46.7 (39.4–53.9)	17.9 (17.3–18.5)	2.61 (2.22–3.05)	29 (21–36)
Gallbladder, bile duct	4.8 (2.6–7.0)	2.6 (2.4–2.9)	1.99 (1.24–3.18)	2.4 (0.2–4.6)	4.3 (2.4–6.1)	3.2 (3.0–3.5)	1.34 (0.86–2.09)	1.1 (−0.8–3)
Hodgkin's disease	1.9 (0.7–3.1)	3.2 (2.8–3.5)	0.57 (0.30–1.11)	−1.4 (−2.7–0.1)	1.4 (0.5–2.3)	2.0 (1.7–2.3)	0.62 (0.33–1.19)	−0.9 (−1.8–0.1)
Kidney	7.7 (3.7–11.7)	14.0 (13.5–14.6)	0.55 (0.33–0.93)	−6.3 (−10–2.2)	5.3 (3.1–7.5)	8.4 (8.0–8.8)	0.70 (0.46–1.06)	−2.3 (−4.5–0.1)
Larynx, nasal, ear, sinus	8.9 (4.3–13.5)	7.1 (6.7–7.5)	1.25 (0.74–2.12)	1.8 (−2.8–6.4)	3.1 (0.4–5.9)	1.4 (1.3–1.6)	2.32 (0.97–5.56)	1.8 (−0.9–4.5)
Leukemia	20.0 (14.4–25.6)	20.6 (19.9–21.2)	1.05 (0.79–1.40)	1.0 (−4.7–6.6)	12.7 (9.0–16.5)	12.2 (11.7–12.6)	1.09 (0.81–1.47)	1.1 (−2.7–4.8)
Lip, mouth, pharynx	23.7 (17.0–30.3)	15.9 (15.3–16.5)	1.49 (1.13–1.98)	7.8 (1.2–14)	7.7 (4.8–10.6)	6.6 (6.2–7.0)	1.16 (0.79–1.71)	1.1 (−1.9–4)
Liver	30.3 (24.6–36.0)	4.1 (3.8–4.4)	7.41 (6.06–9.07)	26 (20–32)	9.8 (6.4–13.2)	2.1 (1.9–2.3)	4.88 (3.34–6.89)	7.7 (4.3–11)
Lung	109 (95–123)	79.3 (78.0–80.5)	1.38 (1.21–1.57)	30 (16–44)	36.2 (29.8–42.6)	33.1 (32.4–33.9)	1.09 (0.91–1.31)	3.1 (−3.4–9.5)
Melanoma	6.6 (2.6–10.6)	57.7 (56.5–58.9)	0.11 (0.06–0.21)	−79 (−84–73)	5.7 (3.4–8.1)	60.0 (58.7–61.2)	0.10 (0.06–0.14)	−72 (−78–66)
Myeloma	18.9 (12.6–25.1)	8.4 (8.0–8.8)	2.24 (1.60–3.12)	10 (4.2–17)	8.8 (5.9–11.6)	5.5 (5.1–5.8)	1.66 (1.19–2.30)	3.5 (0.6–6.3)
Non-Hodgkin's Lymphoma	21.4 (20.0–22.7)	22.8 (21.1–24.5)	1.11 (0.66–1.86)	2.1 (−9.4–14)	14.6 (13.5–15.8)	15.5 (13.9–17.1)	1.23 (0.96–1.56)	3.6 (−1.1–8.3)
Esophagus	8.8 (5.2–12.5)	10.5 (10.1–11.0)	0.86 (0.57–1.31)	−1.4 (−5–2.3)	2.5 (0.8–4.1)	4.6 (4.3–4.8)	0.54 (0.28–1.05)	−2.1 (−3.8–0.5)
Ovarian					25.4 (20.2–30.5)	18.7 (18.1–19.4)	1.35 (1.10–1.66)	6.6 (1.5–12)
Pancreas	20.2 (12.7–27.7)	12.8 (12.3–13.3)	1.58 (1.09–2.29)	7.4 (−0.1–15)	11.4 (6.5–16.3)	9.2 (8.8–9.6)	1.24 (0.81–1.91)	2.2 (−2.7–7.1)
Prostate	130 (114–146)	137 (135–138)	0.95 (0.84–1.08)	−18 (−49–13)				
Stomach	49.8 (38.9–60.8)	18.9 (18.2–19.5)	2.64 (2.11–3.30)	31 (20–42)	22.2 (16.3–28.0)	8.4 (8.0–8.8)	2.64 (2.02–3.44)	14 (7.9–20)
Testicular*	3.9 (1.9–5.9)	8.2 (7.7–8.6)	0.47 (0.28–0.80)	−4.3 (−6.4–2.2)				
Thyroid*	2.7 (1.3–4.1)	2.2 (2.0–2.4)	1.27 (0.74–2.18)	0.6 (−0.9–2)	18.5 (14.6–22.4)	5.2 (4.8–5.5)	3.58 (2.87–4.47)	13 (9.4–17)

* 15+ years

Fig. 1 **a** Standardized rate ratios (SRR) by cancer for Pacific women compared with European/Other women (squares denote point estimates and horizontal lines are 95 % confidence intervals). **b*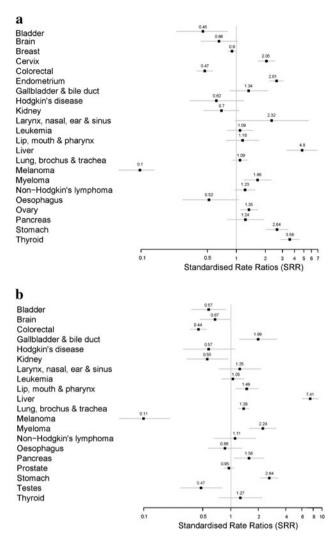* Standardized rate ratios (SRR) by cancer for Pacific men compared with European/Other men (squares denote point estimates and horizontal lines are 95 % confidence intervals)

larynx, nasal, ear and sinus cancers were elevated for Pacific men and women but confidence intervals for rate ratios included one (SRR 1.25 (95 % CI, 0.74–2.12) for men and 2.32 (95 % CI, 0.97–5.56) for women). In contrast to other smoking-related cancers, compared with European/Other, Pacific men and women had lower incidence rates for bladder cancer (SRRs = 0.57; 95 % CI, 0.37–0.87 for men and 0.45; 95 % CI, 0.24–0.81 for women).

Cancers of the stomach, pancreas, and cervix are discussed elsewhere.

Gastrointestinal and hepatobiliary cancers

Pacific people had higher rates for cancer of the stomach, liver, pancreas, gallbladder, and bile duct. Stomach cancer

was the third most commonly diagnosed cancer for Pacific men with an incidence rate of 49.8/100,000 (95 % CI, 38.9–60.8) compared to 18.9/100,000 (95 % CI, 18.2–19.5) for European/Other men (SRR = 2.64; 95 % CI, 2.11–3.30). A similar picture was seen among females although the corresponding incidence rates were much lower at 22.2/100,000 (95 % CI, 16.3–28.0) and 8.4/100,000 (95 % CI, 8.0–8.8) (SRR = 2.64; 95 % CI, 2.02–3.44). In regard to liver cancer, rates among Pacific men and women were 30.3/100,000 (95 % CI, 24.6–36.0) and 9.8/100,000 (95 % CI, 6.4–13.2), respectively, versus 4.1/100,000 (95 % CI, 3.8–4.4) and 2.1/100,000 (95 % CI, 1.9–2.3) for their European/Other counterparts. This meant that rates of liver cancer were over seven and four times greater for Pacific than European/Other men and women, respectively (SRR, 7.41; 95 % CI, 6.06–9.07 and 4.80; 95 % CI, 3.34–6.89). Pancreatic cancer incidence rates were higher for Pacific (20.2/100,000; 95 % CI, 12.7–27.7) than European/Other men (12.8/100,00; 95 % CI, 12.3–13.3), to give an SRR of 1.58; 95 % CI, 1.09–2.29. Gallbladder and bile duct cancer incidence rates were generally low but the incidence rate in Pacific men (4.8/100,000; 95 % CI, 2.6–7.0) was double the European/Other rate (2.6/100,000; 95 % CI, 2.4–2.9), SRR = 1.99 (95 % CI, 1.24–3.18). While Pacific women had elevated rate ratios for pancreatic, gallbladder, and bile duct cancers compared to European/Other, confidence intervals for rate ratios included one (Table 1). There were no clear patterns in terms of trends over time.

Other cancers

Thyroid cancer was elevated for Pacific females only. Incidence rates for females aged 15+ were 18.5/100,000 (95 % CI, 14.6–22.4) among Pacific women and 5.2/100,000 (95 % CI, 4.8–5.5) for European/Other women (SRR = 3.58; 95 % CI, 2.87–4.47).

Pacific men and women had higher rates for myeloma than European/Other (SRR = 2.24 for men; 95 % CI, 1.60–3.12 and 1.66 for women; 95 % CI, 1.19–2.30).

Cancers for which Pacific people had lower rates

In terms of incidence, breast cancer is the most important malignancy for Pacific females albeit at a rate that is 10 % less than European/Other women in New Zealand overall. However, when disaggregated by age, the rate for those aged 25–44 years is higher for Pacific than European/Other women with a standardized rate ratio of 1.16 (95 % CI, 1.01–1.35) (Table 2). Incidence rates for total Pacific women did not show any statistically significant change over time (APC 1.5, p = 0.38), but an 87 % increase in
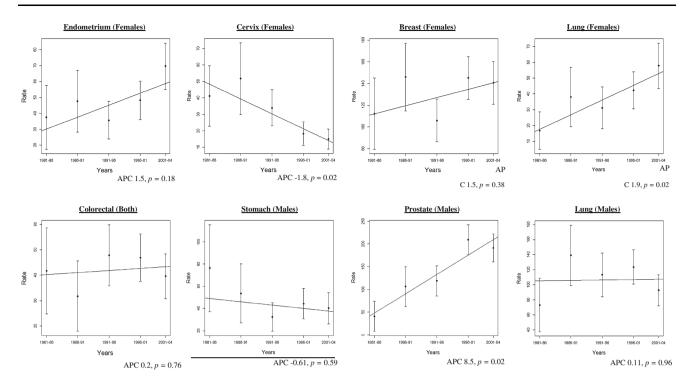
Fig. 2 Age-standardized incidence rates and 95 % confidence intervals over time, regression lines and annual percentage changes (APC) for selected cancers in Pacific men and women

Table 2 Incidence rates for breast, cervical, and endometrial cancers in Pacific and European/Other women and standardized rate ratios (SRR) with 95 % confidence intervals, disaggregated by age

Site	Age group	Pacific	European	SRR
Breast	25–44 years	63.9 (54.8–73.0)	54.9 (53.0–56.8)	1.16 (1.01–1.35)
	45–64 years	216 (189–244)	231 (226–235)	0.94 (0.82–1.07)
	65+ years	218 (170–265)	282 (277–288)	0.77 (0.62–0.96)
Cervix	25–44 years	18.5 (13.1–23.8)	15.2 (14.2–16.2)	1.21 (0.90–1.64)
	45–64 years	51.3 (35.3–67.3)	17.6 (16.3–18.8)	2.92 (2.12–4.02)
	65+ years	55.5 (28.5–82.4)	17.2 (15.7–18.6)	3.23 (1.97–5.29)
Endometrium	25–44 years	13.2 (8.9–17.5)	2.0 (1.6–2.3)	6.36 (4.39–9.22)
	45–64 years	79.8 (61.6–98.1)	28.0 (26.6–33.2)	2.85 (2.26–3.60)
	65+ years	113.0 (77–148)	50.8 (48.3–53.3)	2.22 (1.61–3.05)

* SRR for Pacific relative to European/Other women

breast cancer for Pacific women over 65+ years reached statistical significance ($p < 0.01$).

For men, the cancer with the highest incidence rate was prostate cancer with a standardized incidence rate of 130/100,000 (95 % CI, 114.0–146.0) compared to 137/100,000 (95 % CI, 135.0–138.0) for European/Other men (SRR = 0.95; 95 % CI, 0.84–1.08). There was a marked increase in the incidence of prostate cancer over time for Pacific men from 41.0/100,000 (7.8–74.1) in 1981–1986 to 191/100,000 (160–222) in 2001–2004, APC 8.5, $p = 0.02$.

Despite the colorectal cancer being the most commonly diagnosed malignancy in New Zealand, Pacific people had a

rate approximately 50 % less than that of European/Other people with standardized rate ratios of 0.44 (0.36–0.54) and 0.47 (95 % CI, 0.39–0.57) for men and women, respectively. There were no statistically significant trends over time for Pacific people. By age group, Pacific men over 65 years experienced the largest increase over time (626 %, $p = 0.05$) compared to 34 % for European/Other ($p < 0.01$).

Other cancers for which Pacific people had lower rates include cancers of the brain, kidney, esophagus and testes, melanoma and Hodgkin's disease (Table 1; Fig. 1).

There were no substantive differences between Pacific and European/Other rates for leukemia.

Discussion

There are crucial disparities in cancer incidence between Pacific and European/Other people living in New Zealand. For Pacific males, cancers that are a major source of inequality are associated with tobacco consumption (lung and oral cancers) or due to a persistent burden of infectious disease (liver and stomach). Pacific females have higher rates of invasive gynaecological malignancies (endometrial, cervical, ovarian) which may be related to different distributions of hormone related risk factors (such as obesity, child bearing), and/or access to screening (for cervical cancer). Breast and prostate cancers are the leading cancers for Pacific women and men, respectively.

For the remainder of this discussion, we have looked at specific cancers, in relation to risk factors and screening, and grouped into the following:

1. Cancers for which there are large disparities between Pacific and European people
2. Cancers of importance to Pacific people in terms of incidence rates

Gynaecological cancers

In other developed countries, endometrial cancer has been recognized as a disease of white women [15]. The pattern seen in New Zealand is in contrast to this. Pacific women have the highest rates of endometrial cancer in New Zealand with a risk over double that of European/Other women (RR, 2.61; 95 % CI, 2.22–3.05). Known risk factors for this disease are obesity, diabetes, nulliparity, early menarche, late menopause, and exogenous unopposed estrogen [16–18]. Physical activity is protective with many high-quality studies showing risk reductions of 20 % or more with high levels of physical activity and dose-dependent relationships [19]. Although they are less likely to be nulliparous than European/Other women, Pacific women in New Zealand have the highest rates of obesity and diabetes, and lower levels of physical activity compared to any other ethnicity [20].

While diabetes and obesity are important for hormone dependent cancers such as endometrial (and breast) due to alterations in the hormonal milieu, their role in ovarian cancer has been less convincing [21]. In a systematic review, obesity (BMI > 30 kg/m^2) was found to increase the risk for developing epithelial ovarian cancer by 30 % (RR = 1.30; 95 % CI, 1.12–1.50) compared to those with a normal BMI (<25 kg/m^2) [22]. There is a large body of evidence for lack of an association between diabetes and ovarian cancer [23–26]. Physical activity may have a protective role [27]. Other protective factors include higher parity, lactation, combined oral contraceptive use,

hysterectomy (with ovarian conservation) and tubal ligation [28–30]. The protective nature of pregnancy, breast-feeding, and contraceptive use support the theory of "incessant ovulation" which suggests that the risk of epithelial ovarian cancer is increased through the repetitive ovulatory trauma and exposure to estrogen which stimulates epithelial proliferation and malignant transformation [31, 32]. Certainly, Pacific women in New Zealand are more likely to be multiparous than European/Other women and are also more likely to breastfeed, both of which should be protective [33]. Fertility rates for the census year 2006 were 3.0 and 1.9 births per woman for Pacific and European/Other women, respectively [33]. In regard to the protective effect of hysterectomy (with ovarian conservation), there is no recent data in the literature regarding hysterectomy rates by ethnicity in New Zealand but there is some evidence that increasing parity is strongly associated with risk of hysterectomy in New Zealand and that women with high school or University qualifications are less likely to have a hysterectomy than women who do not [34]. Based on these risk factors, it would seem that Pacific women should have a lower ovarian cancer risk profile than that of European/Other women in New Zealand, yet the risk is 35 % greater (RR, 1.35; 95 % CI, 1.10–1.66), a finding that remains unexplained.

Pacific women in New Zealand have twice the rate of cervical cancer than European/Other women (RR, 2.05; 95 % CI, 1.67–2.52). Over time, a 64 % reduction in cervical cancer for all Pacific women is reassuring; however, it seems Pacific women over 65 years have not enjoyed the same gains. Pacific and Maori women in New Zealand have consistently had low cervical screening participation rates since the institution of the National Cervical Screening Program (NCSP) [35]. While this is improving, 3-year coverage rates to December 2009 for women aged 20–69 years was 69.9 % for Pacific, 68.6 % for Maori and 78.6 % for European/Other [36]. In 2009, New Zealand implemented an HPV immunization program in an effort to combat this highly preventable disease. All girls and young women born from 1 January 1990 are eligible for free HPV immunization. This has been very successful among eligible Pacific females with a rate of 70 % achieved in the year to December 2010 compared to a national average of 46 % [29]. A continued effort to improve cervical screening and HPV immunization uptake is important among Pacific women to reduce inequalities.

Smoking-related cancers

Disparities in lung cancer incidence reflect the differences in tobacco consumption by ethnicity. Although Pacific women have had much lower rates of lung cancer than Pacific men, they have experienced a rapid and statistically

significant increase over time. These patterns are consistent with those seen internationally whereby rates are higher for men than women and while men are reaching (or have reached) the peak of this lung cancer epidemic, incidence rates are still rising for women in many parts of the world [37, 38]. This is reflective of phased tobacco epidemics that affect men before women [39]. In New Zealand, tobacco control among Maori and Pacific has been a major focus in the last two decades and the New Zealand government has recently agreed to a goal of phasing tobacco out of the country by 2025 [40].

Several other cancers are associated with tobacco consumption, most notably bladder, head and neck, and esophageal cancers, but also cervical, kidney, pancreas, and stomach cancers [14, 41]. Consistent with the pattern with lung cancer, Pacific people appeared to have somewhat elevated risks of head and neck, pancreatic, and stomach cancers (see below) compared with European/Other people. However, in contrast to this, Pacific people were found to have significantly lower rates of bladder, kidney, and esophageal cancers. It is not clear why this might be the case.

Gastrointestinal and hepatobiliary cancers

In 1980, gastric cancer was the most frequently diagnosed malignancy globally but since then incidence rates have decreased steadily [42], probably partly due to identification of important environmental risk factors such as food preservation and storage, fruit and vegetable intake and eradication of *Helicobacter pylori*, but also probably due to increasing living standards and lesser crowding. Nonetheless, it is the second most common cause of cancer death worldwide [43]. Rates in New Zealand have decreased over time across all ethnic groups but it remains an important disease for Pacific men. Internationally, *H. pylori* is thought to play a role in ~60 % of gastric cancer cases [44], and it is probably also a major contributor among Pacific people. Infection in childhood seems to be important and is pervasive in high-risk cancer regions compared to low-risk areas where infection later in life is more common. In New Zealand, differences by ethnicity for *H. pylori* seropositivity are significant. A study of patients presenting for endoscopy in South Auckland to investigate dyspepsia yielded seropositivity rates of 45, 85, and 90 % for European/Other, Māori, and Pacific people, respectively [45]. A cross-sectional study in South Auckland examining *H. pylori* prevalence in school children aged 11–12 years and workforce participants aged 40–64 years contributed further to this [46]. Among 255 samples of children studied, 7 % of European/Other children were seropositive, compared to 21 % of Māori and 48 % of all Pacific children. When the latter was looked at by

subpopulation, Tongan children had a prevalence of 71 % and Samoan children 50 %. Household crowding is strongly associated with *H. pylori* infection both in children and adults [47]. *H. pylori* is a risk factor for non-cardia gastric cancer but is inversely associated with malignancy arising in the gastric cardia [48]. Over recent times, there has been a rapid increase in the incidence rates of gastric adenocarcinoma at the cardia reported in the UK, Switzerland, Sweden, and Australia. Increasing levels of obesity and resultant reflux esophagitis are likely to be contributory [49]. Ironically, with improvements in living conditions which should reduce the rate of gastric cancer related to chronic infection, affluence and Westernization among Pacific may well present a further challenge in this disease.

Liver cancer is the third leading cause of cancer death worldwide and most people who develop it will die within 1 year [50]. Hepatocellular carcinoma (HCC) is the most common histological type of primary liver cancer [51]. HCC is 2–4 times more common in men than women [52]. Based on the prevalence of HBsAg status among HCC cases in New Zealand, it is estimated that chronic Hepatitis B infection accounts for 82.7 % of the difference seen between Pacific and European/Other people [53]. In 1988, a universal vaccination program for Hepatitis B was introduced in New Zealand [54] and this vaccinated cohort, now in their early 20s, will not have contributed to the incidence as yet but New Zealand should see HCC due to chronic HBV infection decrease over time. However, there is now burgeoning evidence for causal associations between diabetes, overweight, obesity, and liver cancer [55, 56].

There is a growing body of literature supporting a link between non-alcoholic steatohepatitis (NASH) and HCC [57, 58]. NASH is a form of metabolic liver disease characterized by hepatic steatosis with chronic inflammatory changes and progressive hepatic fibrosis. Risk factors are type II diabetes mellitus, obesity, central adiposity, hypertriglyceridaemia, and age. In New Zealand and Australia, NASH constitutes the largest proportion of patient referrals to liver clinics and surpasses HBV, HCV, and alcoholic liver disease [59]. In the United States, where increasing incidence rates of HCC are thought to parallel the obesity epidemic, NASH is now the most common cause of end-stage liver disease [60]. Concerningly, NASH may predispose to hepatocellular carcinoma without cirrhosis (and without HCV or HBV infection) [61, 62] and this risk may be higher in men who are less likely than women to be cirrhotic and, in fact, develop HCC at an earlier stage of liver fibrosis [58]. The prevalence of NASH in New Zealand is unknown. However, with risk factors for this liver disease highest among Pacific people, vigilance is required in order to prevent escalating rates of HCC related to metabolic liver disease.

Smoking, diabetes and overweight/obesity are important risk factors for pancreatic cancer [63]. Diabetes and obesity are also associated with an increase in risk for colorectal and esophageal cancers. Despite a higher prevalence of these risk factors in Pacific people compared to European/Other, incidence rates of both these malignancies are lower for Pacific people. New Zealand has one of the highest incidence rates of colorectal cancer in the developed world [33]. Pacific people in New Zealand have consistently had lower rates than European/Other, and, with the exception of Hawaii, colon cancer is relatively rare in people living in the Pacific Islands [64, 65]. Etiological hypotheses regarding diet, that is, alcohol, total fat, red meat, low vegetable and fruit intake, are not supported by the pattern of colorectal cancer in New Zealand [66]. While this applies to Māori and non-Māori comparisons in New Zealand, not enough is known about dietary changes over time among Pacific people in New Zealand to comment.

Other

Descriptions of the international variation in thyroid cancer incidence during the 1980s reported the highest rates worldwide among females of Polynesian and Melanesian heritage, particularly women from Hawaii and New Caledonia [67]. There is a female preponderance for this disease, which may reflect important sex hormone effects. There are several papers that lend support to an important association between papillary thyroid cancer risk and menstrual and reproductive history [68, 69]. However, little is known about why Pacific people have higher rates of this disease.

Myeloma is a rare cancer. There are few identifiable risk factors although it is more common with age and has a twofold higher incidence among African Americans than whites [70]. There is evidence of a weak association between obesity and myeloma [71].

The lower rate of kidney cancer for Pacific people, in light of known risk factors (i.e., smoking, obesity, and end-stage renal disease), is surprising, but kidney cancer has also been reported to be relatively infrequent in the Pacific Islands [61]. Similarly, low rates of testicular cancer have been found in many Pacific populations, but it is not clear why this might be the case. (To add to the paradox, testicular cancer rates are comparatively high among Māori) [72]. Risk factors for Hodgkin's disease and brain cancers are not entirely clear although Hodgkin's disease is associated with higher socioeconomic status [73], and brain cancer is more common in whites than blacks in the United States [74]. European/Other people have higher rates than Pacific people for both of these cancers in New Zealand. Lower rates of melanoma for Pacific people are to be expected.

Cancers of importance to Pacific people in terms of incidence rates

Prostate cancer has the highest incidence of any cancer among Pacific men, and breast cancer for Pacific women. While Pacific rates of these two cancers are somewhat lower than European rates, these are still clearly very important for Pacific people.

Breast

The somewhat lower rate of breast cancer among Pacific women is largely in keeping with known risk (or protective) factors for this disease [75]. That is, Pacific women are more likely to bear children at an earlier age than European/Other women and be multiparous [33]. The incidence rate of breast cancer in the 25–44 year age group is higher for Pacific women compared to European/Other women, which may be due to the early cancer-promoting effect of pregnancy [75]. In New Zealand, Pacific women are more likely to be younger than European/Other women at diagnosis, present with more advanced disease [76] and have prognostic phenotypes [77], which are associated with worse disease-free and overall survival [78].

Furthermore, breast screening 2-year coverage rates to November 2010 were below target for Pacific women in New Zealand at 62 % (compared to 56 % for Māori and 69.9 % for European/Other) [79]. Māori and Pacific women have been recognized by Breastscreen Aotearoa as priority populations. Poor screening coverage will result in under diagnosis, and poorer outcomes of disease among these populations.

Overweight and obesity are associated with postmenopausal breast cancer although there is an inverse association for premenopausal breast cancer [80, 81]. Diabetes also increases the risk for developing breast cancer [82]. With increasing rates of obesity and diabetes among Pacific people in New Zealand, the challenge will be to prevent incidence rates of breast cancer from rising.

Prostate

Escalating incidence rates of prostate cancer was observed for both Pacific and European/Other groups over time, but was larger for Pacific men. It is possible this may be related to increased detection of latent tumors as a result of more attentive PSA testing in the community. Nonetheless, while there is no evidence of differences in PSA testing or digital rectal examination (DRE) by ethnicity in New Zealand, there is evidence that PSA testing and DRE are influenced by social class, with those from the lowest socioeconomic group 70–75 % less likely to have a DRE or PSA test than those from the highest social class [83]. An audit of men presenting to Auckland Hospital for prostatic biopsies for

prostate cancer in the 2-year period from 2005 to 2006 found that there was no difference in Gleason score at presentation between Pacific, Maori, and European men but that Pacific and Maori men were more likely to have clinically palpable disease on digital rectal exam suggesting more advanced disease [84]. Pacific and Māori men are less likely to report urinary symptoms than European/Other men [85]. The corollary then is that Pacific and Māori men are likely to be underdiagnosed compared to European men with prostate cancer.

Summary

Pacific people in New Zealand are facing a critical transition. While they continue to experience a disproportionate cancer burden related to infectious agents (e.g., stomach and liver), a new epidemic of cancer associated with diabetes, obesity and physical inactivity is emerging. Pacific people have the highest rates of obesity, including childhood obesity, and diabetes in New Zealand. This is a cause for concern and supports population approaches to reducing these risk factor exposures, improving household conditions (such as overcrowding) and ongoing tobacco control efforts. Disparities in preventable cancers are often inequitable [8, 86]. Where people are limited in the lifestyle choices they are able to make, that is, obesogenic environments and diets, this should be viewed as inequitable also. In addition to a reduction in the burden of cancer that would result from population approaches to lifestyle and behavioral modifications, society will also see improvements in cardiovascular and cerebrovascular disease. Greater effort and resources are required to drive change in order to gain these public health improvements.

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