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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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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 patients with liver and stomach cancers and compared the likelihood and timing of access with the majority European population.

Design, participants and setting We examined all cases of liver and stomach cancers diagnosed during 2007–2019 on the New Zealand Cancer Registry (liver cancer: 866 Māori, 2460 European; stomach cancer: 953 Māori, 3192 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 cancers 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 3-year period (2006–2008). Given the ongoing disparity in survival experienced by Māori patients with liver and stomach cancers, 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 patients with liver and stomach cancers 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 cancers occurring between 2007 and 2019 were extracted from the New Zealand Cancer Registry (NZCR; liver cancer: 866 Māori, 2460 European; stomach cancer: 953 Māori, 3192 European). These individuals were linked via encrypted National Health Index 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).

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 New Zealand deprivation scale (NZDep), 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 patients with liver cancer (2% of the cohort) and 140 patients with stomach cancer (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 patients with liver cancer (3% of the cohort) and 144 patients with stomach cancer (3% of the cohort). There is an overlap between the missingness of deprivation and rurality data, driven by missing census area unit data (ie, 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, third edition) recorded in the 5 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 look-back 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 Surveillance, Epidemiology, and End Results (SEER) Summary Stage method (A–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 (third edition).[12] In order to determine a list of primary surgical procedures (ie, 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 (eg, seven individual oesophagectomy procedures were collapsed into one oesophagectomy category).

Once a final list of relevant procedures was identified, we scanned the NMDS for instances where each patient underwent one of these procedures and included all procedures that occurred for up to 1 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 (eg, 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 (ie, between 90 days pre diagnosis and 1 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-stratified and cancer-stratified population (eg, all Māori patients with liver cancer across the study period), while denominators for the timing of access to first surgical treatment was the ethnicity-stratified 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-stratified and cancer-stratified box-and-whisker plots using standard descriptive statistics (median, mean, IQR, 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 ORs and their 95% CIs. 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 ORs extracted for each model.

Patient and public involvement

The development of our study objectives was 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 with 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 with 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 patients with stomach cancer were male (age-standardised proportion: 68%) compared with 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 with 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 with Māori (34%). Like liver cancer, Māori patients were less likely to have no comorbidity (C3 group=0: 52%) compared with 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 ORs 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 OR 0.94, 95% CI 0.76 to 1.17). Māori appeared marginally less likely to receive curative surgery compared with European patients, although ORs crossed the null (15% vs 19%; adj. OR 0.79, 95% CI 0.56 to 1.12). Compared with European patients, Māori appeared more likely to undergo minor hepatectomy (Māori 8%, European 6%; adj. OR 1.96, 95% CI 1.23 to 3.04), similarly likely to undergo major hepatectomy (Māori 4%, European 5%; adj. OR 0.89, 95% CI 0.53 to 1.59) and less likely to undergo transplant (Māori 2%, European 5%; adj. OR 0.33, 95% CI 0.19 to 0.60). Māori were similarly likely to receive any palliative surgery (20% vs 22%; adj. OR 0.93, 95% CI 0.74 to 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 to 1.20).

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	–	–	2460	–	–	953	–	–	3192	–	–
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	–	1418	44	–
Sex												
Female	226	26	27	830	34	31	416	44	44	1042	33	32
Male	640	74	73	1630	66	69	537	56	56	2150	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	1731	72	72	605	65	64	2179	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	1031	32	37
Unstaged	566	65	65	1607	65	61	330	35	34	1550	49	42
Comorbidity (C3 Index category)												
0	203	23	24	819	33	37	493	52	52	1654	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

NZDep, New Zealand Deprivation Index; SEER, Surveillance, Epidemiology, and End Results programme; URPC, urban/rural profile classification.

Around 40% of patients with stomach cancer had documented surgical treatment, with a similar proportion of Māori and European patients receiving any primary surgery (age-standardised proportions: 41% vs 37%; fully adjusted OR 1.02, 95% CI 0.81 to 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 to 1.21). Māori were less likely to undergo oesophagectomy (3% vs 15%; adj. OR 0.10, 95% CI 0.06 to 0.16), more likely to undergo partial gastrectomy (20% vs 15%; adj. OR 1.34, 95% CI 1.04 to 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 to 1.46). While only around 10% of patients underwent palliative surgical treatment, Māori appeared more likely to undergo any palliative surgery compared with European patients (10% vs 7%; adj. OR 1.46, 95% CI 1.07 to 2.00). Māori appeared more likely to undergo enteroenterostomy than European patients (6% vs 3%; adj. OR 1.98, 95% CI 1.31 to 2.99), but similarly likely to undergo an endoscopic injection (5% vs 4%; adj. OR 0.96, 95% CI 0.63 to 1.45).

The full output of our logistic regression models is shown in online supplemental material 1, where we present ORs iteratively adjusted for each of our covariates. After adjusting for the confounding impact of age and sex, we noted that deprivation, stage and comorbidity

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

		Māori			European			Māori versus European ORs (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 to 1.57)	0.9 (0.75 to 1.08)	0.94 (0.76 to 1.17)
	Received any curative surgery	132	15	15	321	13	19	1.2 (0.96 to 1.49)	0.8 (0.63 to 1.01)	0.79 (0.56 to 1.12)
	Major hepatectomy	31	4	4	77	3	5	1.15 (0.75 to 1.76)	0.81 (0.52 to 1.25)	0.89 (0.53 to 1.49)
	Minor hepatectomy	72	8	8	116	5	6	1.83 (1.35 to 2.49)	1.44 (1.05 to 1.97)	1.96 (1.26 to 3.04)
	Percutaneous drainage	12	1	1	25	1	1	1.37 (0.69 to 2.74)	1.16 (0.57 to 2.38)	1.12 (0.51 to 2.47)
	PTC	5	1	–	26	1	–	–		
	Transplant	18	2	2	86	3	5	0.59 (0.35 to 0.98)	0.37 (0.22 to 0.64)	0.33 (0.19 to 0.6)
	Received any palliative surgery	180	21	20	453	18	22	1.16 (0.96 to 1.41)	0.91 (0.74 to 1.12)	0.93 (0.74 to 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 to 1.45)	0.95 (0.77 to 1.16)	0.95 (0.75 to 1.2)
	TIPS	1	0	–	6	0	–	–		
Stomach	Received any primary surgery	384	40	41	990	31	37	1.5 (1.29 to 1.74)	1.04 (0.89 to 1.23)	1.02 (0.81 to 1.27)
	Received any curative surgery	366	38	39	943	30	35	1.49 (1.28 to 1.73)	1.01 (0.86 to 1.19)	0.96 (0.76 to 1.21)
	Oesophagectomy	25	3	3	342	11	15	0.22 (0.15 to 0.34)	0.12 (0.08 to 0.18)	0.1 (0.06 to 0.16)
	Total gastrectomy	153	16	16	317	10	12	1.74 (1.41 to 2.14)	1.04 (0.82 to 1.3)	1.11 (0.84 to 1.46)
	Partial gastrectomy	188	20	20	420	13	15	1.62 (1.34 to 1.96)	1.47 (1.2 to 1.8)	1.34 (1.04 to 1.73)
	Percutaneous drainage	10	1	1	21	1	1	1.6 (0.75 to 3.41)	1.44 (0.63 to 3.26)	1.61 (0.66 to 3.95)
	Received any palliative surgery	92	10	10	202	6	7	1.58 (1.22 to 2.05)	1.35 (1.02 to 1.78)	1.46 (1.07 to 2)
	Pyloroplasty	3	0	–	32	1	–	–		
	Endoscopic injection	44	5	5	138	4	4	1.07 (0.76 to 1.52)	1.1 (0.76 to 1.59)	0.96 (0.63 to 1.45)
	Enteroenterostomy	61	6	6	97	3	3	2.18 (1.57 to 3.03)	1.67 (1.17 to 2.39)	1.98 (1.31 to 2.99)
	Tumour debulking	2	0	–	1	0	–	–		

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

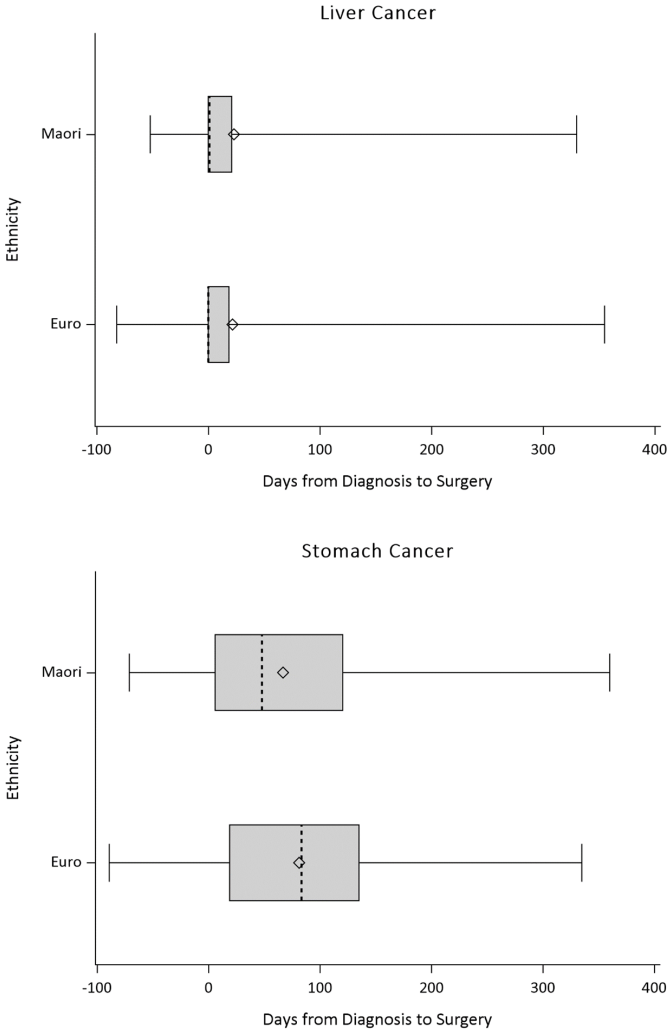

Figure 1 Box-and-whisker plots showing the timing of first primary surgical treatment following diagnosis, among Māori and European patients with liver (top) and stomach (bottom) cancer who received a primary surgical treatment. The width of the box is the IQR (25th–75th percentile). The median is denoted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

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 patients with liver cancer, 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 ORs 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 4 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 to 1.01), while a greater proportion of Māori accessed their first surgery within the first 4 weeks after diagnosis (Māori 33%, European 27%; adj. OR 1.49, 95% I 1.08 to 2.07). For stomach cancer, Māori appeared more likely to access their first primary surgery before 4 weeks post diagnosis (40% vs 26%) and commensurately less likely to access first surgery at a later stage (eg, 12–24 weeks post diagnosis: Māori 26% of first surgeries, European 48%; adj. OR 0.49, 95% CI 0.35 to 0.70).

DISCUSSION

In this study, we used national-level data to examine equity of access to surgical treatment for liver and stomach cancers 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 patients with liver cancer 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 treatments 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 patients with black cirrhosis were four times less likely to access liver transplantation compared with patients with white cirrhosis, even after adjusting for age, sex, insurance status, cirrhosis aetiology and Model for End-Stage Liver Disease Score (adj. HR: 0.24, 95% CI 0.18 to 0.32).

Our findings suggest that we seem to be observing a similar inequity in access to transplant for Māori patients with liver cancer 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

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

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

Fully adjusted model adjusted for age, sex, deprivation, rurality, stage and comorbidity.
*Among those who received a primary surgery.

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 4 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 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 neoadjuvant treatment for this cancer, wherein patients who are eligible for surgery will generally undergo this treatment without presurgical therapy (such as chemotherapy). We also noted that Māori patients with liver cancer 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 4 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 cancers 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 (ie, 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 with 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 not only 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: first, 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. Third, and perhaps most crucially, it is possible that European patients are accessing different types of care compared with Māori and that this impacts on the observed timing through to first surgery. We note that the standard of care for stomach cancer includes preoperative (ie, neoadjuvant) 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 neoadjuvant 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 (ie, after receiving neoadjuvant chemotherapy). However, primary data on neoadjuvant 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 cancers 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 patients 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 neoadjuvant 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 (eg, 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: first, 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 second, 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: first, 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 patients with liver cancer and 30%–40% of patients with stomach cancer 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. Second, 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 result 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 of age, 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 ensure 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 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 (eg, 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 (ie, 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 patients with stomach cancer 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 neoadjuvant chemotherapy—although robust data on systemic treatment are 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 (eg, in the case of gastrectomy) and/or differential access to best-practice treatment (eg, 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).

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants. 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.

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Data availability statement Data may be obtained from a third party and are not publicly available. The data used for this study were 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.

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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)	1.01 (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)	0.93 (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)	0.94 (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)	1.69 (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)	0.39 (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)	1.11 (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)	1.07 (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)	0.12 (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)	1.45 (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)	1.67 (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)	1.56 (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 (1.42-3.1)	1.9 (1.26-2.85)	1.98 (1.31-2.99)