Cancer incidence, mortality and survival for Pacific Peoples in Aotearoa New Zealand

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ABSTRACT

AIMS: Pacific Peoples comprise over 16 culturally diverse ethnic groups and experience a disproportionate burden of preventable cancers, attributable to infectious diseases and obesity. This study aims to provide updated evidence on cancer incidence, mortality and survival rates among Pacific Peoples in Aotearoa New Zealand.

METHODS: The study extracted incident cases of cancer diagnosed between 2007–2019 from the New Zealand Cancer Registry (NZCR) and linked them to the national Mortality Collection to determine individuals who died of cancer over the study period. The study also compared cancer survival rates between Pacific and European peoples in Aotearoa New Zealand. The most commonly diagnosed cancers and the most common causes of cancer death among Pacific Peoples were identified, and key findings were summarised. The European population was utilised as the comparator group for the analyses. The study employed a total ethnicity approach, wherein anyone with a record of Pacific ethnicity was classified as Total Pacific, regardless of other ethnicities. The age- and sex-standardised incidence and mortality rates were calculated, and 1-, 3- and 5-year survival rates determined. We used Cox proportional-hazards models to compare survival outcomes between Pacific and European peoples.

CONCLUSIONS: The study results revealed that Pacific Peoples in Aotearoa New Zealand experience higher cancer incidence and a lower survival rate for several cancers, including lung, liver and stomach cancers, when compared to the European population. This study underscores the need for intervention to reduce the burden of cancer among Pacific Peoples and improve cancer outcomes. This study's findings can inform planning and delivery of interventions to achieve equitable outcomes across the cancer continuum for Pacific Peoples in Aotearoa New Zealand.

Pacific Peoples in Aotearoa New Zealand encompass over 16 culturally diverse and linguistically distinct ethnic groups,[1] and comprise 8% of the population in Aotearoa New Zealand.[2] There is some evidence that Pacific Peoples experience excess cancer incidence and mortality, as well as poorer survival for several cancers, when compared to other ethnic groups in Aotearoa New Zealand.[3,4,5] There is also evidence that Pacific Peoples experience a disproportionate burden of preventable cancers, attributable to infectious diseases and obesity.[6] Major contributors to these disparities have been attributed to underlying upstream determinants, including poverty, inadequate housing, inequities of access, and timeliness and quality of care along the cancer diagnosis and treatment pathways.[7] However, the fuller extent of these cancer disparities, and their drivers, remain under-explored and poorly understood.

A collaborative approach has been suggested as the best means of improving cancer outcomes for Pacific Peoples, both within Ola Manuia: Pacific Health and Wellbeing Action Plan 2020–2025[1] and the New Zealand Cancer Action Plan 2019–2029,[8] with the latter having the goal of reducing cancer disparities and achieving equitable outcomes across the cancer continuum. In order to help guide activities that aim to reduce the cancer burden for Pacific Peoples, we need to understand where the need for intervention is currently greatest. As such, there is need for updated research that draws together current evidence on cancer incidence, mortality and survival, in order to inform planning and delivery of interventions that reduce the burden of cancer for Pacific Peoples.

This study provides evidence of the most commonly diagnosed cancers among Pacific Peoples in Aotearoa New Zealand between 2007–2019, in addition to the most common causes of cancer death. We also compare cancer survival between European and Pacific Peoples in Aotearoa New Zealand. Finally, we summarise our key findings and consider their implications regarding cancer prevention, care access and outcomes for Pacific Peoples in Aotearoa New Zealand.

Methods

Data sources

We extracted all incident cases of cancer diagnosed between 2007–2019 from the New Zealand Cancer Registry (NZCR). The NZCR is a nationally mandated record of all cancers diagnosed in Aotearoa New Zealand, excluding basal and squamous cell skin cancers.[9] We then linked these data to the national Mortality Collection to determine the individuals who died of their cancer over the study period for the purposes of survival analysis. In addition, we extracted all deaths where cancer was listed as the underlying cause from the Mortality Collection to identify all cancer deaths. Because cause-of-death data was only available until the end of 2018, mortality and survival analyses are restricted to 2007–2018.

Variables

Ethnicity at the time of cancer registration was derived from the NZCR for cancer incidence and survival analysis and the Mortality Collection for mortality analysis. We also supplemented ethnicity data from the Mortality Collection with data from the NZCR to maximise ethnicity data completeness. We utilised a modified version of the total ethnicity approach to attribute ethnicity, wherein anyone with a record of Pacific ethnicity was classified as Total Pacific, while those who only have a record of European ethnicity (i.e., non-Pacific/Māori/Asian/Other ethnicities, or sole European) were classified as European. The European group was used as the comparator population, given their status as the majority population within Aotearoa New Zealand.[9] We have purposely chosen to exclude Māori and Asian peoples from the comparator group for two reasons: 1) the existence of stark differences in cancer rates for several key cancers between the majority European population and other ethnic groups (particularly Māori),[10] and 2) consistency with how cancer data for Pacific Peoples have been presented previously.[4,6] The total ethnicity approach was adopted in favour of a prioritised ethnicity approach because prioritised ethnicity prioritises Māori ethnicity over Pacific,[11] which means that those who identify as both Māori and Pacific would not be included in the Pacific group if we were to utilise a prioritised ethnicity approach. Using a total ethnicity approach ensures that all people recorded as Pacific are included in the Total Pacific group, regardless of whether they are also recorded as another ethnicity.

No restriction was placed on **New Zealand residency status**, which allowed for the inclusion of those Pacific (and non-Pacific) peoples diagnosed with their cancer within Aotearoa New Zealand while holding residency in another country. **Cancer type** (e.g., lung cancer) was determined utilising the International Classification of Diseases (ICD) codes on the NZCR. In the case of breast cancer, only female breast cancer cases were included in the analysis.

Statistical analysis

Numerators and denominators

For cancer incidence, our numerator data was the number of cases over the study period, as determined by the NZCR. For mortality, numerator data was the number of deaths where a given cancer was listed as the underlying cause of death within the Mortality Collection. In terms of denominators, age-stratified denominator data for Pacific and European peoples were derived from the usual resident population counts from the 2013 Census,[12] derived from Statistics New Zealand.[13] The 2013 Census population was chosen as the denominator because it is a midpoint within the study period (2007–2019).

Descriptive analysis

In terms of descriptive analysis, we used the NZCR to determine the total number of new cancer cases and incidence rates, with a focus on the top 10 cancers that were the most commonly diagnosed among Pacific Peoples over the study period on the NZCR (based on absolute counts). Similarly, we utilised the Mortality Collection to determine the number of cancer deaths and mortality rates among our cohort, focusing on the top 10 most common cancers listed as an underlying cause of death among Pacific Peoples within the Mortality Collection.

Age- and sex-standardisation

We employed the use of direct age standardisation to calculate age- and sex-standardised cancer incidence rates (SIR) and standardised mortality rates (SMR), along with their 95% confidence intervals (CIs),[14] utilising the World Health Organization (WHO) world standard population as the standard. We used this standard population for two reasons: 1) the WHO world standard population has a similarly young age structure to the Pacific population, which in turn has a younger age structure than the European population;[9] choosing the WHO standard population

normalises this more youthful age structure, and 2) the WHO world standard population was also utilised by Meredith et al. in their previous examination of cancer trends among Pacific Peoples,[6] maximising our ability to compare findings between studies. In those cases where incidence and mortality rates are presented by sex, the denominator and standard population used for these rates are sex specific.

Survival analysis

Kaplan–Meier analysis was utilised to determine 1-, 3- and 5-year cancer-specific survival for Pacific and European peoples separately by cancer type. Cox proportional-hazards modelling was then used to describe the extent to which Pacific Peoples are more or less likely to die of their cancer than Europeans, adjusted for age (continuous variable) and sex. These results were described using hazard ratios (HR), along with their 95% confidence intervals (CIs), with Europeans as the reference group.

All analyses were conducted in SAS v9.4 (SAS Enterprises Inc.) and Microsoft Excel (Microsoft Corporation). Ethical approval was sought and received from the University of Otago Human Ethics Committee, reference HD23/005. The study was led by a Pacific researcher (TC), supported by Pacific (IM and DS-P) and non-Pacific researchers (JG).

Results

What are the most commonly diagnosed cancers among Pacific Peoples in Aotearoa New Zealand?

Incidence rates and rate differences are shown for the total population (Figure 1) and separately for males and females (Appendices 1 and 2). Among Pacific Peoples, the most commonly diagnosed cancer in terms of absolute numbers of cases was breast cancer, with 166 cases per year, followed by prostate (105/year), lung (104/year) and uterine (79/year).

In terms of age- and sex- standardised incidence rates, the highest were breast (SIR: 127/100,000 Pacific women per year) and prostate cancer (109/100,000 Pacific men per year), followed by lung (50/100,000 total Pacific Peoples) and uterus (61/100,000 Pacific women). The other 10 most common types of cancer, such as colorectal, stomach, liver, non-Hodgkin's lymphoma, leukaemia, thyroid and endocrine ranged from 12–32/100,000 Pacific Peoples. The top three most commonly diagnosed cancers among Pacific females were breast cancer (127/100,000 Pacific females), followed by uterus (61/100,000) and lung (34/100,000). For Pacific males, the three most commonly diagnosed cancers were prostate (109/100,000 Pacific males), followed by lung (65/100,000) and colorectal (39/100,000; Figure 1). Compared to the European population, Pacific Peoples had a higher incidence of most of these cancers, particularly uterine (SRD 48) and lung (SRD 25). Pacific Peoples were less likely to be diagnosed with colorectal (SRD females -15, males -13) and prostate (SRD -2; Figure 1).

What are the most common causes of cancer death for Pacific Peoples in Aotearoa New Zealand?

We determined the mortality rates and rate differences for the total population (Figure 2), and separately for males and females (Appendices 3 and 4). In terms of absolute numbers, lung cancer was the most common cause of cancer death among Pacific Peoples, with 72 deaths per year (SMR 35/100,000), followed by breast (34 deaths/year, SMR: 27/100,000 Pacific women) and colorectal (29 deaths/year, SMR: 13/100,000). The remainder of the top 10 cancers (uterus, prostate, stomach, liver, pancreas, ill-defined, leukaemia) caused between 15–23 deaths per year (SMR: 7–20/100,000). The three most common causes of cancer death for Pacific females were breast cancer (27/100,00), lung (22/100,000) and uterus (13/100,000). The three most common causes of cancer death among Pacific males were lung (SMR: 47/100,000), prostate (20/100,000) and liver (16/100,000; Figure 2). Compared to Europeans, Pacific Peoples were more likely to die of all of these cancers, particularly lung (SRD: 26) and uterine (SRD: 11), but less likely to die of colorectal cancer (SRD females -5, SRD males -4; Figure 2).

There was strong overlap between the incidence and mortality data, with eight of the top 10 cancers occurring on both lists. A summary of annual cases, incidence rates and mortality rates is shown in Appendix 5.

Survival

Results from our analysis of cancer survival are shown in Table 1 and Figure 3. We found that Pacific Peoples had poorer cancer survival than Europeans for multiple cancers. The strongest disparity was found for leukaemia (age-sex-adjusted hazard ratio [HR]: 2.1, 95% CI 1.8–2.5), cervix (HR: 1.8, 95% CI 1.3–2.3), breast (HR: 1.7, 95% CI 1.5–1.9) and uterine cancers (HR: 1.7, 95% CI 1.5–2.0). We noted negligible differences in

Figure 1: Age- and sex-standardised incidence rate (SIR) and absolute numbers of annual cases for the top 10 most commonly diagnosed cancers for Pacific Peoples between 2007–2019 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific Peoples and Europeans (bottom). Rates for breast, prostate and uterine cancers are sex specific.

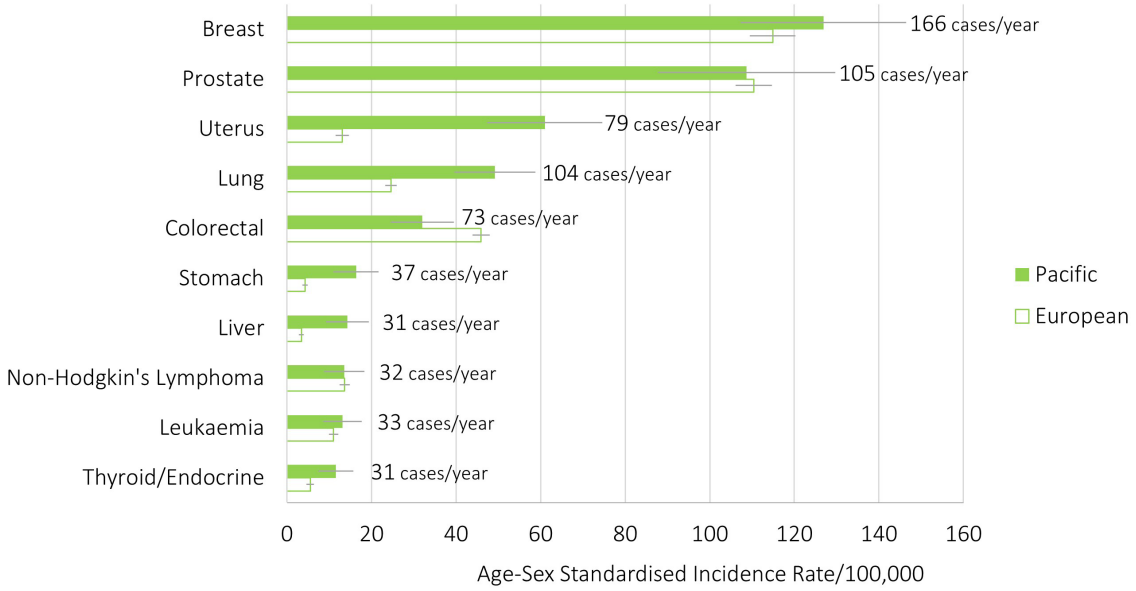


Figure 2: Age- and sex-standardised mortality rate (SMR) and absolute numbers of cases for the top 10 most common causes of cancer death for Pacific Peoples between 2007–2018 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific and European peoples (bottom). Rates for breast, prostate and uterine cancers are sex specific. Ill-defined cancers are those cancers that are unspecified, lack precise definition, or are secondary (i.e., non-primary) cancers.

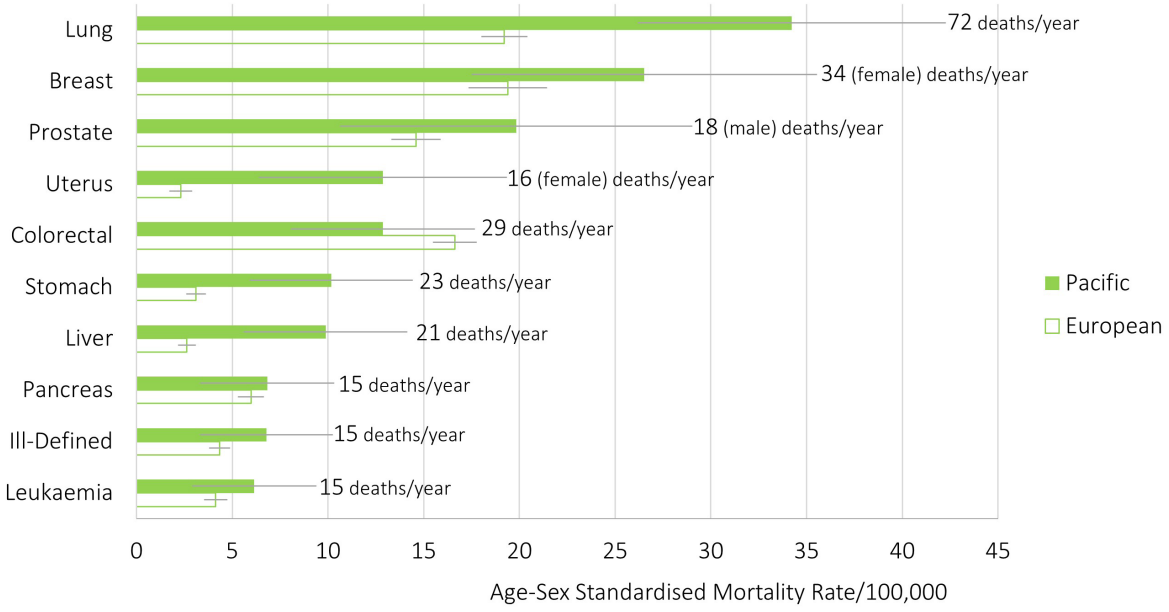
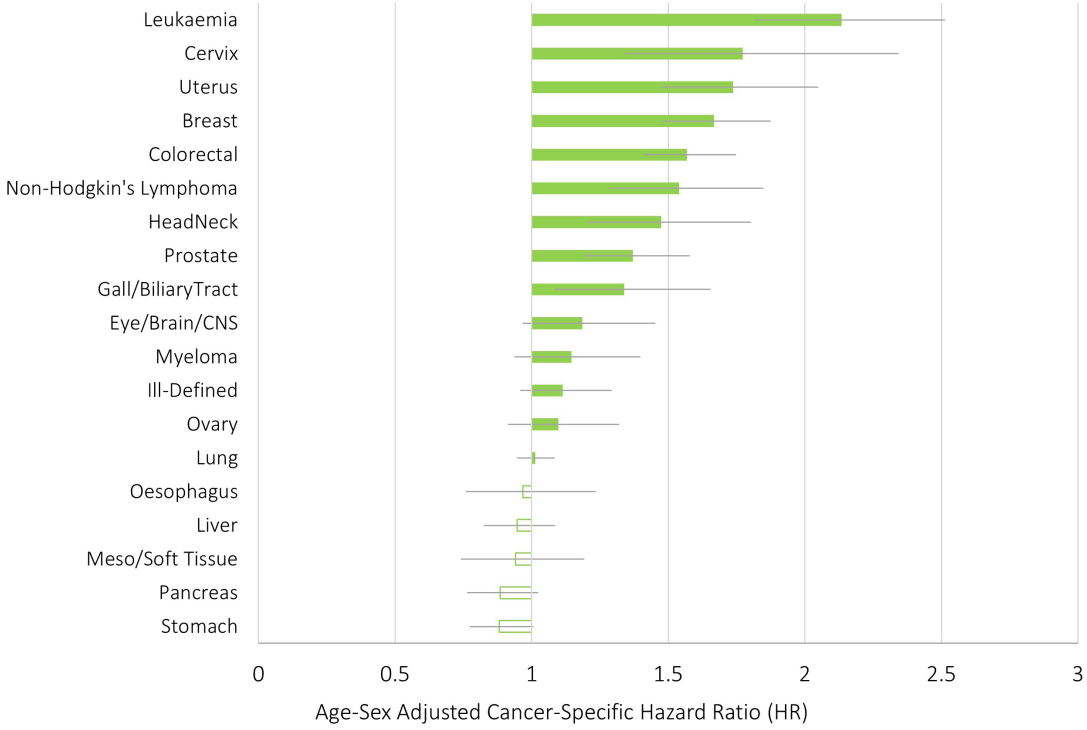
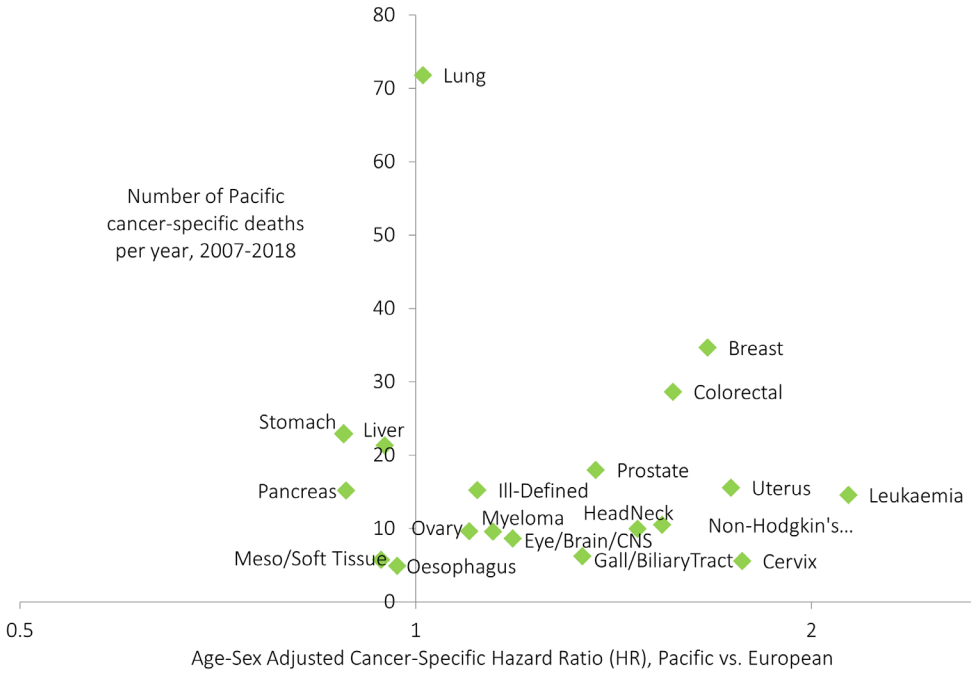


Table 1: Crude (i.e., unadjusted) 1-, 3- and 5-year survival and age–sex-adjusted hazard ratios (HRs) comparing the likelihood of cancer-specific mortality between Pacific and European peoples with cancer. Cancers for which fewer than five Pacific Peoples died per year during the study period were excluded. HRs are adjusted for age and sex for all cancers except breast, cervical, ovarian, prostate and uterine (age only).

	Survival rates (%)						Hazard ratios (HR)	
	1-Year (%)		3-Year (%)		5-Year (%)		Adj. HR (95% CI)	
Cancer name	Pacific	European	Pacific	European	Pacific	European	Pacific	European
Breast	96%	96%	88%	91%	82%	86%	1.7 (1.5–1.9)	Ref
Cervix	80%	88%	62%	76%	59%	72%	1.8 (1.3–2.3)	Ref
Colorectal	76%	79%	59%	64%	53%	58%	1.6 (1.4–1.7)	Ref
Eye, brain and CNS	66%	54%	48%	33%	45%	28%	1.2 (1–1.5)	Ref
Gallbladder and biliary tract	35%	39%	16%	20%	16%	14%	1.3 (1.1–1.7)	Ref
Head and neck	84%	84%	70%	72%	65%	66%	1.5 (1.2–1.8)	Ref
Ill-defined, secondary or unspecified	24%	19%	19%	12%	18%	10%	1.1 (1–1.3)	Ref
Leukaemia	68%	73%	60%	62%	56%	55%	2.1 (1.8–2.5)	Ref
Liver	44%	36%	28%	18%	23%	13%	0.9 (0.8–1.1)	Ref
Lung	39%	36%	19%	17%	16%	13%	1 (0.9–1.1)	Ref
Mesothelioma and soft tissue	74%	60%	53%	38%	49%	32%	0.9 (0.7–1.2)	Ref
Myeloma	82%	81%	63%	62%	49%	49%	1.1 (0.9–1.4)	Ref
Non-Hodgkin's lymphoma	75%	79%	68%	68%	66%	63%	1.5 (1.3–1.8)	Ref
Oesophagus	38%	38%	27%	16%	24%	13%	1 (0.8–1.2)	Ref
Ovary	74%	67%	54%	42%	48%	33%	1.1 (0.9–1.3)	Ref
Pancreas	29%	19%	19%	7%	18%	5%	0.9 (0.8–1)	Ref
Prostate	95%	95%	87%	90%	82%	85%	1.4 (1.2–1.6)	Ref
Stomach	54%	44%	34%	23%	30%	19%	0.9 (0.8–1)	Ref
Uterus	89%	90%	80%	79%	78%	75%	1.7 (1.5–2)	Ref

Figure 3: Forest plot showing cancer-specific mortality hazard ratios (HRs; top) and scatterplot showing the average annual cancer-specific deaths among Pacific Peoples versus the same HRs (reference = Europeans). Cancers for which fewer than five Pacific Peoples died per year during the study period were excluded.





survival for other common causes of cancer death, including lung (HR: 1.0, 95% CI 0.9–1.1), liver (0.9, 95% CI 0.8–1.1), pancreatic (HR: 0.9, 95% CI: 0.8–1) and stomach cancers (0.9, 95% CI 0.9–1; Figure 3).

Figure 3 illustrates the correlation between the disparities in cancer survival rates (x-axis) between Pacific and European populations, and the annual number of cancer-related deaths among Pacific Peoples (y-axis). This visual representation helps to contextualise the relative disparities in cancer survival rates against real-world mortality. This figure shows that over the study period, the most significant survival disparity is found for leukaemia, where Pacific Peoples have more than twice the probability of death compared to Europeans (HR:2.1, 95% CI 1.8–2.5), but of which there are only 15 Pacific people deaths per year. This figure also shows the highest cancer-mortality burden is caused by lung cancer (72 Pacific deaths per year), but the survival disparity is negligible (HR: 1, 95% CI 0.9–1.1; Figure 3).

Figure 3 also illustrates that breast and colorectal cancers pose a significant cancer mortality burden, as demonstrated by the increased number of deaths each year (although not the highest), and shows a notable survival disparity. Specifically, breast cancer caused 34 female deaths per year, and the hazard ratio for overall breast cancer survival was 1.7 (95% CI 1.5–1.9) in Pacific Peoples when compared to Europeans. Similarly, colorectal cancer resulted in 29 deaths per year, with a hazard ratio for overall colorectal cancer survival of 1.6 (95% CI 1.4–1.7) in Pacific Peoples compared to Europeans. It is also worth highlighting uterine and prostate cancers as contributors to cancer-related deaths (16 and 18 deaths per year, respectively), where Pacific Peoples also experienced a survival gap (uterus HR: 1.7, 95% CI 1.5–2 and prostate HR: 1.4, 95% CI 1.2–1.6; Figure 3).

Discussion

In this study, we found striking disparities in cancer incidence, mortality and survival for Pacific peoples when compared to European peoples. These differences are strongly patterned by cancer type, wherein Pacific Peoples are more likely to be diagnosed with (and die from) certain cancers, but not others.

Our findings highlight significant adverse impacts of the differential distribution of the social determinants of health on cancer incidence, mortality and survival for Pacific Peoples.[15] High deprivation, poor living standards, occupation type, housing and employment status in Aotearoa New Zealand play strong roles in driving poor access to care and health outcomes.[16] These factors are set against a backdrop of exposure to cancer-promoting aetiological factors,[17] which perpetuate the compounded ethnic differences at each stage of the cancer continuum (poor cancer screening, delayed diagnosis, treatment, comorbidity, service quality, barriers to timely treatment access and access to follow-up, etc.).[18,19,20]

The most common cancers (Figure 1) and causes of cancer death (Figure 2) among Pacific Peoples can largely be attributed to social determinants, which disproportionately affect Pacific Peoples compared to Europeans.[3,6] These exposures can be broadly grouped as tobacco exposure (lung cancer[21]), infectious diseases (liver[6] and stomach[22] cancers) and obesity (breast,[23] uterine[24] and colorectal cancers[25]). We will now consider each of these broad groups, and their role as drivers of our observed disparities for incidence and mortality.

Tobacco

Smoking is a well-established and significant risk factor for lung cancer and various other cancers.[21,26,27,28] Pacific Peoples are 1.9 times more likely than non-Pacific Peoples to be current smokers.[29] Further vigilance and vigour are required to address tobacco exposure, as modelling studies suggest Aotearoa New Zealand is unlikely to meet its Smokefree 2025 goal.[30] The introduction of the Smokefree Environments and Regulated Products (Smoked Tobacco) Amendment Act looks promising (effective from 1 January 2023), which limits the sale of smoked tobacco products to approved retail outlets and prohibits their sale to individuals born on or after 1 January 2009, with the aim of creating a smokefree generation and preventing the uptake of smoking.[31]

The present study showed a remarkable improvement in the standardised incidence rate (SIR) of lung cancer of 50/100,000, compared to 109/100,000 in the period between 1981 and 2004, reported by Meredith et al.[6] This is a promising finding, as it suggests that reductions over time in tobacco exposure have had a positive effect on lung cancer outcomes for Pacific Peoples. The observed improvement in lung cancer incidence rates is a strong impetus to continue with system-level efforts to reduce tobacco exposure.

Obesity

Obesity has been attributed as one of the main drivers of several types of cancer, especially

breast, colorectal and uterine cancers.[23,32,33,34] Notably, ethnic inequalities in the incidence of obesity-related cancers in Aotearoa New Zealand have widened,[3] with Pacific Peoples 2.5 times more likely to be obese than non-Pacific adults (adjusted for age and gender).[1] In this study, we showed that breast, colorectal and uterine cancers are among the top five most commonly diagnosed and most common causes of cancer death for Pacific Peoples, and that incidence and mortality from breast and uterine cancers are higher among Pacific than among European peoples.

Aotearoa New Zealand has implemented multiple prevention activities to address the structural and behavioural causes of obesity, including the Healthy Eating – Healthy Action programme,[35] the Green Prescription programme,[36] the Food and Beverage Classification System, the Childhood Obesity Plan[37] and the Healthy Families NZ initiative.[38] Despite these efforts, the prevalence of obesity remains high in Aotearoa New Zealand. The limited impact of these interventions may be due to the complexity of the issue and the multitude of factors contributing to obesity, which calls for more substantive interventions and a continued commitment to research and implementation of evidence-based approaches.

Infectious diseases

Helicobacter pylori (*H. pylori*) infection is a well-established and potent modifiable risk factor for stomach cancer,[39] with a higher prevalence among Pacific Peoples in Aotearoa New Zealand than for other ethnic groups.[40] According to previous studies, human papillomavirus (HPV) infection is highly attributable to cervical cancers.[41] Hepatitis B infection is considered to be the primary risk factor for liver cancer, as it increases the risk of developing liver cancer by 30–60 times compared to those without the infection.[42] Research has shown that the estimated prevalence of chronic hepatitis B infection is 7.3% among Pacific Peoples, which is notably higher than the 0.5% observed among Europeans.[43,44] In this study, we found that stomach and liver cancers were among the top 10 most frequently diagnosed and leading causes of cancer deaths within the Pacific population, and that incidence and mortality from these cancers was substantially higher among Pacific Peoples relative to Europeans.

In summary, the intrinsic role tobacco, obesity and infectious diseases play as key drivers of inequities in cancer outcomes for Pacific Peoples means that addressing these social determinants is both crucial and urgent. There is a fertile area for Pacific-led policies and actions to address these social determinants, with a view to reducing excess cancers among Pacific Peoples. An appropriate balance must be reached regarding population-wide and Pacific cancer-focused interventions, tailored to Pacific Peoples' specific needs, values and acceptability to bridge unmet, disproportionate needs and structural disadvantages.[1]

Early detection and screening activities

The disparity in cancer detection and access to screening between Pacific Peoples and Europeans in New Zealand is multifactorial, compounded by ethnic differences on the cancer continuum, as stated above.[16,18,19,20,45] Screening programmes and early detection through primary care are major interventions that can improve cancer outcomes and survival.[16] However, delays in cancer diagnosis among Pacific Peoples when compared to European patients[46] are caused by the former facing more barriers to accessing primary health-care than non-Pacific and non-Māori groups.[47] Furthermore, Pacific Peoples have poorer access to some national screening programmes compared to Europeans,[48,49] resulting in some cancers being diagnosed at a more advanced stage.[50,51] For example, cervical screening participation rates have been steadily decreasing among eligible Pacific women since 2017, and are now 56%, compared to 75% among European/Other women.[49] Some of the impact of this poorer access can be seen in the results of our survival analysis (Table 1/Figure 3), wherein Pacific Peoples had poorer survival for each of the cancers for which we have national screening programmes (breast, colorectal, cervical). We note that these (and other) substantial disparities in cancer survival among Pacific Peoples compared to Europeans became obvious once the confounding impact of age was accounted for within the adjusted hazard ratios; this is because the Pacific population has a much younger age structure to the European population (i.e., there are fewer older Pacific Peoples), and increasing age is a significant risk factor for cancer death.

We must continue to work to ensure that screening and early detection programmes (including the burgeoning lung cancer screening programme[52]) works well for Pacific Peoples, to maximise coverage and improve survival outcomes.

Access to best-practice and timely treatment

The unequal access to cancer services and treatment for Pacific Peoples has been shown to contribute to the observed survival disparities for Pacific population groups.[3,4,53] Specifically, a previous study has reported that Pacific patients had the longest median waiting times (32 days) between cancer diagnosis and treatment, as compared to other ethnic groups, and a higher proportion of Pacific patients (16%) died prior to receiving treatment, compared to non-Pacific patients (11%).[54] Additionally, a study by Schaaf has shown that Pacific men with symptomatic prostate cancer experience delays in treatment.[55] In terms of breast cancer, only 16% of Pacific women received private care for their primary treatment compared to 47% of non-Pacific and non-Māori women,[7] and there is evidence that differential access to private care accounted for 10% of survival disparities in Pacific women with breast cancer.[56] These findings highlight some of the challenges Pacific Peoples face in accessing timely cancer treatment in Aotearoa New Zealand, and underscore the crucial role and need for continual commitment of cancer services in improving survival and cancer outcomes for this population.

Te Aho o Te Kahu, New Zealand's Cancer Control Agency, acknowledges the differential access to cancer treatment for Pacific Peoples among other population groups and has recommended strategies to address these inequities.[4,57] Recommended strategies include a Pacific cancer action plan, increasing access to screening and culturally appropriate care, improving data collection, strengthening the Pacific health workforce, increasing public awareness, including Pacific Peoples in cancer research and fostering partnerships between Pacific communities and cancer service providers.[57]

Other considerations for cancer in Pacific Peoples

Although our focus has been on the most commonly diagnosed and common causes of cancer death among Pacific Peoples in Aotearoa New Zealand, we recognise the importance of addressing all cancer types that impact individuals and their families. For example, while leukaemia is not one of the most commonly diagnosed, it has the largest survival disparity for Pacific Peoples when compared to Europeans (HR:2.1, 95% CI 1.8–2.5), and 15 Pacific deaths per year (Figure 3). There is limited research on ethnicity and treatment outcomes for leukaemia, although it has been suggested that there is ethnic-based variation in the treatment response to ALL.[58] Continued efforts to collect and analyse data on cancer incidence, mortality and survival among Pacific Peoples, including the monitoring of trends for less common cancers, can help to inform the development and implementation of effective cancer control strategies that target the specific needs of Pacific Peoples.[57]

Strengths and limitations

The New Zealand Cancer Registry is mandated by law to compile data on all cancer cases diagnosed in Aotearoa New Zealand, with the exception of basal and squamous cell carcinomas.[59] This means that the study is less prone to underestimating the true number of cancer cases, which can be an issue in studies where certain groups are less likely to seek healthcare or receive appropriate diagnostic testing. Death registration is also mandatory and can be linked to cancer registrations using the NHI number, making the study less prone to biases and inaccuracies that may result from incomplete or inaccurate reporting of deaths. There could have been misclassifications for the cause of death, but it is likely not to significantly impact bias in ethnic comparisons.[60] While we have utilised a total ethnicity approach to maximise the capture of those who identify as Pacific, there may be some misclassification of ethnicity on the cancer registry, whereby Pacific Peoples may be undercounted.[61] The impact of such an undercount would be to make the results reported in this study conservative. The impact of using the total ethnicity approach in the current study is that we included 774 Pacific cancer cases (out of a total of 12,387, or 6% of the cohort) who identified as both Pacific and Māori; we have included a table in **Appendix 6** to show which cancers these cases were diagnosed with, over the study period. As noted in the Methods section, no restriction was placed on New Zealand residency status, which means it was possible for Pacific (and non-Pacific) peoples diagnosed with their cancer within Aotearoa New Zealand to be included in this study even if they held residency in another country. This approach was taken to maximise the inclusivity of the Pacific cohort. It is plausible that Pacific cases were more likely to be misclassified as alive at the end of follow-up because they died in their country of residence;

the impact of this misclassification would again be to make the mortality and survival results within this study conservative. Finally, we note that we have categorised Pacific Peoples as one group for the purposes of this study to maximise data precision. Further research describing differences in cancer incidence and outcomes between Pacific ethnicities within this broader group is needed.

Conclusions

This study presents the most up-to-date data on cancer incidence, mortality and survival among Pacific Peoples in Aotearoa New Zealand. By identifying the cancers with the greatest burden on Pacific communities and examining disparities in survival between Pacific and European peoples post-diagnosis, this study provides insight into where resources can be focused to reduce the overall cancer burden for this population. Introducing interventions to eradicate ethnic disparities at each stage of the cancer continuum (prevention, detection and screening, timely and appropriate access to care) will lead to a reduction in avoidable cancer deaths for Pacific Peoples. Tackling socio-economic inequalities will likely have flow-on effects that will reduce inequalities in risk factor profiles for Pacific Peoples overall. Improving health risk profiles requires a comprehensive strategy that targets both the aetiological causes of the cancers and specific cancers themselves, such as targeting obesity through addressing obesogenic environments, while simultaneously improving access to national screening programmes to maximise early detection for relevant cancers. Cross-government and intersectoral interventions to prevent cancers related to infectious diseases, smoking and obesity will also significantly reduce the cancer burden faced by Pacific Peoples.

COMPETING INTERESTS
Nil.

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AUTHOR ROLES
Tara Cleverley conducted the literature review, drafted the manuscript and revised content based on feedback. Jason Gurney designed the study, conducted the data analysis and revised content based on feedback. Ineke Meredith and Dianne Sika-Paotonu assisted with interpretation of data and provided critical revision of drafts.

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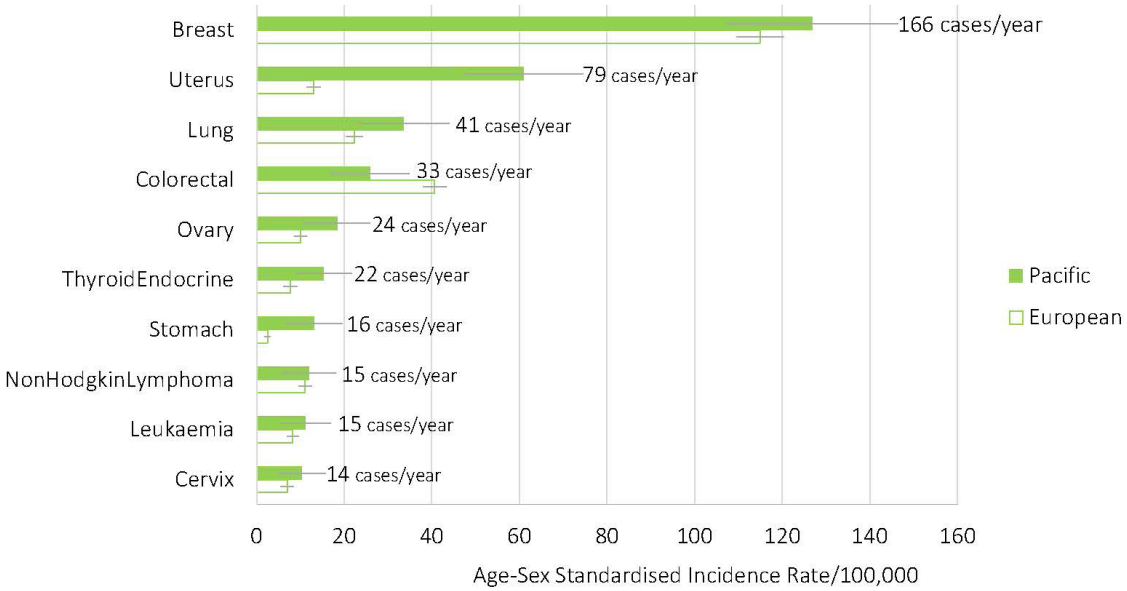
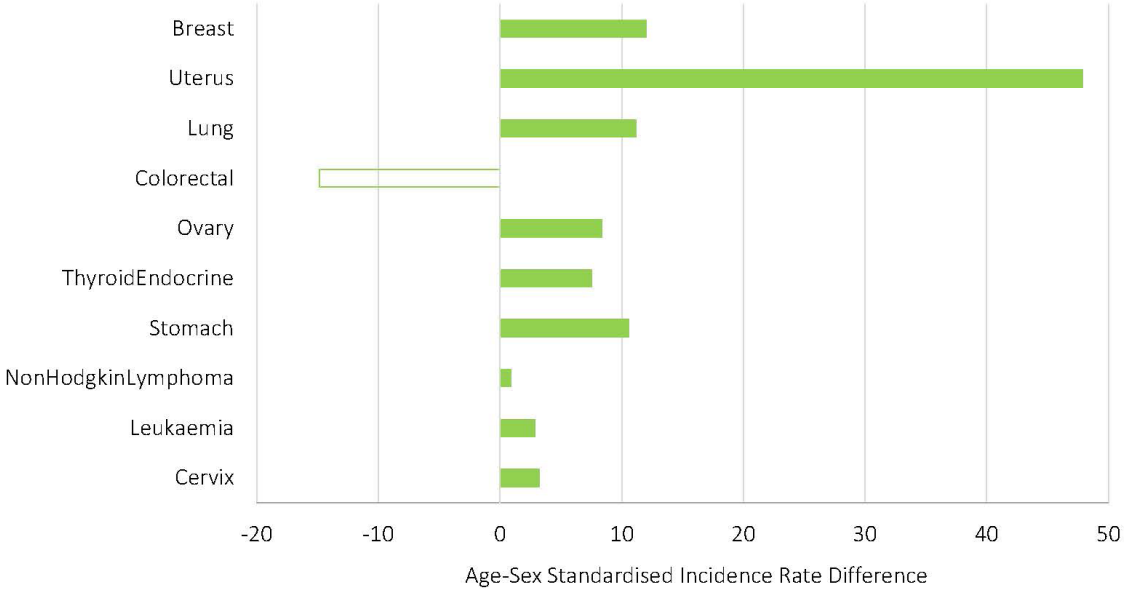
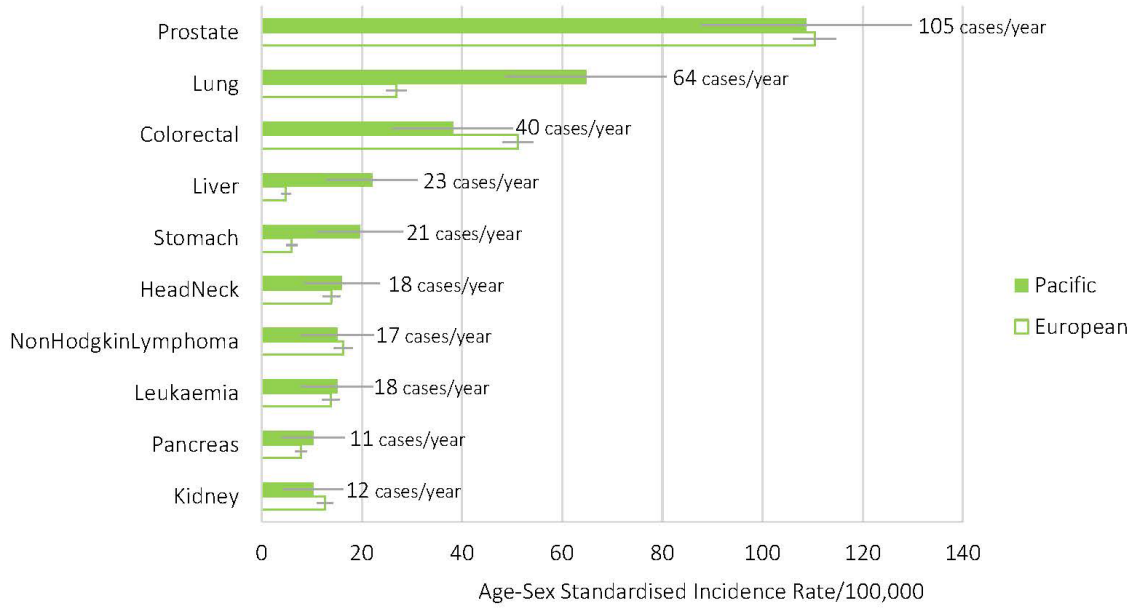
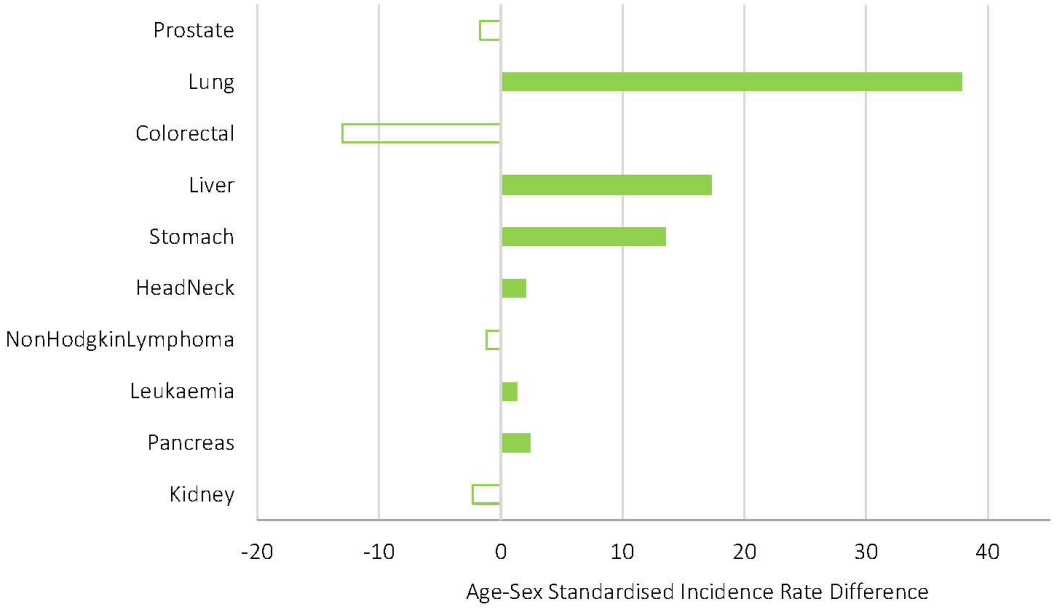
Appendix 1: Age- and sex-standardised incidence rate (SIR) and absolute numbers of annual cases for the top 10 most commonly diagnosed cancers for Pacific **females** between 2007–2019 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific females and European females (bottom).



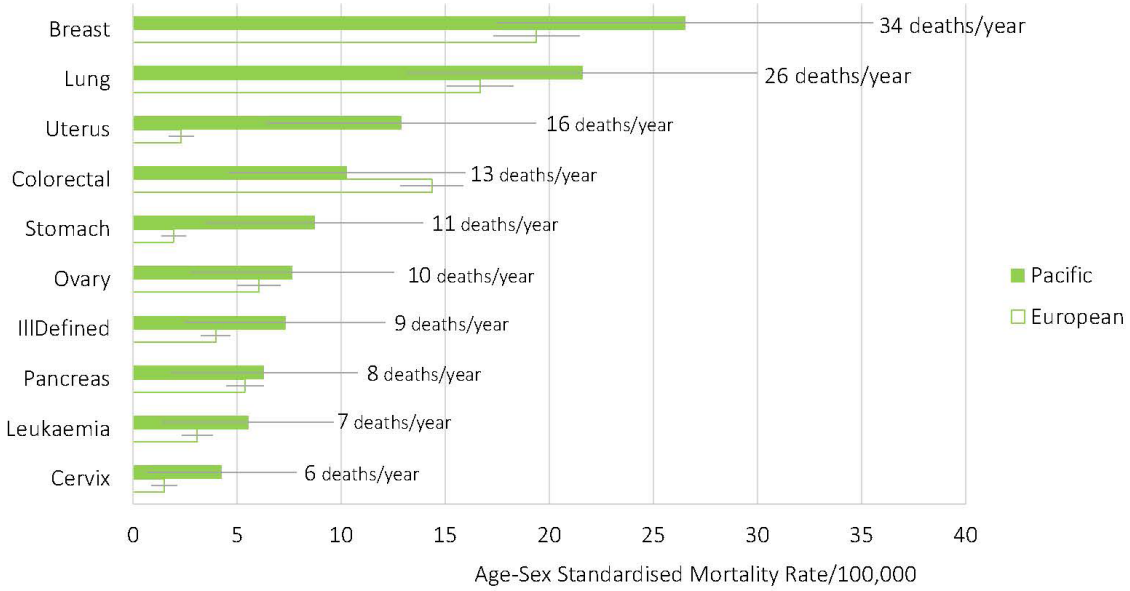


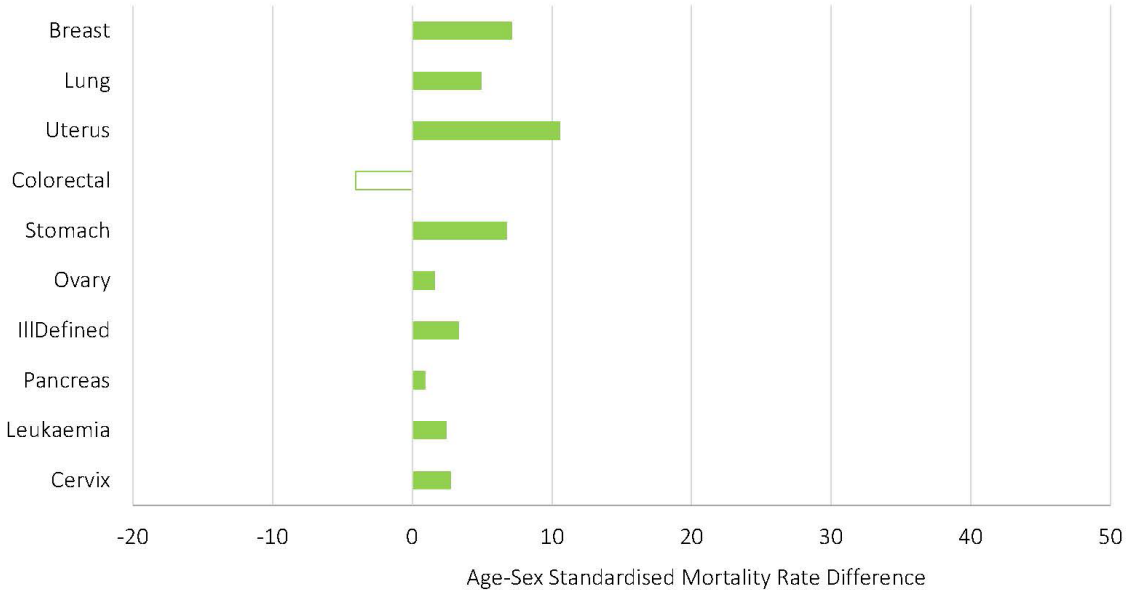
Appendix 2: Age- and sex-standardised incidence rate (SIR) and absolute numbers of annual cases for the top 10 most commonly diagnosed cancers for Pacific **males** between 2007–2019 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific males and European males (bottom).



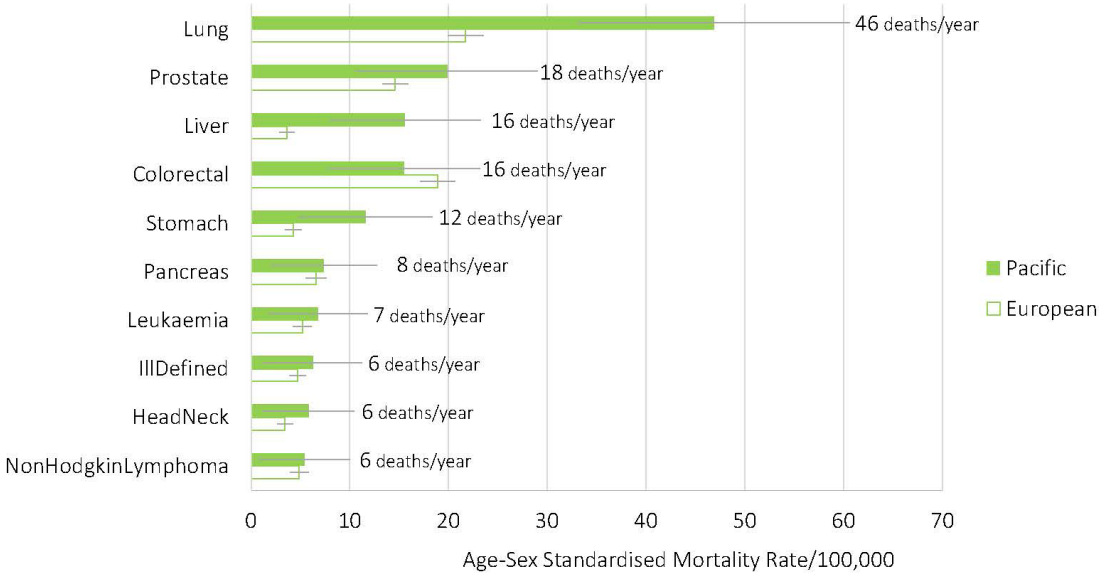


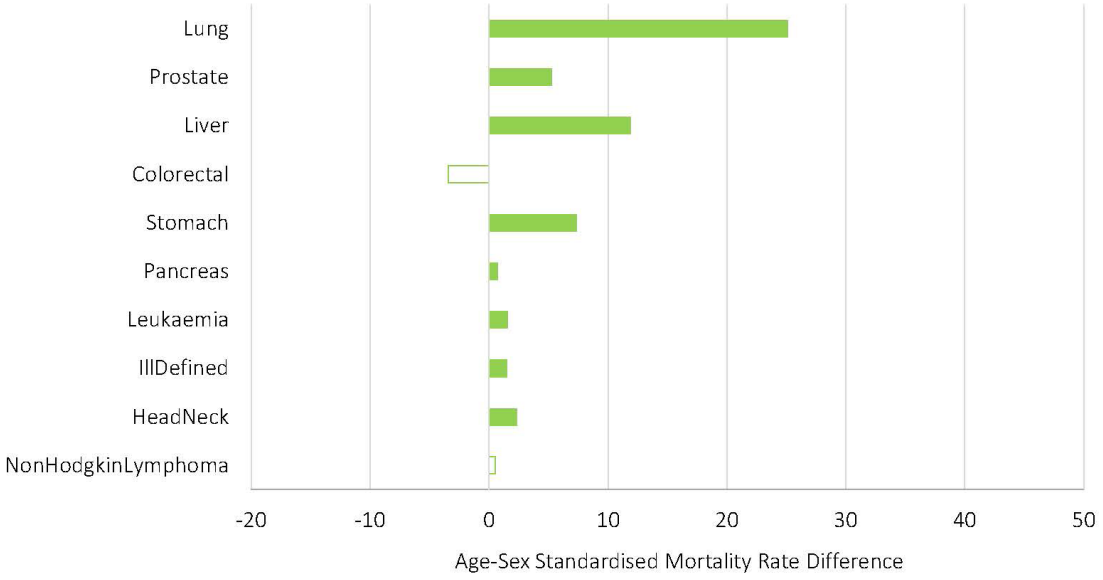
Appendix 3: Age- and sex-standardised mortality rate (SMR) and absolute numbers of cases for the top 10 most common causes of cancer death for Pacific **females** between 2007–2018 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific females and European females (bottom).





Appendix 4: Age- and sex-standardised mortality rate (SMR) and absolute numbers of cases for the top 10 most common causes of cancer death for Pacific **males** between 2007–2018 (top), along with the age- and sex-standardised rate difference (SRD) between Pacific males and European males (bottom).





Appendix 5: Annual cancer cases, incidence rates and mortality rates for Pacific and European peoples. SIR: Standardised incidence rate; SMR: standardised mortality rate.

	Incidence				Mortality			
	Cases/year		SIR (95% CI)		Deaths/year		SMR (95% CI)	
Cancer name	Pacific	European	Pacific	European	Pacific	European	Pacific	European
Bladder	8	353	3.9 (1.2–6.6)	5.4 (4.7–6)	4	189	-	-
Bone and cartilage	5	25	1.5 (0.1–2.9)	0.9 (0.5–1.3)	2	13	-	-
Breast	166	2,370	126.9 (107.3–146.5)	114.9 (109.5–120.3)	34	507	26.5 (17.5–35.5)	19.4 (17.3–21.4)
Cervix	14	97	10.3 (4.8–15.7)	7 (5.4–8.5)	6	34	4.3 (0.7–7.8)	1.5 (0.9–2.1)
Colorectal	73	2,677	32 (24.5–39.5)	45.9 (43.9–48)	29	1,100	12.9 (8.1–17.7)	16.6 (15.5–17.8)
Eye, brain and CNS	18	311	6.4 (3.4–9.4)	7.9 (6.9–8.9)	9	235	3.3 (1–5.5)	5.4 (4.6–6.2)
Gallbladder and biliary tract	12	101	5.4 (2.2–8.5)	1.6 (1.2–2)	6	69	2.9 (0.6–5.2)	1 (0.7–1.3)
Head and neck	29	442	12.2 (7.6–16.7)	9.6 (8.6–10.6)	10	138	4.4 (1.6–7.1)	2.4 (1.9–2.8)
Hodgkin's lymphoma	7	78	2.3 (0.5–4.1)	2.9 (2.2–3.6)	1	16	-	-
Ill-defined, secondary or unspecified	20	356	9 (5–13)	5 (4.4–5.6)	15	328	6.8 (3.3–10.3)	4.3 (3.8–4.9)
Kidney	20	440	8.2 (4.5–11.9)	9.3 (8.3–10.3)	4	161	-	-
Leukaemia	33	534	13.1 (8.5–17.7)	11 (9.9–12.1)	15	261	6.2 (2.9–9.4)	4.1 (3.5–4.7)
Liver	31	190	14.3 (9.2–19.4)	3.4 (2.9–4)	21	157	9.9 (5.6–14.2)	2.6 (2.2–3.1)
Lung	104	1,520	49.1 (39.6–58.7)	24.6 (23.2–26)	72	1,229	34.2 (26.2–42.3)	19.2 (18–20.4)
Melanoma	8	2,493	3.3 (0.9–5.6)	56.2 (53.6–58.8)	2	328	-	-
Mesothelioma and soft tissue	14	207	5.8 (2.7–8.9)	4.3 (3.6–5)	6	142	2.5 (0.4–4.6)	2.5 (2–3)
Myeloma	22	279	10 (5.7–14.2)	4.9 (4.2–5.5)	10	147	4.5 (1.6–7.4)	2.1 (1.7–2.5)

Appendix 5 (continued): Annual cancer cases, incidence rates and mortality rates for Pacific and European peoples. SIR: Standardised incidence rate; SMR: standardised mortality rate.

	Incidence				Mortality			
	Cases/year		SIR (95% CI)		Deaths/year		SMR (95% CI)	
Cancer name	Pacific	European	Pacific	European	Pacific	European	Pacific	European
Non-Hodgkin's lymphoma	32	682	13.5 (8.8–18.3)	13.7 (12.5–14.9)	11	254	4.6 (1.7–7.4)	3.9 (3.4–4.5)
Oesophagus	8	250	3.7 (1.1–6.4)	4.1 (3.5–4.7)	5	210	2.4 (0.3–4.6)	3.3 (2.8–3.8)
Ovary	24	255	18.4 (11–25.8)	10 (8.6–11.5)	10	186	7.7 (2.8–12.5)	6 (5–7.1)
Pancreas	22	433	9.7 (5.6–13.8)	7 (6.3–7.8)	15	385	6.8 (3.3–10.3)	6 (5.3–6.7)
Prostate	105	2,899	108.7 (87.8–129.7)	110.4 (106.1–114.7)	18	555	19.8 (10.6–29)	14.6 (13.3–15.9)
Small intestine	6	79	2.7 (0.5–4.8)	1.5 (1.1–1.9)	2	35	-	-
Stomach	37	244	16.3 (11–21.7)	4.3 (3.7–4.9)	23	191	10.2 (5.9–14.4)	3.1 (2.6–3.6)
Testis	8	107	4.9 (1.4–8.4)	9.9 (8–11.8)	0	5	-	-
Thyroid and endocrine	31	175	11.6 (7.4–15.7)	5.5 (4.6–6.4)	3	24	-	-
Uterus	79	333	61 (47.3–74.6)	13.1 (11.5–14.7)	16	79	12.9 (6.4–19.3)	2.3 (1.7–2.9)