BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-058749
Article Type:	Original research
Date Submitted by the Author:	26-Oct-2021
Complete List of Authors:	Gurney, JK; University of Otago, Department of Public Health Sarfati, Diana; Te Aho o Te Kahu - Cancer Control Agency Stanley, James; University of Otago, Wellington, Public Health; University of Otago, Wellington Kerrison, Clarence; Waikato District Health Board Koea, Jonathan; Waitemata District Health Board
Keywords:	SURGERY, ONCOLOGY, PUBLIC HEALTH

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Equity of timely access to surgery for liver and stomach cancer among Indigenous and non-Indigenous patients in New Zealand

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Keywords: Liver cancer, stomach cancer, surgery, access, indigenous, Māori

Words in main body of text: 4,862

Figures: 1

Tables: 3

Supplementary Tables: 1

Competing Interests statement: The authors have no competing interests to declare.

Abstract

Objectives. When combined, liver and stomach cancers are second only to lung cancer as the most common causes of cancer death for the indigenous Māori population of New Zealand – with Māori also experiencing substantial disparities in the likelihood of survival once diagnosed with these cancers. Since a key driver of this disparity in survival could be access to surgical treatment, we have used national-level data to examine surgical procedures performed on Māori liver and stomach cancer patients, and compared the likelihood and timing of access to the majority European population.

Design, Participants and Setting. We examined all cases of liver and stomach cancer diagnosed 2007-2019 on the New Zealand Cancer Registry (NZCR; liver cancer: 866 Māori, 2,460 European; stomach cancer: 953 Māori, 3,192 European), and linked these cases to all inpatient hospitalisations that occurred over this time to identify curative and palliative surgical procedures. As well as descriptive analysis, we compared the likelihood of access to a given procedure between Māori and Europeans, stratified by cancer and adjusted for confounding and mediating factors. Finally, we compared the timing of access to a given procedure between ethnic groups.

Results and Conclusions. We found that a) access to liver transplant for Māori is lower than for Europeans, which suggests unequal access to transplant lists and subsequent transplantation; b) Māori with stomach cancer appear more likely to require the type of palliation consistent with gastric outlet obstruction, which may suggest reduced access to care before the onset of acute symptoms; and c) differential timing of first stomach cancer surgery between Māori and European patients, which suggests that the latter may be more likely to access neo-adjuvant therapy. However, we may also be cautiously encouraged by the fact that differences in overall access to curative surgical treatment were either marginal (liver) or absent (stomach).

Strengths and Limitations of this Study

- A key strength of this study is that it reports on equity of access to surgical intervention for all patients with liver or stomach cancer across more than a decade, using the most recently available data.
- This national coverage comes at the expense of some data granularity: for example, complete staging information for these two cancers were not available.
- This study only examines equity of access to surgical treatment, not systemic therapy or radiotherapy. Future research should aim to bring these data together at a national level.

Introduction

The Indigenous Māori population of New Zealand experience poorer survival outcomes than the non-Indigenous population for 23 of the 24 most commonly-diagnosed cancers.[1] Of these cancers, both liver and stomach cancer feature prominently as important causes of cancer death for Māori – and when combined, these upper-gastrointestinal cancers rank second only to lung cancer in terms of the absolute number of cancer deaths among Māori each year.[2] Māori patients with liver cancer are nearly a third (31%) more likely to die, and those with stomach cancer 22% more likely to die than non-Māori stomach cancer patients. [1]

Timely access to best-practice treatment is a potentially key driver of these survival disparities. Accumulated evidence suggests that there is little difference between Māori and non-Māori patients in terms of stage of disease at diagnosis for either of these poor-prognosis cancers,[3-5] which implies that survival inequities may be related to access to treatment following diagnosis. Our previous clinical audits [3 4] identified a lack of Māori access to specialist services for the treatment of stomach cancer, but were based on small numbers of patients and only covered a three-year period (2006-2008). Given the ongoing disparity in survival experienced by Māori liver and stomach cancer patients, a more comprehensive and broader approach is required to examine equity in access to surgical services for these cancers.

In this manuscript, we use national-level data to examine all inpatient surgical procedures performed on all Māori liver and stomach cancer patients diagnosed across more than a decade, and compare

the likelihood of access – and the timing of that access – to that experienced by the majority European population.

Methods

Participants and Data Sources

All cases of liver and stomach cancer occurring between 2007 and 2019 were extracted from the New Zealand Cancer Registry (NZCR; liver cancer: 866 Māori, 2,460 European; stomach cancer: 953 Māori, 3,192 European). These individuals were linked via encrypted National Health Index (NHI) number to the National Minimum Dataset (NMDS) to determine access to inpatient surgical procedures from this same period (2007-2019). NMDS data were also extracted for the 2002-2006 period to allow for the calculation of patient comorbidity (see *Variables* below). Ethical approval for this study was sought and received from the University of Otago Human Ethics Committee (reference # HD18/056). Data used for this study were de-identified prior to being provided to the researchers by the New Zealand Ministry of Health.

Demographic and Patient Variables

Date of cancer diagnosis was determined from the NZCR. Age at diagnosis was defined by subtracting date of cancer diagnosis from the individual's date of birth (also recorded on the NZCR). Sex was derived from the NZCR, recorded as either female or male. Prioritised ethnicity was derived from the NZCR, and defined for this study as Māori or European. Level of socioeconomic deprivation was defined using the NZDep deprivation scale, a small area-based deprivation index that uses multiple variables to define the level of are deprivation.[6] Missing data prevented the attribution of deprivation for 83 liver cancer patients (2% of the cohort) and 140 stomach cancer patients (3% of the cohort). Patient rurality was defined using a modified version of the Urban/Rural Profile Classification (URPC),[7] with the area where a patient lived at the time of the cancer diagnosis classified as urban (main urban area + satellite urban area), independent urban or rural. Missing data prevented the attribution of rurality for 87 liver cancer patients (3% of the cohort) and 144 stomach cancer patients (3% of the cohort). There is an overlap between the missing-ness of

deprivation and rurality data, driven by missing census area unit data (i.e. unable to determine patient's place of residence).

Patient **comorbidity** was defined using the C3 Index, a cancer-specific measure of patient comorbidity.[8] It uses public and private inpatient hospitalisation data (NMDS) to define the presence or absence of 42 individual conditions. All International Classification of Diseases (ICD)-coded diagnoses (ICD-10-AM, 3rd edition) recorded in the five years prior to date of diagnosis were used to calculate a C3 index score for each patient, with each condition weighted according to its relationship with non-cancer mortality in a cancer population.[8] Condition weights were then summed to give the final C3 score, categorised as '0' (score <=0), '1' (<=1), '2' (<=2) and '3' (>2). Those with none of the included conditions detected over the lookback period were assigned a score of 0. For our descriptive analysis, comorbidity was included as a categorical variable, while in our regression analysis raw comorbidity score was included as a continuous variable, using restricted cubic splines with knots placed at the 50th, 90th and 95th percentiles.[9]

Cancer **stage at diagnosis** was determined from the NZCR, and based on the SEER Summary Stage method (A to F).[10] Stage was categorised into Local (B), Regional (C and D), Advanced (E) and Unstaged (F).[11]

Surgical Variables

Surgical procedures were extracted from the NMDS using the Australasian College of Health Informatics (ACHI) ICD-10-AM code (3rd Edition).[12] In order to determine a list of primary surgical procedures (i.e. those procedures that directly related to the underlying cancer, whether curative or palliative in intent), we used ICD-10-AM/ACHI codes to first extract all surgical procedures performed on members of the cohort over the study period. Clinical team members then reviewed this list to determine relevant primary procedures that should be included in our investigation. When identifying relevant procedures, clinical team members also identified whether the procedure was generally undertaken with a curative or palliative intent, and also grouped individual procedures into relevant groups in order to collapse the number of individual procedure categories for analysis (for example, seven individual oesophagectomy procedures were collapsed into one oesophagectomy category).

Once a final list of relevant procedures were identified, we scanned the NMDS for instances where each patient underwent one of these procedures, and included all procedures that occurred up to one year post-diagnosis. Since it was possible that some relevant procedures would be performed before the diagnosis date recorded on the NZCR, we also scanned procedures that occurred up to 90 days prior to the date of diagnosis. Based on these scans, we created binary indicators (yes/no) for each cancer type, which determined whether or not a given patient underwent **any primary surgery**, **any curative surgery**, and/or **any palliative surgery**. Patients were not limited to only having either curative surgery or palliative surgery: if one patient received both procedures over the study period, they could be included in both groups. In addition to the 'any' surgery variables, we also determined whether a given patient underwent one of the **specific procedure categories** (e.g. partial gastrectomy). Again, it was possible for patients to contribute to more than one individual procedure category if these were completed within the study period.

We also determined the **delay between diagnosis and receipt of first surgical treatment** for each patient. The first surgical treatment was defined as whichever primary procedure occurred earliest during this period (i.e. between 90 days pre-diagnosis and one year post-diagnosis). The time between diagnosis and first procedure was calculated in days, and also categorised into the following groups: a) on or before diagnosis date; b) 0-3 weeks after diagnosis, c) 4-12 weeks after diagnosis, d) 12-24 weeks after diagnosis; and e) >24 weeks after diagnosis.

Statistical Analysis

For our **descriptive analysis**, we determined frequencies and both crude (unadjusted) and age-standardised proportions for each given variable, stratified by cancer type and ethnicity. Denominators for the proportion of patients receiving surgical treatment were the ethnicity- and cancer-stratified population (e.g. all Māori liver cancer patients across the study period), while denominators for the timing of access to first surgical treatment was the ethnicity- and cancer-stratified number of patients who received any primary surgery. To calculate **age-standardised proportions**, we used direct standardisation methods,[13] with the total Māori cancer population 2007-2019 (30,346) as the standard population. We chose this standard population for two reasons: a) the underlying age structure of this population largely reflects that of Māori patients in the current study; and b) using an Indigenous standard population is a best-practice approach when comparing

Māori to other ethnic groups, as it normalises the age structure of the Māori population.[14 15] In order to visually present the timing of access to first surgery, we constructed ethnicity- and cancer-stratified box-and-whisker plots using standard descriptive statistics (median, mean, interquartile range, minimum and maximum values).

In order to compare the likelihood of access to the various surgical procedures (and the timing of that access) between Māori and European patients, we calculated crude and adjusted logistic regression models, stratified by cancer type, with European patients as the reference group. These model outputs are presented as odds ratios (OR) and their 95% confidence intervals (95% CI). Covariates in the fully-adjusted model were age (continuous variable), sex (male/female), deprivation (NZDep quintile), rurality (URPC category), stage (SEER category), and comorbidity (C3 score, as a splined variable). We calculated three models for the primary analysis: a crude model, an age-adjusted model (to reflect the age-standardised proportion data), and a fully-adjusted model. In order to observe the impact of each modelled variable, we also calculated a series of models in which each covariate was added iteratively, and the resulting odds ratios extracted for each model.

Patient and public involvement

The development of our study objectives were informed by the need to monitor access to surgical treatment for indigenous Māori patients. However, patients were not directly involved in the study.

Results

Patient Characteristics. The characteristics of the cohort are shown in Table 1. Regarding liver cancer: males comprised a majority of both the Māori (age-standardised proportion: 73%) and European (69%) liver cancer cohorts. More than half of Māori patients (51%) resided in the two most-deprived deciles (NZDep deciles 9-10), compared to 19% of European patients. The proportion of patients living in rural areas was similar for Māori (14%) and European (11%) patients.

The distribution of stage at diagnosis was also similar between Māori and European patients, with around a quarter of both groups having advanced disease (22% Māori, 25% European), while the majority of diagnoses remained unstaged for both groups (65% Māori, 61% European). Māori patients were less likely to have no comorbidity (24%) compared to Europeans (37%), and had a marginally higher proportion with the greatest comorbidity burden (29% vs. 22%).

Regarding stomach cancer (Table 1): a greater proportion of European stomach cancer patients were male (age-standardised proportion: 68%) compared to Māori (56%). Similar to liver cancer, more than half of Māori patients (51%) resided in the two most-deprived deciles (NZDep deciles 9-10), compared to 16% of European patients. The proportion of patients living in rural areas was similar for Māori (17%) and European (14%) patients. While an identical proportion of Māori and European patients were registered as having advanced disease (both 37%), a greater proportion of European patients (42%) were registered with unstaged disease compared to Māori (34%). Like liver cancer, Māori patients were less likely to have no comorbidity (C3 group = 0: 52%) compared to Europeans (62%), and had a higher proportion with the greatest comorbidity burden (C3 group = 3: 24% vs. 13%).

Receipt of surgery. The number and proportion of Māori and European patients receiving primary surgical treatment, along with crude and adjusted odds ratios comparing likelihood of surgery between ethnic groups, are shown in Table 2. Only around a third of all patients with liver cancer had documented surgical treatment, with a similar proportion of Māori and European patients receiving any primary surgery (age-standardised proportions: 33% vs. 35%; fully-adjusted odds ratio [OR] 0.94, 95% CI 0.76-1.17). Māori appeared marginally less likely to receive curative surgery compared to European patients, although odds ratios crossed the null (15% vs. 19%; adj. OR 0.79, 95% CI 0.56-1.12). Compared to European patients, Māori appeared more likely to undergo minor hepatectomy (Māori 8%, European 6%; adj. OR 1.96, 95% CI 1.23-3.04), similarly likely to undergo major hepatectomcy (Māori 4%, European 5%; adj. OR 0.89, 95% CI 0.53-1.59) and less likely to undergo transplant (Māori 2%, European 5%; adj. OR 0.33, 95% CI 0.19-0.60). Māori were similarly likely to receive any palliative surgery (20% vs. 22%; adj. OR 0.93, 95% CI 0.74-1.17). The most common palliative procedure was liver ablation, with Māori and European patients similarly likely to undergo this procedure (Māori 19%, European 20%; adj. OR 0.95, 95% CI 0.75-1.20).

Around 40% of patients with stomach cancer had documented surgical treatment, with a similar proportion of Mā~ori and European patients receiving any primary surgery (age-standardised proportions: 41% vs. 37%; fully-adjusted odds ratio [OR] 1.02, 95% CI 0.81-1.27, Table 2). Māori and European patients were similarly likely to undergo any curative surgery (39% vs. 35%; adj. OR 0.96, 95% CI 0.79-1.21). Māori were less likely to undergo oesophagectomy (3% vs. 15%; adj. OR 0.10, 95% CI 0.06-0.16), more likely to undergo partial gastrectomy (20% vs. 15%; adj. OR 1.34, 95% CI 1.04-1.73), and appeared similarly likely to undergo total gastrectomy in the adjusted models (16% vs. 12%; adj. OR 1.11, 95% CI 0.84-1.46). While only around 10% of patients underwent palliative surgical treatment, Māori appeared more likely to undergo any palliative surgery compared to European patients (10% vs. 7%; adj. OR 1.46, 95% CI 1.07-2.00). Māori appeared more likely to undergo enteroenterostomy than European patients (6% vs. 3%; adj. OR 1.98, 95% CI 1.31-2.99), but similarly likely to undergo an endoscopic injection (5% vs. 4%; adj. OR 0.96, 95% CI 0.63-1.45).

The full output of our logistic regression models is shown in Supplementary Material 1, where we present odds ratios iteratively adjusted for each of our covariates. After adjusting for the confounding impact of age and sex, we noted that deprivation, stage and comorbidity had some impact on the observed relationship, but the extent of this impact – and whether it reduced or exacerbated any differences – varied between procedures. For example, when comparing the likelihood of minor hepatectomy between Māori and European liver cancer patients, adjusting for deprivation exacerbated the disparity (OR from 1.46 to 1.68); while doing the same in the context of partial gastrectomy for stomach cancer had no material impact (ORs from 1.43 to 1.44).

Timing of surgery. A box-and-whisker plot showing the time from diagnosis to first surgery (among those who had a primary surgery) is shown in Figure 1, while frequencies, proportions and odds ratios comparing the timing of first surgery from diagnosis are shown in Table 3. The timing of first liver cancer surgery was centred around the date of diagnosis, and a similar proportion of Māori (age standardised proportion: 75% of those who accessed primary surgery) and European (76%) patients had received their first surgery before four weeks post-diagnosis. However, of these patients, a greater proportion of Europeans received their first surgery prior to the diagnosis date (Māori 42%, European 49%; adj. OR 0.74, 95% CI 0.55-1.01), while a greater proportion of Māori accessed their first surgery within the first four weeks after diagnosis (Māori 33%, European 27%; adj. OR 1.49, 95% I 1.08-2.07). For stomach cancer, Māori appeared more likely to access their first

primary surgery before four weeks post-diagnosis (40% vs. 26%), and commensurately less likely to access first surgery at a later stage (e.g. 12-24 weeks post-diagnosis: Māori 26% of first surgeries, European 48%; adj. OR 0.49, 95% CI 0.35-0.70).

Table 1: Characteristics of the cohort.

	Liver						Stomach					
	Māori			European			Māori			European		
	n	%	Age Std. %	n	%	Age Std. %	n	%	Age Std. %	n	%	Age Std. %
Total	866	-	-	2,460	-	-	953	-	-	3,192	-	-
Age (years)												
<50	140	16%	-	128	5%	-	216	23%	-	195	6%	-
50-64	429	50%	-	718	29%	-	343	36%	-	696	22%	-
65-74	186	21%	-	683	28%	-	227	24%	-	883	28%	-
75+	111	13%	-	931	38%	-	167	18%	-	1,418	44%	-
Sex												
Female	226	26%	27%	830	34%	31%	416	44%	44%	1,042	33%	32%
Male	640	74%	73%	1,630	66%	69%	537	56%	56%	2,150	67%	68%
Deprivation (NZDep Decile)												
1-2 (least deprived)	51	6%	6%	372	16%	16%	40	4%	4%	487	16%	16%
3-4	61	7%	7%	429	18%	18%	80	9%	8%	563	18%	18%
5-6	105	12%	12%	525	22%	21%	118	13%	12%	668	22%	21%
7-8	194	23%	23%	580	24%	23%	208	22%	22%	778	25%	24%
9-10 (most deprived)	439	52%	51%	487	20%	19%	485	52%	51%	578	19%	16%
Rurality (URPC Category)												
Urban	582	69%	67%	1,731	72%	72%	605	65%	64%	2,179	71%	68%
Independent Urban	150	18%	18%	399	17%	14%	161	17%	17%	493	16%	14%
Rural	117	14%	14%	260	11%	11%	164	18%	17%	399	13%	14%
Stage (SEER Category)												
Local	89	10%	10%	178	7%	10%	107	11%	11%	210	7%	7%
Regional	23	3%	2%	87	4%	4%	163	17%	17%	401	13%	14%
Advanced	188	22%	22%	588	24%	25%	353	37%	37%	1,031	32%	37%
Unstaged	566	65%	65%	1,607	65%	61%	330	35%	34%	1,550	49%	42%
Comorbidity (C3 Index Category)												
0	203	23%	24%	819	33%	37%	493	52%	52%	1,654	52%	62%
1	250	29%	28%	534	22%	23%	129	14%	14%	463	15%	14%
2	158	18%	19%	424	17%	18%	98	10%	10%	381	12%	10%
3	255	29%	29%	683	28%	22%	233	24%	24%	694	22%	13%

Table 2: Receipt of surgery following liver or stomach cancer diagnosis, by ethnicity.

		Māori			European			Māori vs. European Odds Ratios (95% CI)		
Cancer	Surgery Type	*n*	*%*	*Age Std. %*	*n*	*%*	*Age Std. %*	*Crude*	*Age Adjusted*	*Fully Adjusted*
Liver	Received Any Primary Surgery	290	33%	33%	676	27%	35%	1.33 (1.13-1.57)	0.9 (0.75-1.08)	0.94 (0.76-1.17)
	Received Any Curative Surgery	132	15%	15%	321	13%	19%	1.2 (0.96-1.49)	0.8 (0.63-1.01)	0.79 (0.56-1.12)
	Major Hepatectomy	31	4%	4%	77	3%	5%	1.15 (0.75-1.76)	0.81 (0.52-1.25)	0.89 (0.53-1.49)
	Minor Hepatectomy	72	8%	8%	116	5%	6%	1.83 (1.35-2.49)	1.44 (1.05-1.97)	1.96 (1.26-3.04)
	Percutaneous Drainage	12	1%	1%	25	1%	1%	1.37 (0.69-2.74)	1.16 (0.57-2.38)	1.12 (0.51-2.47)
	PTC	5	1%	-	26	1%	-		-	
	Transplant	18	2%	2%	86	3%	5%	0.59 (0.35-0.98)	0.37 (0.22-0.64)	0.33 (0.19-0.6)
	Received Any Palliative Surgery	180	21%	20%	453	18%	22%	1.16 (0.96-1.41)	0.91 (0.74-1.12)	0.93 (0.74-1.17)
	Endoscopic Injection	7	1%	-	25	1%	-		-	
	Hepaticoenterostomy	3	0%	-	20	1%	-		-	
	Liver Ablation	169	20%	19%	416	17%	20%	1.19 (0.98-1.45)	0.95 (0.77-1.16)	0.95 (0.75-1.2)
	TIPS	1	0%	-	6	0%	-		-	
Stomach	Received Any Primary Surgery	384	40%	41%	990	31%	37%	1.5 (1.29-1.74)	1.04 (0.89-1.23)	1.02 (0.81-1.27)
	Received Any Curative Surgery	366	38%	39%	943	30%	35%	1.49 (1.28-1.73)	1.01 (0.86-1.19)	0.96 (0.76-1.21)
	Oesophagectomy	25	3%	3%	342	11%	15%	0.22 (0.15-0.34)	0.12 (0.08-0.18)	0.1 (0.06-0.16)
	Total Gastrectomy	153	16%	16%	317	10%	12%	1.74 (1.41-2.14)	1.04 (0.82-1.3)	1.11 (0.84-1.46)
	Partial Gastrectomy	188	20%	20%	420	13%	15%	1.62 (1.34-1.96)	1.47 (1.2-1.8)	1.34 (1.04-1.73)
	Percutaneous Drainage	10	1%	1%	21	1%	1%	1.6 (0.75-3.41)	1.44 (0.63-3.26)	1.61 (0.66-3.95)
	Received Any Palliative Surgery	92	10%	10%	202	6%	7%	1.58 (1.22-2.05)	1.35 (1.02-1.78)	1.46 (1.07-2)
	Pyloroplasty	3	0%	-	32	1%	-		-	
	Endoscopic Injection	44	5%	5%	138	4%	4%	1.07 (0.76-1.52)	1.1 (0.76-1.59)	0.96 (0.63-1.45)
	Enteroenterostomy	61	6%	6%	97	3%	3%	2.18 (1.57-3.03)	1.67 (1.17-2.39)	1.98 (1.31-2.99)
	Tumour Debulking	2	0%	-	1	0%	-		-	

Note: Fully-adjusted model adjusted for age, sex, deprivation, rurality, stage and comorbidity. Age-standardised proportions and odds ratios were not calculated when the number of Māori cases was <10.

Table 3: Timing of receipt of surgery following liver or stomach cancer diagnosis, by ethnicity.

		Māori			European			Māori vs. European Odds Ratios (95% CI)		
Cancer	Timing	*n*	*%*	*Age Std. %*	*n*	*%*	*Age Std. %*	*Crude*	*Age Adjusted*	*Fully Adjusted*
Liver	Timing of First Surgery From Diagnosis:[1]									
	On or before diagnosis date	128	44%	42%	340	50%	49%	0.78 (0.59-1.03)	0.81 (0.61-1.07)	0.74 (0.55-1.01)
	0-3 weeks (after diagnosis)	98	34%	33%	188	28%	27%	1.33 (0.99-1.78)	1.44 (1.06-1.95)	1.49 (1.08-2.07)
	4-12 weeks	36	12%	15%	79	12%	13%	1.07 (0.7-1.63)	0.98 (0.64-1.5)	1.1 (0.7-1.74)
	12-24 weeks	19	7%	7%	48	7%	8%	0.92 (0.53-1.59)	0.82 (0.47-1.44)	0.71 (0.38-1.31)
	> 24 weeks	9	3%	3%	21	3%	4%	1 (0.45-2.21)	0.92 (0.41-2.05)	1.08 (0.45-2.58)
	Median in days (IQR)	1 (0-21)			0 (0-18.5)					
Stomach	Timing of First Surgery From Diagnosis:[1]									
	On or before diagnosis date	75	20%	19%	154	16%	15%	1.32 (0.97-1.79)	1.4 (1.01-1.95)	1.13 (0.77-1.66)
	0-4 weeks (after diagnosis)	79	21%	21%	137	14%	11%	1.61 (1.19-2.19)	2.06 (1.48-2.87)	1.64 (1.11-2.42)
	4-12 weeks	99	26%	26%	208	21%	18%	1.31 (0.99-1.72)	1.61 (1.19-2.16)	1.19 (0.84-1.7)
	12-24 weeks	96	25%	25%	416	42%	48%	0.46 (0.35-0.6)	0.34 (0.25-0.45)	0.49 (0.35-0.7)
	> 24 weeks	35	9%	9%	75	8%	9%	1.22 (0.8-1.86)	1 (0.63-1.59)	1.44 (0.83-2.5)
	Median in days (IQR)	48 (6-120.5)			83.5 (19-135)					

[1] Among those who received a primary surgery. **Note:** Fully-adjusted model adjusted for age, sex, deprivation, rurality, stage and comorbidity.

Discussion

In this study, we used national-level data to examine equity of access to surgical treatment for liver and stomach cancer between Māori and European patients. Our key findings for each of these cancers are discussed separately below, following which we draw these findings together and consider their meaning.

Liver cancer

While Māori liver cancer patients appeared similarly likely to access any primary surgery – with only around a third of each cohort doing so – there were some differences in the types of treatment being accessed. While Māori appeared somewhat more likely to access minor hepatectomy, there was a difference in access to transplant – with Māori patients around 66% less likely to access transplant than European patients, even after adjusting for potential confounding and mediating factors (including comorbidity). Ethnic disparities in access to transplant have been observed elsewhere: reviews of existing literature have found ethnic disparities in access to liver transplant waiting lists, as well as ultimate access to liver transplantation.[16 17] A recent seven-centre US study [18] found that Black cirrhosis patients were four times less likely to access liver transplantation compared to White patients, even after adjusting for age, sex, insurance status, cirrhosis aetiology, and Model for End-Stage Liver Disease (MELD) score (adj. hazard ratio: 0.24, 95% CI 0.18-0.32).

Our findings suggest that we seem to be observing a similar inequity in access to transplant for Māori liver cancer patients in New Zealand. Given that our results are adjusted for comorbidity, it is plausible that there are other (non-physical) factors which influence transplant selection that inequitably favour European over Māori patients: for example, factors such as mental health, social stability and the availability of a well-resourced support network that can provide crucial care to the patient during their long recovery period post-transplant. There may be other factors regarding the availability of suitable donor matching for Māori, but there is currently a lack of robust evidence that this is the case. Further examination of barriers to transplant that are unique to Māori is urgently needed, including a need to examine the responsiveness of our transplant workforce relative to the needs of Māori.

Māori and European patients were similarly likely to access first primary surgery in the period up to four weeks post-diagnosis. We noted that 42% of Māori and 49% of European patients had their

first primary surgery on or before their diagnosis date: this is most likely because the pathology samples used to register the cancer and record its date of diagnosis on the New Zealand Cancer Registry (NZCR) were derived from the first primary surgery. It is possible that these patients were clinically staged prior to their first surgery, but this staging information (and the date that this stage was attributed) is not available at a national level. The lack of delay between diagnosis and surgery may also partially reflect the absence of neo-adjuvant treatment for this cancer, wherein patients who are eligible for surgery will generally undergo this treatment without pre-surgical therapy (such as chemotherapy). We also noted that Māori liver cancer patients were somewhat less likely to have their first surgery prior to diagnosis than European patients (and commensurately somewhat more likely to have their first surgery in the four weeks post-diagnosis); while it is possible that this might reflect earlier access to first treatment for European patients, the granularity of our data do not allow us to assess factors which might help to support this notion (such as dates of referral to secondary and tertiary services, etc.).

Stomach cancer

Māori and European patients appeared similarly likely to access curative surgery for stomach cancer; however, there appeared to be a difference in the type of curative surgery being accessed, with European patients considerably more likely to undergo oesophagectomy, and Māori patients more likely to undergo partial (and to an extent total) gastrectomy. This finding is in-keeping with our previous audit of clinical notes,[3] and is most likely to be explained by differences in the types of stomach cancer most commonly found among these two ethnic groups. Our previous audit [3] found that Māori patients were substantially more likely to have their tumour located in the distal portion of the stomach (age-standardised proportion: Māori 40%, European 21%), likely due to disparities in exposure to *Helicobacter Pylori* infection,[19] while non-Māori (i.e. largely European) patients were more likely to have their tumour located proximally (Māori 26%, European 39%). This may explain why Europeans may be more likely to be candidates for oesophagectomy, and why Māori may be more likely to be candidates for gastrectomy. An additional plausible explanation is that Māori may be less likely to be offered a higher-risk procedure that involves opening the chest, possibly due to an increased perceived surgical risk compared to European patients. However, this explanation

requires further examination, and we note that we have adjusted for differences between groups in comorbidity burden.

Māori appeared to be more likely to access any palliative surgery compared to European patients, and were around twice as likely to undergo an enteroenterostomy. Since this procedure is often performed to address a gastric outlet obstruction, the increased frequency of this procedure among Māori may be related to the increased burden of distal stomach cancers among Māori patients,[3] which may mean that Māori are more likely to present with an obstructed stomach than European patients. Overall, this finding suggests an increased need for surgical palliation of acute stomach obstruction among Māori patients – which may relate to the type of stomach cancers typically experienced by Māori, but also to a lack of access to early diagnosis and treatment before an obstruction occurs. The extent to which these (or other) factors are driving this disparity is unclear from the data available for this study.

In terms of the timing of first primary surgery for stomach cancer, it appeared that Māori accessed first surgery earlier in their cancer journey than European patients. There are several potential reasons for this observation: firstly, it is of course possible that Māori have more timely access to surgical care than European patients – however, given previous evidence that Māori experience greater barriers to timely cancer care,[20-22] this seems unlikely. The second potential explanation is that it is possible that we are missing data from some private hospitals (which would likely mostly be for European patients); however, as noted in our earlier clinical audit, privately-funded surgery for stomach cancer is extremely uncommon,[3] and thus we do not believe that this can explain this difference. Thirdly, and perhaps most crucially, it is possible that European patients are accessing different types of care compared to Māori, and that this impacts on the observed timing through to first surgery. We note that the standard of care for stomach cancer includes pre-operative (i.e. neo-adjuvant) chemotherapy.[23]Given known barriers in access to systemic therapy,[21 24 25] European patients may be more likely to access neo-adjuvant systemic therapy (and/or radiotherapy) prior to surgery, which may explain why we observed that European patients were substantially more likely to have their first procedure 12-24 weeks after diagnosis (i.e. after receiving neo-adjuvant chemotherapy). Inequities in access to this best-practice treatment may also help to partially explain disparities in subsequent survival outcomes experienced by Māori with stomach cancer.[1] It would therefore be beneficial to augment the surgical data used for this study with systemic therapy (and

radiotherapy data), and future research should aim to bring these data together in order to understand the plausibility of this third explanation.

What do these findings mean?

Our purpose for examining equity of access to surgical treatment for liver and stomach cancer is to try to identify potential mechanisms by which Māori patients may experience barriers to best-practice care, with the ultimate goal of eliminating inequities in survival between Māori and non-Māori patients. We have identified some areas of inequity that deserve further examination: a) access to liver transplant for Māori patients appears lower than for European patients despite adjustment for some factors which might influence this access, which suggests unequal access to transplant lists and subsequent transplantation; b) Māori with stomach cancer appear more likely to require the type of palliation consistent with gastric outlet obstruction, which may suggest reduced access to care before the onset of acute symptoms; and c) our observations with respect to the differential timing of first stomach cancer surgery between Māori and European patients suggests that the latter may be more likely to access neo-adjuvant therapy.. These observations are consistent with various pieces of evidence of reduced access to and through surgical services for Māori patients,[26 27] with this reduced access likely driven by a combination of proximal factors (e.g. greater barriers to accessing early diagnosis and subsequent care, greater morbidity) and distal factors (including the social determinants of health, such as institutionalised racism [28]).

However, there are also some encouraging signals from our findings: firstly, while it is somewhat difficult to interpret the results for liver cancer, we noted an absence of disadvantage toward Māori in timing of access to surgical treatment for stomach cancer (Table 3); and secondly, differences in access to any curative surgery were marginal (in the case of liver cancer) or non-existent (in the case of stomach cancer; Table 2). There are two factors that might be driving these observations: firstly, both liver and stomach cancers have a generally poor prognosis (for both Māori and non-Māori patients), with 5-year survival for both cancers around 25%.[1] This poor prognosis is primarily driven by a tendency for this cancer to be detected at an advanced stage, rather than at an early stage when curative treatment is possible (which explains why only 15-20% of liver cancer patients and 30-40% of stomach cancer patients in this study accessed some form of curative surgery). Perhaps this high rate of advanced disease at diagnosis, combined with the subsequent low rate of curative

treatment, means that there are fewer opportunities along the care pathway for Māori to be disadvantaged relative to Europeans. Secondly, the treatment of upper-gastrointestinal cancers is sufficiently complex that it generally requires specialisation and capacity to rescue, with the majority of complex procedures consequently performed within a few treatment hubs around the country. Curative surgical care in private hospitals for these cancers is rare,[3] again providing less opportunity for disparities to occur between Māori and non-Māori in terms of timely access to high-quality care. It is possible that fewer clinicians providing care in fewer locations results in fewer opportunities for disparities in access to occur along the care pathway; this rationale has been used to explain the similarity of child cancer survival outcomes between Māori and non-Māori children under 10 years old, with care of all these children generally taking place within a few key centres.[29] While reassuring, these findings must be contextualised alongside the substantial inequity that exists between Māori and European New Zealanders in terms of mortality from liver or stomach cancer, driven by strong disparities in the incidence of these two cancers between these ethnic groups.[2]

Strengths and Limitations

A key strength of this study is that it reports on equity of access to surgical intervention for all patients with liver or stomach cancer across more than a decade, using the most recently available data. This national-level data ensures that our findings are representative of the current state of access equity in New Zealand. A weakness of this national-level data is the lack of complete staging information for these two cancers, with nearly two-thirds of liver cancers and more than a third of stomach cancers remaining unstaged on the New Zealand Cancer Registry (NZCR). The absence of robust staging information prevents us from conducting stage-stratified analyses for this study. A second weakness is the granularity of treatment information available from National Collections – we only have the fact of the procedure, not the reason for its conduct – and thus, in places, we have needed to infer the most likely reason (for example, enteroenterostomy and bowel obstruction). A third weakness is that some of the included cancers are only diagnosed clinically (i.e. not via pathology report following a surgical procedure): in this case, the NZCR attributes diagnosis on the basis of inpatient hospitalisation discharge summaries. This is relatively uncommon for stomach cancer (since most are endoscopically diagnosed), but occurs among more than half of all liver cancer diagnoses (Susan Hanna, NZCR, personal communication). In this situation, the

date of diagnosis is recorded on the NZCR as the date of first admission to hospital where a diagnosis of liver or stomach cancer was made. Finally, as noted above, this study only examines equity of access to surgical treatment, not systemic therapy or radiotherapy. Future research should aim to bring these data together at a national level – and while this is not currently straightforward (or perhaps even possible, certainly in terms of retrospective analysis of routine data sources), rapid improvements in cancer data infrastructure are currently underway across the sector, led by Te Aho o Te Kahu (our national Cancer Control Agency).[30]

Conclusions

In this study we examined equity of access to surgical treatment among all Māori and European patients diagnosed with liver or stomach cancer. We found little evidence of differential access to primary surgery overall; however, when examining individual procedures, we found that Māori with liver cancer were less likely to access transplant and more likely to access minor hepatectomy than European patients, even after adjusting for age, sex, deprivation, rurality, stage and comorbidity. We also found that Māori patients with stomach cancer were more likely to undergo partial gastrectomy, while European patients were more likely to undergo oesophagectomy; and that Māori stomach cancer patients were more likely to undergo palliative surgery than European patients, particularly enteroenterostomy. We also found that European patients were substantially more likely to have their surgery delayed following diagnosis, indicating that this population group may have better access to neo-adjuvant chemotherapy – although robust data on systemic treatment is required to substantiate this observation. Overall, our findings suggest that differences exist in terms of the types of surgeries received by Māori patients, which may indicate differences in disease type (e.g. in the case of gastrectomy) and/or differential access to best-practice treatment (e.g. in the case of liver transplant, or possibly in access to chemotherapy prior to surgery). However, we may also be cautiously encouraged by the fact that differences in overall access to curative surgical treatment were either marginal (liver) or absent (stomach).

Figure Legend

Figure 1: Box-and-whisker plots showing the timing of first primary surgical treatment following diagnosis, among Māori and European liver (top) and stomach (bottom) cancer patients who received a primary surgical treatment. The width of the box is the interquartile range (25th to 75th percentile); the median is denoted by a dashed line; the mean is denoted by a diamond; and the whiskers correspond to the minimum and maximum values.

Acknowledgements

We would like to acknowledge Chris Lewis and the Ministry of Health's National Collections team for assisting with the data extraction for this study.

Funding Statement

This study was funded by the Health Research Council of New Zealand (reference # HRC 18/588).

Data Sharing Statement

The data used for this study was provided following ethical review from the New Zealand Ministry of Health National Collections team. Data requests can be made by contacting data-enquiries@health.govt.nz.

Conflict of Interest Statement

The authors have no competing interests to declare.

Author Roles

Jason Gurney conceptualised the study, designed the study methodology, conducted the data analysis, interpreted the results and drafted the manuscript; **Diana Sarfati** assisted with study

conceptualisation and provided critical review of drafts; James Stanley provided biostatistical support and critical review of drafts; Clarence Kerrison assisted with clinical guidance and critical review of drafts; Jonathan Koea provided clinical oversight, methodological support, clinical guidance and critical review of drafts.

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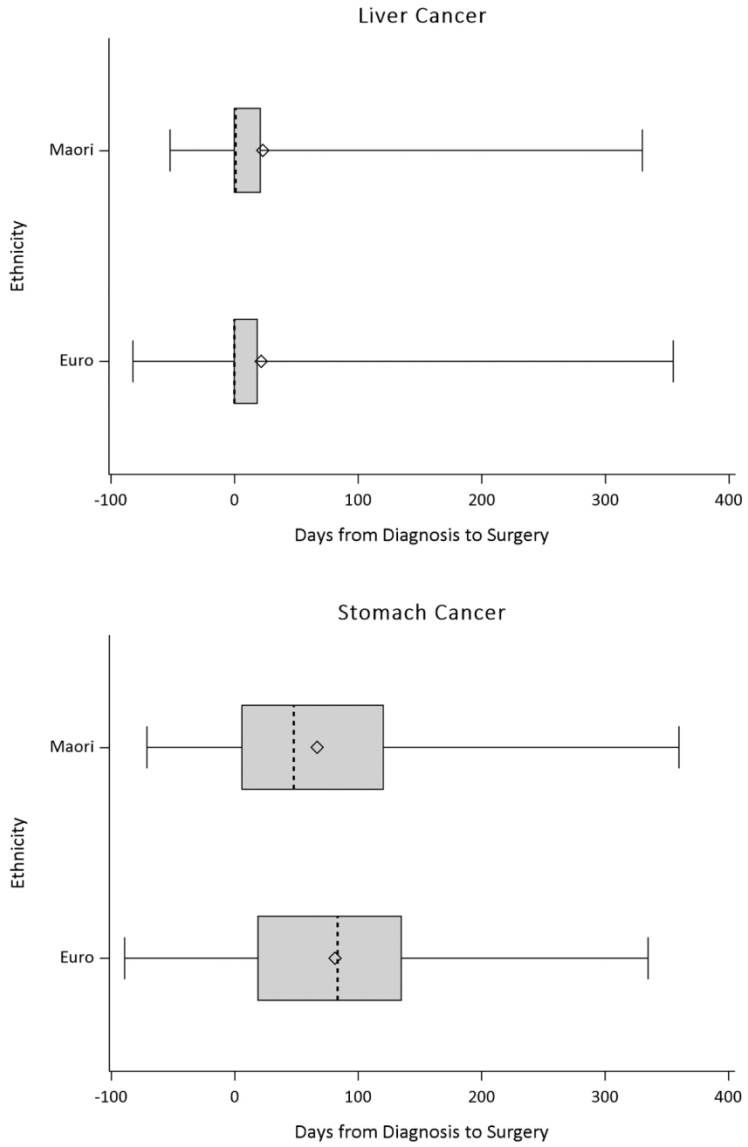

Figure 1: Box-and-whisker plots showing the timing of first primary surgical treatment following diagnosis, among Māori and European liver (top) and stomach (bottom) cancer patients who received a primary surgical treatment. The width of the box is the interquartile range (25th to 75th percentile); the median is denoted by a dashed line; the mean is denoted by a diamond; and the whiskers correspond to the minimum and maximum values.

190x254mm (200 x 200 DPI)

Supplementary Material 1: Odds ratios comparing the likelihood of surgery receipt between Māori and European liver and stomach cancer patients, iteratively adjusted for covariates.

		Māori vs. European Odds Ratios (95% CI)						
Cancer	Surgery Type	*Crude*	*+ Age*	*+ Sex*	*+ Deprivation*	*+ Rurality*	*+ Stage*	*+ Comorbidity*
Liver	Received Any Primary Surgery	1.33 (1.13-1.57)	0.9 (0.75-1.08)	0.89 (0.74-1.07)	1.03 (0.85-1.24)	1.0 (0.84-1.23)	0.96 (0.77-1.19)	0.94 (0.76-1.17)
	Received Any Curative Surgery	1.2 (0.96-1.49)	0.8 (0.63-1.01)	0.8 (0.63-1.01)	0.93 (0.73-1.2)	0.9 (0.72-1.19)	0.79 (0.56-1.12)	0.79 (0.56-1.12)
	Major Hepatectomy	1.15 (0.75-1.76)	0.81 (0.52-1.25)	0.84 (0.54-1.3)	0.97 (0.61-1.56)	0.9 (0.59-1.51)	0.89 (0.53-1.49)	0.89 (0.53-1.49)
	Minor Hepatectomy	1.83 (1.35-2.49)	1.44 (1.05-1.97)	1.46 (1.06-2)	1.68 (1.19-2.36)	1.6 (1.2-2.38)	1.96 (1.26-3.04)	1.96 (1.26-3.04)
	Percutanoeus Drainage	1.37 (0.69-2.74)	1.16 (0.57-2.38)	1.16 (0.57-2.38)	1.2 (0.55-2.58)	1.21 (0.56-2.62)	1.15 (0.53-2.52)	1.12 (0.51-2.47)
	Transplant	0.59 (0.35-0.98)	0.37 (0.22-0.64)	0.35 (0.21-0.6)	0.39 (0.23-0.69)	0.38 (0.22-0.68)	0.34 (0.19-0.6)	0.33 (0.19-0.6)
	Received Any Palliative Surgery	1.16 (0.96-1.41)	0.91 (0.74-1.12)	0.89 (0.72-1.09)	0.99 (0.79-1.23)	0.98 (0.79-1.21)	0.94 (0.75-1.17)	0.93 (0.74-1.17)
	Liver Ablation	1.19 (0.98-1.45)	0.95 (0.77-1.16)	0.92 (0.74-1.13)	1 (0.8-1.25)	0.99 (0.8-1.24)	0.95 (0.76-1.2)	0.95 (0.75-1.2)
Stomach	Received Any Primary Surgery	1.5 (1.29-1.74)	1.04 (0.89-1.23)	1.06 (0.9-1.25)	1.11 (0.93-1.33)	1.1 (0.93-1.32)	0.98 (0.79-1.23)	1.02 (0.81-1.27)
	Received Any Curative Surgery	1.49 (1.28-1.73)	1.01 (0.86-1.19)	1.03 (0.87-1.21)	1.07 (0.9-1.28)	1.01 (0.89-1.28)	0.92 (0.73-1.16)	0.96 (0.76-1.21)
	Oesophagectomy	0.22 (0.15-0.34)	0.12 (0.08-0.18)	0.13 (0.08-0.2)	0.12 (0.08-0.19)	0.13 (0.08-0.2)	0.09 (0.06-0.15)	0.1 (0.06-0.16)
	Partial Gastrectomy	1.62 (1.34-1.96)	1.47 (1.2-1.8)	1.43 (1.17-1.76)	1.44 (1.15-1.79)	1.4 (1.16-1.81)	1.3 (1.01-1.66)	1.34 (1.04-1.73)
	Total Gastrectomy	1.74 (1.41-2.14)	1.04 (0.82-1.3)	1.08 (0.86-1.36)	1.15 (0.89-1.48)	1.16 (0.9-1.49)	1.05 (0.8-1.39)	1.11 (0.84-1.46)
	Percutanoeus Drainage	1.6 (0.75-3.41)	1.44 (0.63-3.26)	1.52 (0.67-3.44)	1.69 (0.71-4.02)	1.68 (0.7-3.98)	1.55 (0.64-3.77)	1.61 (0.66-3.95)
	Received Any Palliative Surgery	1.58 (1.22-2.05)	1.35 (1.02-1.78)	1.38 (1.04-1.83)	1.54 (1.14-2.08)	1.54 (1.16-2.12)	1.46 (1.07-2)	1.46 (1.07-2)
	Endoscopic Injection	1.07 (0.76-1.52)	1.1 (0.76-1.59)	1.1 (0.76-1.6)	1.1 (0.74-1.63)	1.06 (0.71-1.58)	1.07 (0.71-1.61)	0.96 (0.63-1.45)
	Enteroenterostomy	2.18 (1.57-3.03)	1.67 (1.17-2.39)	1.68 (1.17-2.41)	2.04 (1.38-3)	2 (1.42-3.1)	1.9 (1.26-2.85)	1.98 (1.31-2.99)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	4-7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8, Supp Material
		(b) Indicate number of participants with missing data for each variable of interest	4-6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9, Supp. Material
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-9, Supp Material
		(*b*) Report category boundaries when continuous variables were categorized	5-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-9, Supp Material
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Equity of timely access to liver and stomach cancer surgery for Indigenous patients in New Zealand: a national cohort study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-058749.R1
Article Type:	Original research
Date Submitted by the Author:	07-Feb-2022
Complete List of Authors:	Gurney, JK; University of Otago, Department of Public Health Sarfati, Diana; Te Aho o Te Kahu - Cancer Control Agency Stanley, James; University of Otago, Wellington, Public Health; University of Otago, Wellington Kerrison, Clarence; Waikato District Health Board Koea, Jonathan; Waitemata District Health Board
Primary Subject Heading:	Oncology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	SURGERY, ONCOLOGY, PUBLIC HEALTH

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Equity of timely access to liver and stomach cancer surgery for Indigenous patients in New Zealand: a national cohort study

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Keywords: Liver cancer, stomach cancer, surgery, access, indigenous, Māori

Words in main body of text: 4,862

Figures: 1

Tables: 3

Supplementary Tables: 1

Competing Interests statement: The authors have no competing interests to declare.

Abstract

Objectives. When combined, liver and stomach cancers are second only to lung cancer as the most common causes of cancer death for the indigenous Māori population of New Zealand – with Māori also experiencing substantial disparities in the likelihood of survival once diagnosed with these cancers. Since a key driver of this disparity in survival could be access to surgical treatment, we have used national-level data to examine surgical procedures performed on Māori liver and stomach cancer patients, and compared the likelihood and timing of access to the majority European population.

Design, Participants and Setting. We examined all cases of liver and stomach cancer diagnosed 2007-2019 on the New Zealand Cancer Registry (NZCR; liver cancer: 866 Māori, 2,460 European; stomach cancer: 953 Māori, 3,192 European), and linked these cases to all inpatient hospitalisations that occurred over this time to identify curative and palliative surgical procedures. As well as descriptive analysis, we compared the likelihood of access to a given procedure between Māori and Europeans, stratified by cancer and adjusted for confounding and mediating factors. Finally, we compared the timing of access to a given procedure between ethnic groups.

Results and Conclusions. We found that a) access to liver transplant for Māori is lower than for Europeans; b) Māori with stomach cancer appear more likely to require the type of palliation consistent with gastric outlet obstruction; and c) differential timing of first stomach cancer surgery between Māori and European patients. However, we may also be cautiously encouraged by the fact that differences in overall access to curative surgical treatment were either marginal (liver) or absent (stomach).

Strengths and Limitations of this Study

- A key strength of this study is that it reports on equity of access to surgical intervention for all patients with liver or stomach cancer across more than a decade, using the most recently available data.
- This national coverage comes at the expense of some data granularity: for example, complete staging information for these two cancers were not available.
- This study only examines equity of access to surgical treatment, not systemic therapy or radiotherapy. Future research should aim to bring these data together at a national level.

Introduction

The Indigenous Māori population of New Zealand experience poorer survival outcomes than the non-Indigenous population for 23 of the 24 most commonly-diagnosed cancers.[1] Of these cancers, both liver and stomach cancer feature prominently as important causes of cancer death for Māori – and when combined, these upper-gastrointestinal cancers rank second only to lung cancer in terms of the absolute number of cancer deaths among Māori each year.[2] Māori patients with liver cancer are nearly a third (31%) more likely to die, and those with stomach cancer 22% more likely to die than non-Māori stomach cancer patients. [1]

Timely access to best-practice treatment is a potentially key driver of these survival disparities. Accumulated evidence suggests that there is little difference between Māori and non-Māori patients in terms of stage of disease at diagnosis for either of these poor-prognosis cancers,[3-5] which implies that survival inequities may be related to access to treatment following diagnosis. Our previous clinical audits [3 4] identified a lack of Māori access to specialist services for the treatment of stomach cancer, but were based on small numbers of patients and only covered a three-year period (2006-2008). Given the ongoing disparity in survival experienced by Māori liver and stomach cancer patients, a more comprehensive and broader approach is required to examine equity in access to surgical services for these cancers.

In this manuscript, we use national-level data to examine all inpatient surgical procedures performed on all Māori liver and stomach cancer patients diagnosed across more than a decade, and compare

the likelihood of access – and the timing of that access – to that experienced by the majority European population.

Methods

Participants and Data Sources

All cases of liver and stomach cancer occurring between 2007 and 2019 were extracted from the New Zealand Cancer Registry (NZCR; liver cancer: 866 Māori, 2,460 European; stomach cancer: 953 Māori, 3,192 European). These individuals were linked via encrypted National Health Index (NHI) number to the National Minimum Dataset (NMDS) to determine access to inpatient surgical procedures from this same period (2007-2019). NMDS data were also extracted for the 2002-2006 period to allow for the calculation of patient comorbidity (see *Variables* below). Ethical approval for this study was sought and received from the University of Otago Human Ethics Committee (reference # HD18/056). Data used for this study were de-identified prior to being provided to the researchers by the New Zealand Ministry of Health.

Demographic and Patient Variables

Date of cancer diagnosis was determined from the NZCR. Age at diagnosis was defined by subtracting date of cancer diagnosis from the individual's date of birth (also recorded on the NZCR). Sex was derived from the NZCR, recorded as either female or male. Prioritised ethnicity was derived from the NZCR, and defined for this study as Māori or European. Level of socioeconomic deprivation was defined using the NZDep deprivation scale, a small area-based deprivation index that uses multiple variables to define the level of are deprivation.[6] Missing data prevented the attribution of deprivation for 83 liver cancer patients (2% of the cohort) and 140 stomach cancer patients (3% of the cohort). Patient rurality was defined using a modified version of the Urban/Rural Profile Classification (URPC),[7] with the area where a patient lived at the time of the cancer diagnosis classified as urban (main urban area + satellite urban area), independent urban or rural. Missing data prevented the attribution of rurality for 87 liver cancer patients (3% of the cohort) and 144 stomach cancer patients (3% of the cohort). There is an overlap between the missing-ness of

deprivation and rurality data, driven by missing census area unit data (i.e. unable to determine patient's place of residence).

Patient **comorbidity** was defined using the C3 Index, a cancer-specific measure of patient comorbidity.[8] It uses public and private inpatient hospitalisation data (NMDS) to define the presence or absence of 42 individual conditions. All International Classification of Diseases (ICD)-coded diagnoses (ICD-10-AM, 3rd edition) recorded in the five years prior to date of diagnosis were used to calculate a C3 index score for each patient, with each condition weighted according to its relationship with non-cancer mortality in a cancer population.[8] Condition weights were then summed to give the final C3 score, categorised as '0' (score <=0), '1' (<=1), '2' (<=2) and '3' (>2). Those with none of the included conditions detected over the lookback period were assigned a score of 0. For our descriptive analysis, comorbidity was included as a categorical variable, while in our regression analysis raw comorbidity score was included as a continuous variable, using restricted cubic splines with knots placed at the 50th, 90th and 95th percentiles.[9]

Cancer **stage at diagnosis** was determined from the NZCR, and based on the SEER Summary Stage method (A to F).[10] Stage was categorised into Local (B), Regional (C and D), Advanced (E) and Unstaged (F).[11]

Surgical Variables

Surgical procedures were extracted from the NMDS using the Australasian College of Health Informatics (ACHI) ICD-10-AM code (3rd Edition).[12] In order to determine a list of primary surgical procedures (i.e. those procedures that directly related to the underlying cancer, whether curative or palliative in intent), we used ICD-10-AM/ACHI codes to first extract all surgical procedures performed on members of the cohort over the study period. Clinical team members then reviewed this list to determine relevant primary procedures that should be included in our investigation. When identifying relevant procedures, clinical team members also identified whether the procedure was generally undertaken with a curative or palliative intent, and also grouped individual procedures into relevant groups in order to collapse the number of individual procedure categories for analysis (for example, seven individual oesophagectomy procedures were collapsed into one oesophagectomy category).

Once a final list of relevant procedures were identified, we scanned the NMDS for instances where each patient underwent one of these procedures, and included all procedures that occurred up to one year post-diagnosis. Since it was possible that some relevant procedures would be performed before the diagnosis date recorded on the NZCR, we also scanned procedures that occurred up to 90 days prior to the date of diagnosis. Based on these scans, we created binary indicators (yes/no) for each cancer type, which determined whether or not a given patient underwent **any primary surgery**, **any curative surgery**, and/or **any palliative surgery**. Patients were not limited to only having either curative surgery or palliative surgery: if one patient received both procedures over the study period, they could be included in both groups. In addition to the 'any' surgery variables, we also determined whether a given patient underwent one of the **specific procedure categories** (e.g. partial gastrectomy). Again, it was possible for patients to contribute to more than one individual procedure category if these were completed within the study period.

We also determined the **delay between diagnosis and receipt of first surgical treatment** for each patient. The first surgical treatment was defined as whichever primary procedure occurred earliest during this period (i.e. between 90 days pre-diagnosis and one year post-diagnosis). The time between diagnosis and first procedure was calculated in days, and also categorised into the following groups: a) on or before diagnosis date; b) 0-3 weeks after diagnosis, c) 4-12 weeks after diagnosis, d) 12-24 weeks after diagnosis; and e) >24 weeks after diagnosis.

Statistical Analysis

For our **descriptive analysis**, we determined frequencies and both crude (unadjusted) and age-standardised proportions for each given variable, stratified by cancer type and ethnicity. Denominators for the proportion of patients receiving surgical treatment were the ethnicity- and cancer-stratified population (e.g. all Māori liver cancer patients across the study period), while denominators for the timing of access to first surgical treatment was the ethnicity- and cancer-stratified number of patients who received any primary surgery. To calculate **age-standardised proportions**, we used direct standardisation methods,[13] with the total Māori cancer population 2007-2019 (30,346) as the standard population. We chose this standard population for two reasons: a) the underlying age structure of this population largely reflects that of Māori patients in the current study; and b) using an Indigenous standard population is a best-practice approach when comparing

Māori to other ethnic groups, as it normalises the age structure of the Māori population.[14 15] In order to visually present the timing of access to first surgery, we constructed ethnicity- and cancer-stratified box-and-whisker plots using standard descriptive statistics (median, mean, interquartile range, minimum and maximum values).

In order to compare the likelihood of access to the various surgical procedures (and the timing of that access) between Māori and European patients, we calculated crude and adjusted logistic regression models, stratified by cancer type, with European patients as the reference group. These model outputs are presented as odds ratios (OR) and their 95% confidence intervals (95% CI). Covariates in the fully-adjusted model were age (continuous variable), sex (male/female), deprivation (NZDep quintile), rurality (URPC category), stage (SEER category), and comorbidity (C3 score, as a splined variable). We calculated three models for the primary analysis: a crude model, an age-adjusted model (to reflect the age-standardised proportion data), and a fully-adjusted model. In order to observe the impact of each modelled variable, we also calculated a series of models in which each covariate was added iteratively, and the resulting odds ratios extracted for each model.

Patient and public involvement

The development of our study objectives were informed by the need to monitor access to surgical treatment for indigenous Māori patients. However, patients were not directly involved in the study.

Results

Patient Characteristics. The characteristics of the cohort are shown in Table 1. Regarding liver cancer: males comprised a majority of both the Māori (age-standardised proportion: 73%) and European (69%) liver cancer cohorts. More than half of Māori patients (51%) resided in the two most-deprived deciles (NZDep deciles 9-10), compared to 19% of European patients. The proportion of patients living in rural areas was similar for Māori (14%) and European (11%) patients.

The distribution of stage at diagnosis was also similar between Māori and European patients, with around a quarter of both groups having advanced disease (22% Māori, 25% European), while the majority of diagnoses remained unstaged for both groups (65% Māori, 61% European). Māori patients were less likely to have no comorbidity (24%) compared to Europeans (37%), and had a marginally higher proportion with the greatest comorbidity burden (29% vs. 22%).

Regarding stomach cancer (Table 1): a greater proportion of European stomach cancer patients were male (age-standardised proportion: 68%) compared to Māori (56%). Similar to liver cancer, more than half of Māori patients (51%) resided in the two most-deprived deciles (NZDep deciles 9-10), compared to 16% of European patients. The proportion of patients living in rural areas was similar for Māori (17%) and European (14%) patients. While an identical proportion of Māori and European patients were registered as having advanced disease (both 37%), a greater proportion of European patients (42%) were registered with unstaged disease compared to Māori (34%). Like liver cancer, Māori patients were less likely to have no comorbidity (C3 group = 0: 52%) compared to Europeans (62%), and had a higher proportion with the greatest comorbidity burden (C3 group = 3: 24% vs. 13%).

Table 1: Characteristics of the cohort.

	Liver						Stomach					
	Māori			European			Māori			European		
	n	%	Age Std. %	n	%	Age Std. %	n	%	Age Std. %	n	%	Age Std. %
Total	866	-	-	2,460	-	-	953	-	-	3,192	-	-
Age (years)												
<50	140	16%	-	128	5%	-	216	23%	-	195	6%	-
50-64	429	50%	-	718	29%	-	343	36%	-	696	22%	-
65-74	186	21%	-	683	28%	-	227	24%	-	883	28%	-
75+	111	13%	-	931	38%	-	167	18%	-	1,418	44%	-
Sex												
Female	226	26%	27%	830	34%	31%	416	44%	44%	1,042	33%	32%
Male	640	74%	73%	1,630	66%	69%	537	56%	56%	2,150	67%	68%
Deprivation (NZDep Decile)												
1-2 (least deprived)	51	6%	6%	372	16%	16%	40	4%	4%	487	16%	16%
3-4	61	7%	7%	429	18%	18%	80	9%	8%	563	18%	18%
5-6	105	12%	12%	525	22%	21%	118	13%	12%	668	22%	21%
7-8	194	23%	23%	580	24%	23%	208	22%	22%	778	25%	24%
9-10 (most deprived)	439	52%	51%	487	20%	19%	485	52%	51%	578	19%	16%
Rurality (URPC Category)												
Urban	582	69%	67%	1,731	72%	72%	605	65%	64%	2,179	71%	68%
Independent Urban	150	18%	18%	399	17%	14%	161	17%	17%	493	16%	14%
Rural	117	14%	14%	260	11%	11%	164	18%	17%	399	13%	14%
Stage (SEER Category)												
Local	89	10%	10%	178	7%	10%	107	11%	11%	210	7%	7%
Regional	23	3%	2%	87	4%	4%	163	17%	17%	401	13%	14%
Advanced	188	22%	22%	588	24%	25%	353	37%	37%	1,031	32%	37%
Unstaged	566	65%	65%	1,607	65%	61%	330	35%	34%	1,550	49%	42%
Comorbidity (C3 Index Category)												
0	203	23%	24%	819	33%	37%	493	52%	52%	1,654	52%	62%
1	250	29%	28%	534	22%	23%	129	14%	14%	463	15%	14%
2	158	18%	19%	424	17%	18%	98	10%	10%	381	12%	10%
3	255	29%	29%	683	28%	22%	233	24%	24%	694	22%	13%

Receipt of surgery. The number and proportion of Māori and European patients receiving primary surgical treatment, along with crude and adjusted odds ratios comparing likelihood of surgery between ethnic groups, are shown in Table 2. Only around a third of all patients with liver cancer had documented surgical treatment, with a similar proportion of Māori and European patients receiving any primary surgery (age-standardised proportions: 33% vs. 35%; fully-adjusted odds ratio [OR] 0.94, 95% CI 0.76-1.17). Māori appeared marginally less likely to receive curative surgery compared to European patients, although odds ratios crossed the null (15% vs. 19%; adj. OR 0.79, 95% CI 0.56-1.12). Compared to European patients, Māori appeared more likely to undergo minor hepatectomy (Māori 8%, European 6%; adj. OR 1.96, 95% CI 1.23-3.04), similarly likely to undergo major hepatectomcy (Māori 4%, European 5%; adj. OR 0.89, 95% CI 0.53-1.59) and less likely to undergo transplant (Māori 2%, European 5%; adj. OR 0.33, 95% CI 0.19-0.60). Māori were similarly likely to receive any palliative surgery (20% vs. 22%; adj. OR 0.93, 95% CI 0.74-1.17). The most common palliative procedure was liver ablation, with Māori and European patients similarly likely to undergo this procedure (Māori 19%, European 20%; adj. OR 0.95, 95% CI 0.75-1.20).

Around 40% of patients with stomach cancer had documented surgical treatment, with a similar proportion of Mā~ori and European patients receiving any primary surgery (age-standardised proportions: 41% vs. 37%; fully-adjusted odds ratio [OR] 1.02, 95% CI 0.81-1.27, Table 2). Māori and European patients were similarly likely to undergo any curative surgery (39% vs. 35%; adj. OR 0.96, 95% CI 0.79-1.21). Māori were less likely to undergo oesophagectomy (3% vs. 15%; adj. OR 0.10, 95% CI 0.06-0.16), more likely to undergo partial gastrectomy (20% vs. 15%; adj. OR 1.34, 95% CI 1.04-1.73), and appeared similarly likely to undergo total gastrectomy in the adjusted models (16% vs. 12%; adj. OR 1.11, 95% CI 0.84-1.46). While only around 10% of patients underwent palliative surgical treatment, Māori appeared more likely to undergo any palliative surgery compared to European patients (10% vs. 7%; adj. OR 1.46, 95% CI 1.07-2.00). Māori appeared more likely to undergo enteroenterostomy than European patients (6% vs. 3%; adj. OR 1.98, 95% CI 1.31-2.99), but similarly likely to undergo an endoscopic injection (5% vs. 4%; adj. OR 0.96, 95% CI 0.63-1.45).

The full output of our logistic regression models is shown in Supplementary Material 1, where we present odds ratios iteratively adjusted for each of our covariates. After adjusting for the confounding impact of age and sex, we noted that deprivation, stage and comorbidity had some impact on the observed relationship, but the extent of this impact – and whether it reduced or

exacerbated any differences – varied between procedures. For example, when comparing the likelihood of minor hepatectomy between Māori and European liver cancer patients, adjusting for deprivation exacerbated the disparity (OR from 1.46 to 1.68); while doing the same in the context of partial gastrectomy for stomach cancer had no material impact (ORs from 1.43 to 1.44).

Table 2: Receipt of surgery following liver or stomach cancer diagnosis, by ethnicity.

		Māori			European			Māori vs. European Odds Ratios (95% CI)		
Cancer	Surgery Type	*n*	*%*	*Age Std. %*	*n*	*%*	*Age Std. %*	*Crude*	*Age Adjusted*	*Fully Adjusted*
Liver	Received Any Primary Surgery	290	33%	33%	676	27%	35%	1.33 (1.13-1.57)	0.9 (0.75-1.08)	0.94 (0.76-1.17)
	Received Any Curative Surgery	132	15%	15%	321	13%	19%	1.2 (0.96-1.49)	0.8 (0.63-1.01)	0.79 (0.56-1.12)
	Major Hepatectomy	31	4%	4%	77	3%	5%	1.15 (0.75-1.76)	0.81 (0.52-1.25)	0.89 (0.53-1.49)
	Minor Hepatectomy	72	8%	8%	116	5%	6%	1.83 (1.35-2.49)	1.44 (1.05-1.97)	1.96 (1.26-3.04)
	Percutanoeus Drainage	12	1%	1%	25	1%	1%	1.37 (0.69-2.74)	1.16 (0.57-2.38)	1.12 (0.51-2.47)
	PTC	5	1%	-	26	1%	-		-	
	Transplant	18	2%	2%	86	3%	5%	0.59 (0.35-0.98)	0.37 (0.22-0.64)	0.33 (0.19-0.6)
	Received Any Palliative Surgery	180	21%	20%	453	18%	22%	1.16 (0.96-1.41)	0.91 (0.74-1.12)	0.93 (0.74-1.17)
	Endoscopic Injection	7	1%	-	25	1%	-		-	
	Hepaticoenterostomy	3	0%	-	20	1%	-		-	
	Liver Ablation	169	20%	19%	416	17%	20%	1.19 (0.98-1.45)	0.95 (0.77-1.16)	0.95 (0.75-1.2)
	TIPS	1	0%	-	6	0%	-		-	
Stomach	Received Any Primary Surgery	384	40%	41%	990	31%	37%	1.5 (1.29-1.74)	1.04 (0.89-1.23)	1.02 (0.81-1.27)
	Received Any Curative Surgery	366	38%	39%	943	30%	35%	1.49 (1.28-1.73)	1.01 (0.86-1.19)	0.96 (0.76-1.21)
	Oesophagectomy	25	3%	3%	342	11%	15%	0.22 (0.15-0.34)	0.12 (0.08-0.18)	0.1 (0.06-0.16)
	Total Gastrectomy	153	16%	16%	317	10%	12%	1.74 (1.41-2.14)	1.04 (0.82-1.3)	1.11 (0.84-1.46)
	Partial Gastrectomy	188	20%	20%	420	13%	15%	1.62 (1.34-1.96)	1.47 (1.2-1.8)	1.34 (1.04-1.73)
	Percutanoeus Drainage	10	1%	1%	21	1%	1%	1.6 (0.75-3.41)	1.44 (0.63-3.26)	1.61 (0.66-3.95)

Received Any Palliative Surgery	92	10%	10%	202	6%	7%	1.58 (1.22-2.05)	1.35 (1.02-1.78)	1.46 (1.07-2)
Pyloroplasty	3	0%	-	32	1%	-		-	
Endoscopic Injection	44	5%	5%	138	4%	4%	1.07 (0.76-1.52)	1.1 (0.76-1.59)	0.96 (0.63-1.45)
Enteroenterostomy	61	6%	6%	97	3%	3%	2.18 (1.57-3.03)	1.67 (1.17-2.39)	1.98 (1.31-2.99)
Tumour Debulking	2	0%	-	1	0%	-		-	

Note: Fully-adjusted model adjusted for age, sex, deprivation, rurality, stage and comorbidity. Age-standardised proportions and odds ratios were not calculated when the number of Māori cases was <10. PTC = percutaneous transhepatic cholangiography; TIPS = transjugular intrahepatic portosystemic shunt.

Timing of surgery. A box-and-whisker plot showing the time from diagnosis to first surgery (among those who had a primary surgery) is shown in Figure 1, while frequencies, proportions and odds ratios comparing the timing of first surgery from diagnosis are shown in Table 3. The timing of first liver cancer surgery was centred around the date of diagnosis, and a similar proportion of Māori (age standardised proportion: 75% of those who accessed primary surgery) and European (76%) patients had received their first surgery before four weeks post-diagnosis. However, of these patients, a greater proportion of Europeans received their first surgery prior to the diagnosis date (Māori 42%, European 49%; adj. OR 0.74, 95% CI 0.55-1.01), while a greater proportion of Māori accessed their first surgery within the first four weeks after diagnosis (Māori 33%, European 27%; adj. OR 1.49, 95% I 1.08-2.07). For stomach cancer, Māori appeared more likely to access their first primary surgery before four weeks post-diagnosis (40% vs. 26%), and commensurately less likely to access first surgery at a later stage (e.g. 12-24 weeks post-diagnosis: Māori 26% of first surgeries, European 48%; adj. OR 0.49, 95% CI 0.35-0.70).

Table 3: Timing of receipt of surgery following liver or stomach cancer diagnosis, by ethnicity.

		Māori			European			Māori vs. European Odds Ratios (95% CI)		
Cancer	Timing	*n*	*%*	*Age Std. %*	*n*	*%*	*Age Std. %*	*Crude*	*Age Adjusted*	*Fully Adjusted*
Liver	Timing of First Surgery From Diagnosis:[1]									
	On or before diagnosis date	128	44%	42%	340	50%	49%	0.78 (0.59-1.03)	0.81 (0.61-1.07)	0.74 (0.55-1.01)
	0-3 weeks (after diagnosis)	98	34%	33%	188	28%	27%	1.33 (0.99-1.78)	1.44 (1.06-1.95)	1.49 (1.08-2.07)
	4-12 weeks	36	12%	15%	79	12%	13%	1.07 (0.7-1.63)	0.98 (0.64-1.5)	1.1 (0.7-1.74)
	12-24 weeks	19	7%	7%	48	7%	8%	0.92 (0.53-1.59)	0.82 (0.47-1.44)	0.71 (0.38-1.31)
	> 24 weeks	9	3%	3%	21	3%	4%	1 (0.45-2.21)	0.92 (0.41-2.05)	1.08 (0.45-2.58)
	Median in days (IQR)	1 (0-21)			0 (0-18.5)					
Stomach	Timing of First Surgery From Diagnosis:[1]									
	On or before diagnosis date	75	20%	19%	154	16%	15%	1.32 (0.97-1.79)	1.4 (1.01-1.95)	1.13 (0.77-1.66)
	0-4 weeks (after diagnosis)	79	21%	21%	137	14%	11%	1.61 (1.19-2.19)	2.06 (1.48-2.87)	1.64 (1.11-2.42)
	4-12 weeks	99	26%	26%	208	21%	18%	1.31 (0.99-1.72)	1.61 (1.19-2.16)	1.19 (0.84-1.7)
	12-24 weeks	96	25%	25%	416	42%	48%	0.46 (0.35-0.6)	0.34 (0.25-0.45)	0.49 (0.35-0.7)
	> 24 weeks	35	9%	9%	75	8%	9%	1.22 (0.8-1.86)	1 (0.63-1.59)	1.44 (0.83-2.5)
	Median in days (IQR)	48 (6-120.5)			83.5 (19-135)					

[1] Among those who received a primary surgery. **Note:** Fully-adjusted model adjusted for age, sex, deprivation, rurality, stage and comorbidity.

Discussion

In this study, we used national-level data to examine equity of access to surgical treatment for liver and stomach cancer between Māori and European patients. Our key findings for each of these cancers are discussed separately below, following which we draw these findings together and consider their meaning.

Liver cancer

While Māori liver cancer patients appeared similarly likely to access any primary surgery – with only around a third of each cohort doing so – there were some differences in the types of treatment being accessed. While Māori appeared somewhat more likely to access minor hepatectomy, there was a difference in access to transplant – with Māori patients around 66% less likely to access transplant than European patients, even after adjusting for potential confounding and mediating factors (including comorbidity). Ethnic disparities in access to transplant have been observed elsewhere: reviews of existing literature have found ethnic disparities in access to liver transplant waiting lists, as well as ultimate access to liver transplantation.[16 17] A recent seven-centre US study [18] found that Black cirrhosis patients were four times less likely to access liver transplantation compared to White patients, even after adjusting for age, sex, insurance status, cirrhosis aetiology, and Model for End-Stage Liver Disease (MELD) score (adj. hazard ratio: 0.24, 95% CI 0.18-0.32).

Our findings suggest that we seem to be observing a similar inequity in access to transplant for Māori liver cancer patients in New Zealand. Given that our results are adjusted for comorbidity, it is plausible that there are other (non-physical) factors which influence transplant selection that inequitably favour European over Māori patients: for example, factors such as mental health, social stability and the availability of a well-resourced support network that can provide crucial care to the patient during their long recovery period post-transplant. There may be other factors regarding the availability of suitable donor matching for Māori, but there is currently a lack of robust evidence that this is the case. Further examination of barriers to transplant that are unique to Māori is urgently needed, including a need to examine the responsiveness of our transplant workforce relative to the needs of Māori.

Māori and European patients were similarly likely to access first primary surgery in the period up to four weeks post-diagnosis. We noted that 42% of Māori and 49% of European patients had their

first primary surgery on or before their diagnosis date: this is most likely because the pathology samples used to register the cancer and record its date of diagnosis on the New Zealand Cancer Registry (NZCR) were derived from the first primary surgery. It is possible that these patients were clinically staged prior to their first surgery, but this staging information (and the date that this stage was attributed) is not available at a national level. The lack of delay between diagnosis and surgery may also partially reflect the absence of neo-adjuvant treatment for this cancer, wherein patients who are eligible for surgery will generally undergo this treatment without pre-surgical therapy (such as chemotherapy). We also noted that Māori liver cancer patients were somewhat less likely to have their first surgery prior to diagnosis than European patients (and commensurately somewhat more likely to have their first surgery in the four weeks post-diagnosis); while it is possible that this might reflect earlier access to first treatment for European patients, the granularity of our data do not allow us to assess factors which might help to support this notion (such as dates of referral to secondary and tertiary services, etc.).

Stomach cancer

Māori and European patients appeared similarly likely to access curative surgery for stomach cancer; however, there appeared to be a difference in the type of curative surgery being accessed, with European patients considerably more likely to undergo oesophagectomy, and Māori patients more likely to undergo partial (and to an extent total) gastrectomy. This finding is in-keeping with our previous audit of clinical notes,[3] and is most likely to be explained by differences in the types of stomach cancer most commonly found among these two ethnic groups. Our previous audit [3] found that Māori patients were substantially more likely to have their tumour located in the distal portion of the stomach (age-standardised proportion: Māori 40%, European 21%), likely due to disparities in exposure to *Helicobacter Pylori* infection,[19] while non-Māori (i.e. largely European) patients were more likely to have their tumour located proximally (Māori 26%, European 39%). This may explain why Europeans may be more likely to be candidates for oesophagectomy, and why Māori may be more likely to be candidates for gastrectomy.

Māori appeared to be more likely to access any palliative surgery compared to European patients, and were around twice as likely to undergo an enteroenterostomy. Since this procedure is often performed to address a gastric outlet obstruction, the increased frequency of this procedure among

Māori may be related to the increased burden of distal stomach cancers among Māori patients,[3] which may mean that Māori are more likely to present with an obstructed stomach than European patients. Overall, this finding suggests an increased need for surgical palliation of acute stomach obstruction among Māori patients – which may relate to the type of stomach cancers typically experienced by Māori, but also to a lack of access to early diagnosis and treatment before an obstruction occurs. The extent to which these (or other) factors are driving this disparity is unclear from the data available for this study.

In terms of the timing of first primary surgery for stomach cancer, it appeared that Māori accessed first surgery earlier in their cancer journey than European patients. There are several potential reasons for this observation: firstly, it is of course possible that Māori have more timely access to surgical care than European patients – however, given previous evidence that Māori experience greater barriers to timely cancer care,[20-22] this seems unlikely. The second potential explanation is that it is possible that we are missing data from some private hospitals (which would likely mostly be for European patients); however, as noted in our earlier clinical audit, privately-funded surgery for stomach cancer is extremely uncommon,[3] and thus we do not believe that this can explain this difference. Thirdly, and perhaps most crucially, it is possible that European patients are accessing different types of care compared to Māori, and that this impacts on the observed timing through to first surgery. We note that the standard of care for stomach cancer includes pre-operative (i.e. neo-adjuvant) chemotherapy.[23] Given known barriers in access to systemic therapy,[21 24 25] it is possible that European patients may be more likely to access neo-adjuvant systemic therapy (and/or radiotherapy) prior to surgery, which may explain why we observed that European patients were substantially more likely to have their first procedure 12-24 weeks after diagnosis (i.e. after receiving neo-adjuvant chemotherapy). However, primary data on neo-adjuvant access to systemic therapy is required to substantiate this explanation. It would be beneficial to augment the surgical data used for this study with systemic therapy (and radiotherapy data), and future research should aim to bring these data together.

What do these findings mean?

Our purpose for examining equity of access to surgical treatment for liver and stomach cancer is to try to identify potential mechanisms by which Māori patients may experience barriers to best-

practice care, with the ultimate goal of eliminating inequities in survival between Māori and non-Māori patients. We have identified some areas of inequity that deserve further examination: a) access to liver transplant for Māori patients appears lower than for European patients despite adjustment for some factors which might influence this access, which suggests unequal access to transplant lists and subsequent transplantation; b) Māori with stomach cancer appear more likely to require the type of palliation consistent with gastric outlet obstruction, which may suggest reduced access to care before the onset of acute symptoms; and c) our observations with respect to the differential timing of first stomach cancer surgery between Māori and European patients suggests that the latter may be more likely to access neo-adjuvant therapy.. These observations are consistent with various pieces of evidence of reduced access to and through surgical services for Māori patients,[26 27] with this reduced access likely driven by a combination of proximal factors (e.g. greater barriers to accessing early diagnosis and subsequent care, greater morbidity) and distal factors (including the social determinants of health, such as institutionalised racism [28]).

However, there are also some encouraging signals from our findings: firstly, while it is somewhat difficult to interpret the results for liver cancer, we noted an absence of disadvantage toward Māori in timing of access to surgical treatment for stomach cancer (Table 3); and secondly, differences in access to any curative surgery were marginal (in the case of liver cancer) or non-existent (in the case of stomach cancer; Table 2). There are two factors that might be driving these observations: firstly, both liver and stomach cancers have a generally poor prognosis (for both Māori and non-Māori patients), with 5-year survival for both cancers around 25%.[1] This poor prognosis is primarily driven by a tendency for this cancer to be detected at an advanced stage, rather than at an early stage when curative treatment is possible (which explains why only 15-20% of liver cancer patients and 30-40% of stomach cancer patients in this study accessed some form of curative surgery). Perhaps this high rate of advanced disease at diagnosis, combined with the subsequent low rate of curative treatment, means that there are fewer opportunities along the care pathway for Māori to be disadvantaged relative to Europeans. Secondly, the treatment of upper-gastrointestinal cancers is sufficiently complex that it generally requires specialisation and capacity to rescue, with the majority of complex procedures consequently performed within a few treatment hubs around the country. Curative surgical care in private hospitals for these cancers is rare,[3] again providing less opportunity for disparities to occur between Māori and non-Māori in terms of timely access to high-quality care. It is possible that fewer clinicians providing care in fewer locations results in fewer opportunities for

disparities in access to occur along the care pathway; this rationale has been used to explain the similarity of child cancer survival outcomes between Māori and non-Māori children under 10 years old, with care of all these children generally taking place within a few key centres.[29] While reassuring, these findings must be contextualised alongside the substantial inequity that exists between Māori and European New Zealanders in terms of mortality from liver or stomach cancer, driven by strong disparities in the incidence of these two cancers between these ethnic groups.[2]

Strengths and Limitations

A key strength of this study is that it reports on equity of access to surgical intervention for all patients with liver or stomach cancer across more than a decade, using the most recently available data. This national-level data ensures that our findings are representative of the current state of access equity in New Zealand. A weakness of this national-level data is the lack of complete staging information for these two cancers, with nearly two-thirds of liver cancers and more than a third of stomach cancers remaining unstaged on the New Zealand Cancer Registry (NZCR). The absence of robust staging information prevents us from conducting stage-stratified analyses for this study. A second weakness is the granularity of treatment information available from National Collections – we only have the fact of the procedure, not the reason for its conduct – and thus, in places, we have needed to infer the most likely reason (for example, enteroenterostomy and bowel obstruction). We also included percutaneous drainage as a curative treatment, since it may be performed following neoadjuvant chemotherapy within the context of a curative treatment plan; however, we note that this treatment can also be performed in a palliative context. We recognise that in cancer treatment there is often crossover between what is 'curative' and what is 'palliative' treatment – and that the administrative nature of the data that we used prevented us distinguishing between the two. A third weakness is that some of the included cancers are only diagnosed clinically (i.e. not via pathology report following a surgical procedure): in this case, the NZCR attributes diagnosis on the basis of inpatient hospitalisation discharge summaries. This is relatively uncommon for stomach cancer (since most are endoscopically diagnosed), but occurs among more than half of all liver cancer diagnoses (Susan Hanna, NZCR, personal communication). In this situation, the date of diagnosis is recorded on the NZCR as the date of first admission to hospital where a diagnosis of liver or stomach cancer was made. Finally, as noted above, this study only examines

equity of access to surgical treatment, not systemic therapy or radiotherapy. Future research should aim to bring these data together at a national level – and while this is not currently straightforward (or perhaps even possible, certainly in terms of retrospective analysis of routine data sources), rapid improvements in cancer data infrastructure are currently underway across the sector, led by Te Aho o Te Kahu (our national Cancer Control Agency).[30]

Conclusions

In this study we examined equity of access to surgical treatment among all Māori and European patients diagnosed with liver or stomach cancer. We found little evidence of differential access to primary surgery overall; however, when examining individual procedures, we found that Māori with liver cancer were less likely to access transplant and more likely to access minor hepatectomy than European patients, even after adjusting for age, sex, deprivation, rurality, stage and comorbidity. We also found that Māori patients with stomach cancer were more likely to undergo partial gastrectomy, while European patients were more likely to undergo oesophagectomy; and that Māori stomach cancer patients were more likely to undergo palliative surgery than European patients, particularly enteroenterostomy. We also found that European patients were substantially more likely to have their surgery delayed following diagnosis, indicating that this population group may have better access to neo-adjuvant chemotherapy – although robust data on systemic treatment is required to substantiate this observation. Overall, our findings suggest that differences exist in terms of the types of surgeries received by Māori patients, which may indicate differences in disease type (e.g. in the case of gastrectomy) and/or differential access to best-practice treatment (e.g. in the case of liver transplant, or possibly in access to chemotherapy prior to surgery). However, we may also be cautiously encouraged by the fact that differences in overall access to curative surgical treatment were either marginal (liver) or absent (stomach).

Figure Legend

Figure 1: Box-and-whisker plots showing the timing of first primary surgical treatment following diagnosis, among Māori and European liver (top) and stomach (bottom) cancer patients who received a primary surgical treatment. The width of the box is the interquartile range (25th to 75th

percentile); the median is denoted by a dashed line; the mean is denoted by a diamond; and the whiskers correspond to the minimum and maximum values.

Acknowledgements

We would like to acknowledge Chris Lewis and the Ministry of Health's National Collections team for assisting with the data extraction for this study.

Funding Statement

This study was funded by the Health Research Council of New Zealand (reference # HRC 18/588).

Data Sharing Statement

The data used for this study was provided following ethical review from the New Zealand Ministry of Health National Collections team. Data requests can be made by contacting data-enquiries@health.govt.nz.

Conflict of Interest Statement

The authors have no competing interests to declare.

Author Roles

Jason Gurney conceptualised the study, designed the study methodology, conducted the data analysis, interpreted the results and drafted the manuscript; Diana Sarfati assisted with study conceptualisation and provided critical review of drafts; James Stanley provided biostatistical support and critical review of drafts; Clarence Kerrison assisted with clinical guidance and critical review of drafts; Jonathan Koea provided clinical oversight, methodological support, clinical guidance and critical review of drafts.

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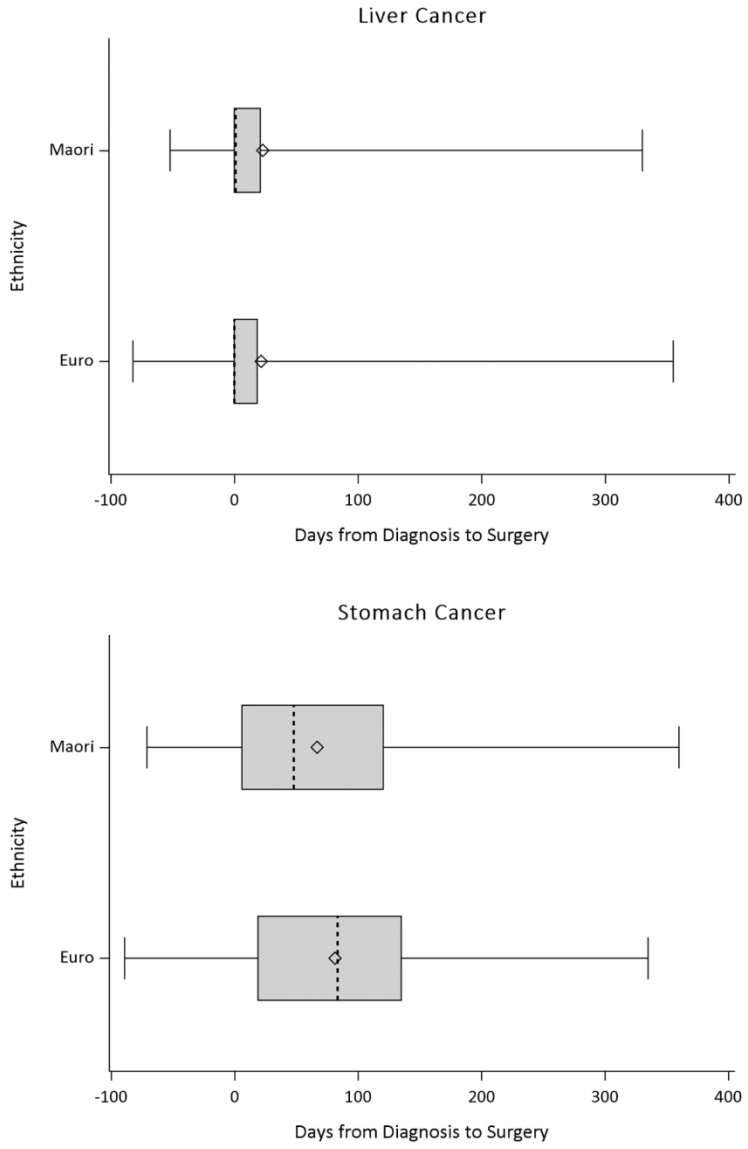

Figure 1: Box-and-whisker plots showing the timing of first primary surgical treatment following diagnosis, among Māori and European liver (top) and stomach (bottom) cancer patients who received a primary surgical treatment. The width of the box is the interquartile range (25th to 75th percentile); the median is denoted by a dashed line; the mean is denoted by a diamond; and the whiskers correspond to the minimum and maximum values.

190x254mm (200 x 200 DPI)

Supplementary Material 1: Odds ratios comparing the likelihood of surgery receipt between Māori and European liver and stomach cancer patients, iteratively adjusted for covariates.

		Māori vs. European Odds Ratios (95% CI)						
Cancer	Surgery Type	*Crude*	*+ Age*	*+ Sex*	*+ Deprivation*	*+ Rurality*	*+ Stage*	*+ Comorbidity*
Liver	Received Any Primary Surgery	1.33 (1.13-1.57)	0.9 (0.75-1.08)	0.89 (0.74-1.07)	1.03 (0.85-1.24)	1.0 (0.84-1.23)	0.96 (0.77-1.19)	0.94 (0.76-1.17)
	Received Any Curative Surgery	1.2 (0.96-1.49)	0.8 (0.63-1.01)	0.8 (0.63-1.01)	0.93 (0.73-1.2)	0.9 (0.72-1.19)	0.79 (0.56-1.12)	0.79 (0.56-1.12)
	Major Hepatectomy	1.15 (0.75-1.76)	0.81 (0.52-1.25)	0.84 (0.54-1.3)	0.97 (0.61-1.56)	0.9 (0.59-1.51)	0.89 (0.53-1.49)	0.89 (0.53-1.49)
	Minor Hepatectomy	1.83 (1.35-2.49)	1.44 (1.05-1.97)	1.46 (1.06-2)	1.68 (1.19-2.36)	1.6 (1.2-2.38)	1.96 (1.26-3.04)	1.96 (1.26-3.04)
	Percutanoeus Drainage	1.37 (0.69-2.74)	1.16 (0.57-2.38)	1.16 (0.57-2.38)	1.2 (0.55-2.58)	1.21 (0.56-2.62)	1.15 (0.53-2.52)	1.12 (0.51-2.47)
	Transplant	0.59 (0.35-0.98)	0.37 (0.22-0.64)	0.35 (0.21-0.6)	0.39 (0.23-0.69)	0.38 (0.22-0.68)	0.34 (0.19-0.6)	0.33 (0.19-0.6)
	Received Any Palliative Surgery	1.16 (0.96-1.41)	0.91 (0.74-1.12)	0.89 (0.72-1.09)	0.99 (0.79-1.23)	0.98 (0.79-1.21)	0.94 (0.75-1.17)	0.93 (0.74-1.17)
	Liver Ablation	1.19 (0.98-1.45)	0.95 (0.77-1.16)	0.92 (0.74-1.13)	1 (0.8-1.25)	1 (0.8-1.24)	0.95 (0.76-1.2)	0.95 (0.75-1.2)
Stomach	Received Any Primary Surgery	1.5 (1.29-1.74)	1.04 (0.89-1.23)	1.06 (0.9-1.25)	1.11 (0.93-1.33)	1.1 (0.93-1.32)	0.98 (0.79-1.23)	1.02 (0.81-1.27)
	Received Any Curative Surgery	1.49 (1.28-1.73)	1.01 (0.86-1.19)	1.03 (0.87-1.21)	1.07 (0.9-1.28)	1.01 (0.89-1.28)	0.92 (0.73-1.16)	0.96 (0.76-1.21)
	Oesophagectomy	0.22 (0.15-0.34)	0.12 (0.08-0.18)	0.13 (0.08-0.2)	0.12 (0.08-0.19)	0.13 (0.08-0.2)	0.09 (0.06-0.15)	0.1 (0.06-0.16)
	Partial Gastrectomy	1.62 (1.34-1.96)	1.47 (1.2-1.8)	1.43 (1.17-1.76)	1.44 (1.15-1.79)	1.4 (1.16-1.81)	1.3 (1.01-1.66)	1.34 (1.04-1.73)
	Total Gastrectomy	1.74 (1.41-2.14)	1.04 (0.82-1.3)	1.08 (0.86-1.36)	1.15 (0.89-1.48)	1.16 (0.9-1.49)	1.05 (0.8-1.39)	1.11 (0.84-1.46)
	Percutanoeus Drainage	1.6 (0.75-3.41)	1.44 (0.63-3.26)	1.52 (0.67-3.44)	1.69 (0.71-4.02)	1.68 (0.7-3.98)	1.55 (0.64-3.77)	1.61 (0.66-3.95)
	Received Any Palliative Surgery	1.58 (1.22-2.05)	1.35 (1.02-1.78)	1.38 (1.04-1.83)	1.54 (1.14-2.08)	1.54 (1.16-2.12)	1.46 (1.07-2)	1.46 (1.07-2)
	Endoscopic Injection	1.07 (0.76-1.52)	1.1 (0.76-1.59)	1.1 (0.76-1.6)	1.1 (0.74-1.63)	1.06 (0.71-1.58)	1.07 (0.71-1.61)	0.96 (0.63-1.45)
	Enteroenterostomy	2.18 (1.57-3.03)	1.67 (1.17-2.39)	1.68 (1.17-2.41)	2.04 (1.38-3)	2 (1.42-3.1)	1.9 (1.26-2.85)	1.98 (1.31-2.99)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	4-7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8, Supp Material
		(b) Indicate number of participants with missing data for each variable of interest	4-6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9, Supp. Material
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-9, Supp Material
		(*b*) Report category boundaries when continuous variables were categorized	5-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-9, Supp Material
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.