Disparities in post-operative mortality between Māori and non-Indigenous ethnic groups in New Zealand

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ABSTRACT

AIM: To describe disparities in post-operative mortality experienced by Indigenous Māori compared to non-Indigenous New Zealanders.

METHODS: We completed a national study of all those undergoing a surgical procedure between 2005 and 2017 in New Zealand. We examined 30-day and 90-day post-operative mortality for all surgical specialties and by common procedures. We compared age-standardised rates between ethnic groups (Māori, Pacific, Asian, European, MELAA/Other) and calculated hazard ratios (HRs) using Cox proportional hazards regression modelling adjusted for age, sex, deprivation, rurality, comorbidity, ASA score, anaesthetic type, procedure risk and procedure specialty.

RESULTS: From nearly 3.9 million surgical procedures (876,976 acute, 2,990,726 elective/waiting list), we observed ethnic disparities in post-operative mortality across procedures, with the largest disparities occurring between Māori and Europeans. Māori had higher rates of 30- and 90-day post-operative mortality across most broad procedure categories, with the disparity between Māori and Europeans strongest for elective/waiting list procedures (eg, elective/waiting list musculoskeletal procedures, 30-day mortality: adj. HR 1.93, 95% CI 1.56–2.39).

CONCLUSIONS: The disparities we observed are likely driven by a combination of healthcare system, process and clinical team factors, and we have presented the key mechanisms within these factors.

Around 4.2 million people worldwide die each year within 30 days of a surgical procedure—around a million more deaths than those due to HIV, malaria and tuberculosis combined.[1] Within countries, the overall risk of post-operative mortality is strongly related to the type of procedure undertaken,[2] the underlying health of the patient undergoing the procedure[3] and the quality of available perioperative care.[4] Both within and across countries, there is some evidence of increased rates of post-operative mortality for Indigenous patients compared with non-Indigenous, with the most consistent evidence coming from studies that have focused on cardiac procedures.[5,6] For example, Native Americans undergoing transcatheter aortic valve implantation (TAVI) were found to be more than seven times more likely to die post-operatively than Whites (adj. odds ratio [OR] 7.2, 95% CI 2.6–20.0). However, our own recent systematic review identified important limitations in the current body of evidence, including major issues with the quality of Indigenous identification and often little or no adjustment for important confounders such as age, comorbidity and deprivation status.[7] Studies have generally focused on a single or small set of procedures, leaving large gaps in our knowledge across the range of surgical specialties.

Given the consistent international patterns of worse access to the determinants of good health, impaired access to healthcare and lesser quality of healthcare provided to

Indigenous compared to non-Indigenous populations,[8–10] it is unsurprising that there are Indigenous disparities in post-operative mortality. However, these disparities are in breach of the United Nations Declaration on the Rights of Indigenous Peoples, which states that Indigenous peoples have both the right to good health and the "right to access, without any discrimination, all social and health services."[11] In New Zealand, disparities in outcomes for the Indigenous Māori population can be considered a breach of the Treaty of Waitangi, New Zealand's founding document.[12]

This study aims to address several key gaps in the existing evidence base around Indigenous post-operative mortality. In order to achieve this aim, our objectives were (a) to use New Zealand's high-quality national-level data to examine the post-operative mortality burden for Indigenous Māori compared to other ethnic groups for a wide range of surgical specialties, adjusting for important confounders, and (b) to provide some explanation of likely drivers of Indigenous disparities in post-operative mortality where they are identified.

Methods

Participants and data sources

Our study cohort included all individuals who underwent a procedure in a New Zealand hospital between 1 January 2005 and 31 December 2017, as recorded on the National Minimum Dataset (NMDS).[13] The NMDS is a record of all publicly funded hospitalisations that occur within New Zealand (a country with universal healthcare), as well as privately funded hospitalisations at those larger private facilities that report to the NMDS.[13] Diagnoses and procedures are coded to International Classification of Diseases (ICD)-10-AM (third edition for this study). We restricted our analysis to New Zealand residents to ensure follow-up for post-operative death. We also excluded patients with an American Society of Anesthesiologists (ASA) physical status score of 6 (ASA score is further defined later in this section).

Patient comorbidity at the start of each admission (see section *Variables* below) was measured using NMDS data for the prior five-year period. Date of death was defined using the National Health Index (NHI) dataset.[14]

Variables

All variables were derived from the NMDS. Ethnicity data were categorised in the prioritised order of Māori, Pacific, Asian, European or Middle Eastern/Latin American/African/Other (MELAA/Other) to generate mutually exclusive groups.[15] Ethnicity data collection and recording on the NMDS is guided by ethnicity data protocols in which patients self-identify their ethnicity using a standardised question. Ethnicity data were missing for n=114,095 procedures (2.9% of procedures), with these patients/procedures excluded from further analysis. Patient age at the time of procedure was categorised as <55, 55–64, 65–74 or 75+. Patient sex was categorised as either male or female. Sex data were missing for n=21 procedures (<0.0001% of total procedures). Patient area-level socioeconomic deprivation was based on individuals' geo-coded residential address, determined by using New Zealand's 2013 Index of Deprivation (NZDep).[16] NZDep scores were categorised as quintiles from 1 (least deprived) to 5 (most deprived). Missing data prevented attribution of deprivation for n=62,315 procedures (1.6% of procedures). Patient rurality was defined using a modified version of the Urban/Rural Profile Classification (URPC),[17] a categorisation system which allows mapping of residential address data down to three classifications: urban (main urban area + satellite urban area); independent urban area; and rural (all rural areas). Missing data prevented attribution of rurality for n=65,102 procedures (1.7% of procedures).

Patient comorbidity was defined using the M3 Index of multimorbidity.[18] NMDS data from five years prior to admission were coded for the presence of any of the 61 M3 conditions using ICD-10-AM codes, which were then weighted and summed to arrive at the M3 score.[18] M3 scores were categorised as 0, >0–1, >1–2, >2–3 or 3+ for descriptive analysis and included as a splined variable within Cox models [18] with knots at the 0th, 90th and 95th percentiles.[19] ASA physical status score was determined from ICD anaesthesia codes at the time of the procedure and categorised as either 1–2 (healthy or mild/moderate disease), 3 (severe but stable disease), 4–5 (severe

disease with immediate threat to life) or unknown.[20] Primary anaesthetic type was defined using ICD codes and categorised as general only, regional only or general plus regional (ICD codes: general anaesthetic 9251410-9251499, regional anaesthetic 9250610- 9250899). Procedure specialty was determined by mapping procedures to the Australasian College of Health Informatics (ACHI) procedure code "block," which is organised by anatomical specialty.[21] Procedure risk was established using a modified version[22] of the Johns Hopkins Surgical Risk Classification System,[23] which classifies surgical risk into five categories according to factors including the invasive nature of the procedure and potential for blood loss.[22] In the event that a patient underwent a procedure on more than one system (eg, cardiovascular and respiratory systems) during the same operation, the procedure with the greatest severity (according to the Johns Hopkins Surgical Risk Classification System) was selected as the index procedure. In the event of a "tie" between procedures in terms of severity, the first procedure appearing in the sequential list of procedures within the NMDS was selected as the index procedure.

In addition to stratification by procedure speciality, we selected four individual procedures for closer examination: two cardiovascular procedures (coronary artery bypass graft [CABG] and valve repair), a collection of similar digestive system procedures (small intestine, colon or rectal resection) and a vascular/musculoskeletal procedure (lower-limb amputation). These procedures were chosen because (1) they are common and allowed sufficient data for meaningful comparisons between most ethnic groups, (2) they are frequently related to post-operative death among Māori and (3) they cover several surgical specialities (cardiac, gastro-intestinal and vascular/musculoskeletal).

All analyses were stratified by admission type, which was categorised as either acute or elective/waiting list based on NMDS data. Post-operative mortality was defined as death from any cause recorded within either 30 or 90 days of a procedure.

Statistical analysis

Key characteristics of the cohort were described, stratified by ethnicity and admission type, and included count data as well as crude and direct age-standardised rates. We used the 2001 total Māori population as the standard population,[24] which is an Indigenous standard [25] that uses Māori as the target population. Those with missing data (primarily NZDep and rurality, both missing in <2% of the cohort) were excluded from regression analyses (since the models required complete data for all included variables) but were included in descriptive analyses.

We conducted Cox proportional hazards regression modelling to compare the risk of post-operative death, focusing on 30-day mortality. Follow-up was censored if no death occurred within 30 days of the procedure (ie, the end of follow-up); if the same procedure occurred within 30 days of the original procedure (revisions), the first procedure was used as the index procedure and the second (revision) procedure was not included in analyses (mortality after the revision but within 30 days of the initial procedure was counted as a consequence of the initial procedure). Hazard ratios (HR) and their 95% confidence intervals (95% CI) were calculated between ethnic groups for mortality within 30 days, with the majority European ethnic group as the reference. Separate Cox models were conducted for acute and elective/waiting list procedures. For analyses examining combined procedures, models were adjusted for age, sex, deprivation, rurality, comorbidity, ASA score, anaesthetic type, procedure risk and procedure specialty (removed when models were stratified by specialty). Where procedures (eg, CABG) were examined separately, procedure speciality and procedure risk were removed as covariates.

Data management and analysis was performed in SAS v9.4 (SAS Institute Inc., USA), Stata 16 (StataCorp LLC, USA) and Microsoft Excel 2016 (Microsoft Corp., USA). The study received ethical approval from the University of Otago Human Ethics Committee (reference: H18/085). In terms of ensuring the study's responsiveness to Māori, this study was led by a Māori epidemiologist (JG), supported by Māori academics, clinicians, public servants and community health workers (MM, CD, PH, BR, JS, CT, JK), and situated within an equity-focused research group (the Cancer and

Chronic Conditions [C3] Research Group, of which JG is the director).

Results

Supplementary Material 1 shows the number of procedures, stratified by covariate. A total of 876,976 acute procedures were performed (age-standardised proportions: 22% Māori, 10% Pacific, 6% Asian, 2% MELAA/Other, 60% European), along with 2,990,726 elective/waiting list procedures (16% Māori, 6% Pacific, 7% Asian, 2% MELAA/Other, 69% European). Our description and interpretation focuses on comparisons between Māori (as the Indigenous peoples of New Zealand) and Europeans (as the majority non-Indigenous population).

Table 1 shows the number and age-standardised rate of death within 30-days of a procedure, stratified by ethnicity, for both acute and elective/waiting list procedures. For all acute procedures combined, the 30-day mortality rate was highest among Māori (age-standardised rate: 1.1/100 acute procedures, European 0.7/100). This pattern of higher mortality rates for Māori compared to European was consistent across procedure specialties (eg, cardiovascular: Māori 3.9/100, European 2.7/100; neurosurgery: Māori 4.7/100, European 3.7/100). Similar patterns were observed for 90-day mortality (Supplementary Material 2). In our fully adjusted model, Māori were 14% more likely to die within 30 days when all acute procedures were combined (adj. HR 1.14, 95% CI 1.09–1.20; Table 2). In comparison to European patients, the chance of post-operative mortality for Māori was 21% higher following an acute cardiovascular procedure (1.21, 95% CI 1.06-1.38), nearly 25% higher following an acute digestive system procedure (1.24, 95% CI 1.13–1.35) and more than 30% higher following an acute musculoskeletal system procedure (1.33, 95% CI 1.20–1.47).

Māori also had the highest rate of 30-day mortality for elective/waiting list procedures combined (age-standardised rate: Māori 0.2/100, European 0.1/100) and by surgical specialty (eg, cardiovascular: Māori 1.0/100, European 0.4/100; digestive system: Māori 0.4/100, European 0.1/100). Fully adjusted models showed Māori were 35% more likely to die within 30 days for all elective/waiting list procedures combined (adj. HR: 1.35, 95% CI 1.25–1.46; Table 2). Māori were 26% more likely to die within 30 days of an elective/waiting list cardiovascular procedure (1.26, 95% CI 1.07–1.50); more than 30% more likely following a digestive system procedure (1.32, 95% CI 1.14–1.53); 21% more likely following a respiratory procedure (1.21, 95% CI 0.93–1.57); nearly 50% more likely following a urinary procedure (1.49, 95% CI 1.05–2.12); and nearly twice as likely following a musculoskeletal procedure (1.93, 95% CI 1.56-2.39) than European patients.

Individual procedures

We observed strong disparities between Māori and European patients for post-operative mortality following specific procedures (Table 3). Māori undergoing CABG in an acute setting were 71% more likely to die within 30 days (age std. rate: Māori 8.0/100, European 1.0/100; adj. HR: 1.71, 95% CI 1.18–2.48) and 53% more likely in an elective/waiting list setting (Māori 1.9/100, European 0.9/100; adj. HR 1.53, 95% CI 1.10-2.12). Māori undergoing acute valve repair or replacement appeared more likely to die within 30 days (Māori 8.9/100, European 2.8/100; adj. HR: 1.34, 95% CI 0.87–2.08) and also appeared more likely to die in an elective/waiting list setting (Māori 2.0/100, European 0.7/100; adj. HR: 1.39, 95% CI 0.98–1.99), although the confidence limits included small effect sizes and the possibility of no difference. For small intestine or bowel resection, Māori patients were nearly 30% more likely to die within 30 days of an acute procedure (Māori 5.9/100, European 2.5/100; adj. HR: 1.27. 95% CI 1.08-1.50) and 92% more likely in an elective/waiting list setting (Māori 1.5/100, European 0.4/100; adj. HR: 1.92, 95% CI 1.46–2.53). Finally, Māori undergoing acute lower-limb amputation appeared marginally more likely to die within 30 days although the confidence limits again included the possibility of no difference (Māori 5.2/100, European 4.0/100; adj. HR: 1.17, 95% CI 0.95–1.45), but they were more than twice as likely in an elective/waiting list setting (Māori 2.9/100, European 0.8/100; adj. HR 2.04: 95% CI 1.31–3.18).

There was a tendency for the strongest ethnic disparities to occur within the elective/waiting list setting compared to the

Table 1: Number and rate of 30-day mortality following acute and elective/waiting list procedures by ethnicity, for both the combined procedures and stratified by procedure specialty. Rates are age-standardised to the 2001 total Māori population.

	Māori			Pacific			Asian			MELAA/Other			European		
	Deaths	Death rate (n/100)		Deaths	Death rate (n/100)		Deaths	Death rate (n/100)		Deaths	Death rate (n/100)		Deaths	Death rate (n/100)	
	N	Crude	Age std.	N	Crude	Age std.	N	Crude	Age std.	N	Crude	Age std.	N	Crude	Age std.
Acute															
Combined procedures	2,268	1.4	1.1 (1–1.1)	888	1.3	1 (0.9–1)	608	1.3	0.8 (0.7–0.9)	180	1.3	0.7 (0.6–0.8)	13,372	2.3	0.7 (0.7–0.7)
Procedure specialty															
Cardiovascular	331	5	3.9 (3.4–4.4)	169	5	3.5 (2.9–4.2)	119	7	4 (3–5.2)	24	4.5	2.6 (1.3–4.5)	1,471	6.2	2.7 (2.4–3.1)
Digestive system	670	2.3	1.4 (1.3–1.6)	238	2	1.4 (1.2–1.6)	149	1.4	0.8 (0.6–0.9)	59	1.7	1 (0.7–1.3)	4,040	3.1	0.8 (0.8–0.9)
Respiratory system	164	6.2	5.7 (4.8–6.7)	98	6.9	5.7 (4.5–7)	60	7.4	5.5 (4–7.3)	18	8.6	7.1 (4–11.3)	648	9.2	5.3 (4.7–5.9)
Neurosurgery	312	5.3	4.7 (4.2–5.3)	106	4.6	4.1 (3.3–5.1)	91	6.3	4.9 (3.7–6.2)	15	3.5	3 (1.5–5.2)	965	5.3	3.7 (3.4–4)
Musculoskeletal	478	0.9	0.6 (0.5–0.7)	148	0.8	0.4 (0.4–0.5)	128	1.4	0.4 (0.3–0.6)	42	1	0.2 (0.1–0.3)	4,928	2.3	0.3 (0.3–0.3)
Urinary system	69	2.4	1.7 (1.2–2.3)	38	2.4	1.7 (1.1–2.5)	17	1.2	0.5 (0.2–1)	7	1.9	0.5 (0.2–1.2)	339	2.5	0.9 (0.7–1.1)
Other	244	0.4	0.4 (0.4–0.5)	91	0.3	0.3 (0.2–0.3)	44	0.2	0.2 (0.2–0.3)	15	0.3	0.2 (0.1–0.4)	981	0.6	0.3 (0.3–0.3)
Elective/waiting list															
Combined procedures	887	0.2	0.2 (0.1–0.2)	296	0.2	0.1 (0.1–0.2)	193	0.1	0.1 (0.1–0.1)	61	0.1	0.1 (0–0.1)	4,966	0.2	0.1 (0.1–0.1)
Procedure specialty															
Cardiovascular	205	1.5	1 (0.9–1.2)	103	1.4	1 (0.7–1.2)	49	1.1	0.8 (0.5–1.1)	24	2	1.4 (0.7–2.5)	941	1.3	0.4 (0.4–0.5)
Digestive system	236	0.6	0.4 (0.3–0.4)	73	0.7	0.4 (0.3–0.5)	53	0.3	0.2 (0.1–0.3)	12	0.2	0.1 (0–0.1)	1,661	0.6	0.1 (0.1–0.2)
Respiratory system	81	1.8	1.3 (1–1.7)	26	1.5	1.1 (0.6–1.6)	27	1.4	0.9 (0.5–1.5)	7	1.5	1.3 (0.4–2.8)	356	1.6	0.8 (0.6–0.9)
Neurosurgery	46	0.7	0.6 (0.4–0.8)	18	0.7	0.7 (0.4–1)	7	0.3	0.2 (0.1–0.4)	5	0.5	0.2 (0–0.7)	233	0.4	0.3 (0.2–0.3)
Musculoskeletal	124	0.2	0.1 (0.1–0.1)	20	0.1	0.1 (0–0.1)	13	0.1	0 (0–0.1)	7	0.1	0 (0–0.1)	666	0.1	0 (0–0)
Urinary system	48	0.5	0.2 (0.1–0.3)	5	0.1	0.1 (0–0.2)	9	0.2	0.1 (0–0.3)	2	0.1	0 (0–0.2)	258	0.3	0.1 (0.1–0.1)
Other	147	0.1	0.1 (0–0.1)	51	0.1	0 (0–0)	35	0	0 (0–0)	4	0	0 (0–0)	851	0.1	0 (0–0)

Table 2: Risk of 30-day mortality between ethnic groups, for both combined procedures and stratified by procedure specialty. Europeans are used as the reference group. Hazard ratios are adjusted for age, sex, deprivation, rurality, comorbidity, ASA score, anaesthetic type and procedure risk. Hazard ratios for combined procedures are additionally adjusted for procedure specialty.

	Māori		Pacific		Asian		MELAA/Other		European	
	Hazard ratio (95% CI)		Hazard ratio (95% CI)		Hazard ratio (95% CI)		Hazard ratio (95% CI)		Hazard ratio (95% CI)	
	Crude	Adj.[1]	Crude	Adj.[1]	Crude	Adj.[1]	Crude	Adj.[1]	Crude	Adj.[1]
Acute										
Total procedures	0.6 (0.57–0.63)	1.14 (1.09–1.2)	0.54 (0.5–0.57)	1.03 (0.95–1.11)	0.57 (0.53–0.62)	1.14 (1.04–1.23)	0.53 (0.46–0.62)	1.04 (0.89–1.22)	Ref	
Procedure specialty										
Cardiovascular	0.8 (0.71–0.91)	1.21 (1.06–1.38)	0.79 (0.67–0.93)	1.19 (0.99–1.42)	1.13 (0.94–1.36)	1.37 (1.13–1.67)	0.71 (0.48–1.07)	0.86 (0.56–1.35)	Ref	
Digestive system	0.73 (0.67–0.79)	1.24 (1.13–1.35)	0.65 (0.57–0.74)	1.13 (0.99–1.3)	0.43 (0.37–0.51)	0.93 (0.78–1.1)	0.55 (0.42–0.71)	1.02 (0.78–1.35)	Ref	
Respiratory system	0.67 (0.57–0.8)	0.92 (0.77–1.11)	0.75 (0.61–0.93)	0.98 (0.77–1.24)	0.81 (0.62–1.05)	1.16 (0.88–1.53)	0.94 (0.59–1.51)	1.4 (0.85–2.3)	Ref	
Neurosurgery	0.99 (0.87–1.12)	1.06 (0.92–1.22)	0.85 (0.7–1.04)	0.9 (0.72–1.11)	1.19 (0.96–1.47)	1.1 (0.88–1.37)	0.65 (0.39–1.08)	0.94 (0.56–1.57)	Ref	
Musculoskeletal	0.41 (0.37–0.45)	1.33 (1.2–1.47)	0.33 (0.28–0.39)	1 (0.84–1.18)	0.64 (0.53–0.76)	1.34 (1.12–1.6)	0.45 (0.33–0.61)	1.06 (0.78–1.44)	Ref	
Urinary system	0.94 (0.73–1.22)	1.04 (0.78–1.38)	0.95 (0.68–1.33)	1.13 (0.78–1.63)	0.49 (0.3–0.8)	0.93 (0.56–1.52)	0.75 (0.35–1.58)	1.45 (0.68–3.09)	Ref	
Other	0.65 (0.56–0.75)	1.09 (0.93–1.27)	0.49 (0.39–0.61)	0.92 (0.73–1.16)	0.36 (0.27–0.49)	1.01 (0.74–1.39)	0.47 (0.28–0.78)	0.93 (0.55–1.58)	Ref	
Elective/waiting list										
Total procedures	1.05 (0.98–1.13)	1.35 (1.25–1.46)	0.86 (0.76–0.96)	1.05 (0.93–1.2)	0.51 (0.44–0.59)	1.01 (0.87–1.17)	0.58 (0.45–0.75)	1.17 (0.91–1.5)	Ref	
Procedure specialty										
Cardiovascular	1.18 (1.01–1.37)	1.26 (1.07–1.5)	1.07 (0.87–1.31)	1.14 (0.9–1.45)	0.88 (0.66–1.17)	1.02 (0.76–1.37)	1.57 (1.04–2.35)	2.06 (1.37–3.09)	Ref	
Digestive system	1.15 (1–1.32)	1.32 (1.14–1.53)	1.2 (0.95–1.51)	1.29 (1.01–1.65)	0.53 (0.4–0.7)	1.05 (0.8–1.38)	0.37 (0.21–0.64)	0.83 (0.47–1.46)	Ref	
Respiratory system	1.12 (0.88–1.43)	1.21 (0.93–1.57)	0.9 (0.6–1.34)	0.86 (0.56–1.33)	0.86 (0.58–1.27)	1.38 (0.93–2.06)	0.93 (0.44–1.95)	1.17 (0.55–2.48)	Ref	
Neurosurgery	1.57 (1.14–2.15)	0.93 (0.66–1.31)	1.7 (1.05–2.75)	0.97 (0.58–1.63)	0.63 (0.3–1.33)	0.66 (0.31–1.41)	1.29 (0.53–3.13)	1.81 (0.74–4.42)	Ref	
Musculoskeletal	1.52 (1.25–1.84)	1.93 (1.56–2.39)	0.62 (0.4–0.97)	1.11 (0.7–1.75)	0.56 (0.32–0.97)	0.98 (0.55–1.74)	0.65 (0.31–1.37)	1.38 (0.65–2.9)	Ref	
Urinary system	1.48 (1.09–2.01)	1.49 (1.05–2.12)	0.41 (0.17–0.98)	0.52 (0.21–1.28)	0.62 (0.32–1.21)	1.09 (0.56–2.15)	0.48 (0.12–1.93)	0.85 (0.21–3.44)	Ref	
Other	0.83 (0.7–0.99)	1.43 (1.18–1.73)	0.68 (0.51–0.9)	1 (0.74–1.34)	0.39 (0.28–0.55)	0.95 (0.68–1.34)	0.19 (0.07–0.51)	0.43 (0.16–1.16)	Ref	

acute setting. For example, Māori undergoing a musculoskeletal procedure in an acute setting were 33% more likely to die in an acute setting (adj. HR: 1.33, 95% CI 1.20–1.47), whereas in an elective/waiting list setting, this disparity increased to 93% (1.93, 95% CI 1.56–2.39).

Disparities for Pacific and MELAA/Other patients (compared to European patients) were broadly similar to those observed for Māori, but with reduced statistical precision due to lower numbers of patients and deaths (Supplementary Material 3). For example, Pacific patients were 30% more likely to die within 30 days of an elective/waiting list digestive system procedure than European patients (adj. HR: 1.29, 95% CI 1.01–1.65), whereas MELAA/Other patients were twice as likely to die following an elective/waiting list cardiovascular procedure (2.06, 95% CI 1.37–3.09).

When examining the impact of each of our modelled covariates on disparities (Table 4), using 30-day mortality comparisons between Māori and Europeans as the exemplar, we observed that adjusting for age increased the magnitude of the disparity and each subsequent covariate attenuated the disparity. The strongest attenuation across procedures occurred when adjusting for deprivation, comorbidity and ASA score.

Table 3: Death within 30 days of selected individual procedures, including numbers of deaths, crude and age-standardised death rate and adjusted hazard ratios (HR) comparing likelihood of death between Māori and European/Other patients. Hazard ratios are adjusted for age, sex, deprivation, rurality, comorbidity, ASA score and anaesthetic type. For brevity, results for Pacific, Asian and MELAA/Other patients are shown in Supplementary Material 3.

	Māori				European			
	Deaths	Death rate (n/100)		Hazard ratio (95% CI)	Deaths	Death rate (n/100)		Hazard ratio (95% CI)
	N	Crude	Age std.	Adj. HR	N	Crude	Age std.	Adj. HR
Acute								
Cardiovascular								
Coronary artery bypass graft	38	6.6	8 (4.6–12.6)	1.71 (1.18–2.48)	192	3.9	1 (0.5–1.9)	Ref
Valve repair/replacement	31	8.2	8.9 (5.6–13)	1.34 (0.87–2.08)	123	6.5	2.8 (1.5–4.6)	Ref
Digestive								
SI or bowel resection	188	10.4	5.9 (4.6–7.4)	1.27 (1.08–1.5)	1,386	9.1	2.5 (2.1–2.9)	Ref
Musculoskeletal								
Lower-limb amputation	152	8.6	5.2 (3.8–6.9)	1.17 (0.95–1.45)	499	7.8	4 (2.9–5.2)	Ref
Elective/waiting list								
Cardiovascular								
Coronary artery bypass graft	52	3.4	1.9 (0.9–3.4)	1.53 (1.1–2.12)	284	2.3	0.9 (0.5–1.5)	Ref
Valve repair/replacement	47	3.2	2 (1.2–2.9)	1.39 (0.98–1.99)	305	3.2	0.7 (0.4–1.2)	Ref
Digestive								
SI or bowel resection	64	3.6	1.5 (0.8–2.4)	1.92 (1.46–2.53)	614	2.1	0.4 (0.3–0.5)	Ref
Musculoskeletal								
Lower-limb amputation	36	5	2.9 (1.6–4.8)	2.04 (1.31–3.18)	103	2.6	0.8 (0.4–1.5)	Ref

Discussion

We observed substantial and compelling evidence of ethnic disparities in post-operative mortality across procedures, with the clearest disparities occurring between Indigenous Māori and the majority European population. Māori had higher rates of post-operative mortality across most broad procedure categories, with the strongest disparities seen in elective/waiting list procedures. Disparities for Māori were larger for some procedure specialty groups (cardiovascular, digestive, musculoskeletal) and not apparent for others (neurosurgery). Large disparities were observed for each of the most common causes of post-operative death for Māori, including CABG, cardiac valve repair, bowel resection and lower-limb amputation. The absence of any ethnic disparities in either acute or elective/waiting list neurosurgical procedures may be due to high post-operative mortality from these procedures and the small number of sites and providers of neurosurgical care in New Zealand.

The patterns of disparities observed for Māori were largely mirrored for Pacific and MELAA/Other groups; for example, Pacific peoples appeared more likely to die following a cardiovascular, digestive or musculoskeletal procedure, but not neurosurgical procedures. However, the strength of this evidence was impacted by relatively low procedure numbers and deaths for these groups.

Our observation of substantial disparities in post-operative mortality for Māori is largely in keeping with previous evidence in this context, including our recently published systematic review,[7] which found evidence of disparities in post-operative mortality for Māori across many individual procedures,[20, 26–31] for Native Americans undergoing some cardiac,[5] bariatric[32] and total knee procedures[33] and for Indigenous Australians undergoing cardiac procedures.[6]

Why do these disparities exist?

Structural factors. Understanding the root cause of disparities in post-operative mortality requires consideration of the structural and systemic differences experienced by Indigenous ethnic groups compared to the European population. These include the ramifications of colonisation, which include institutionalised racism and subsequent structural disparities that impact access to the social determinants of good health.[34] Jones's theoretic framework for understanding racism suggests three levels: institutionalised, personally mediated and internalised.[35] In the context of perioperative outcomes, institutionalised racism drives disparities by ensuring that the system delivering healthcare privileges non-Indigenous peoples; personally-mediated racism drives disparities through patient stereotyping and differential provision of care; and internalised racism drives disparities by forcing Indigenous peoples to accept these disparities and the conditions from which they arose. In their work on the impact of racism on clinical decision-making, Van Ryn and colleagues illustrated the mechanisms by which healthcare providers impact disparities in treatment, including implicit and explicit beliefs and stereotypes among clinicians that negatively impact on clinical decision-making.[36,37] In order to maximise the cultural safety of our health system for Indigenous patients, "reflective self-assessment of power, privilege and biases"[38] should occur at each step of the care pathway—right from policy and funding decision-making through to the coalface delivery of clinical care.

Differences in clinical indication and comorbidity. From our analysis, we did observe that some of the disparity in post-operative mortality between ethnic groups could be explained by a greater comorbidity/ASA burden (a marker of perioperative morbidity). These differences are themselves linked to differences in access to the social determinants of good health[34] and have been observed to influence disparities in surgical outcomes between ethnic groups in other international settings, such as the United States.[39] However, it must be noted that substantial disparities remained in our study even after adjusting for differences between groups in these key factors.

Differences in access to best-practice pre-operative care. We observed that there was a tendency for the strongest ethnic disparities to occur within the elective/waiting list setting rather than the acute setting. This may be because of overall poorer outcomes in the acute setting, which

Table 4: Step-by-step adjusted hazard ratios comparing mortality risk between Māori and European patients, adjusted sequentially for demographic, health system and patient-level factors.

	Māori vs European hazard ratios (95% CI)			
	Coronary artery bypass graft	**Valve repair / replacement**	**SI/bowel resection**	**Lower-limb amputation**
Acute				
Unadjusted	1.73 (1.22–2.45)	1.27 (0.86–1.89)	1.16 (0.99–1.35)	1.1 (0.92–1.32)
Demographic factors				
Age	2.29 (1.6–3.26)	1.69 (1.11–2.57)	1.92 (1.64–2.24)	1.67 (1.37–2.04)
Sex	2.07 (1.44–2.96)	1.67 (1.09–2.53)	1.92 (1.64–2.25)	1.63 (1.33–1.98)
Deprivation	2 (1.38–2.88)	1.6 (1.04–2.46)	1.73 (1.47–2.03)	1.51 (1.23–1.86)
Rurality	1.96 (1.35–2.83)	1.58 (1.03–2.43)	1.75 (1.49–2.06)	1.51 (1.23–1.86)
Health system factors				
Anaesthetic type	1.96 (1.36–2.84)	1.57 (1.02–2.43)	1.74 (1.48–2.05)	1.52 (1.24–1.88)
Patient factors				
Comorbidity	1.74 (1.2–2.53)	1.39 (0.9–2.15)	1.58 (1.34–1.86)	1.36 (1.11–1.68)
ASA score	1.71 (1.18–2.48)	1.34 (0.87–2.08)	1.27 (1.08–1.5)	1.17 (0.95–1.45)
Elective/waiting list				
Unadjusted	1.49 (1.11–2)	1 (0.73–1.36)	1.75 (1.36–2.27)	1.95 (1.34–2.85)
Demographic factors				
Age	2.28 (1.68–3.1)	1.97 (1.42–2.73)	3.03 (2.33–3.94)	3.63 (2.42–5.43)
Sex	2.17 (1.59–2.95)	1.87 (1.34–2.59)	3.02 (2.33–3.93)	3.62 (2.42–5.42)
Deprivation	1.97 (1.43–2.73)	1.86 (1.32–2.63)	2.74 (2.09–3.59)	3.22 (2.09–4.95)
Rurality	1.99 (1.44–2.76)	1.88 (1.33–2.66)	2.77 (2.11–3.63)	3.13 (2.04–4.83)
Health system factors				
Anaesthetic type	1.99 (1.44–2.76)	1.88 (1.33–2.65)	2.77 (2.11–3.63)	3.09 (2–4.76)
Patient factors				
Comorbidity	1.58 (1.14–2.19)	1.43 (1–2.03)	2.2 (1.67–2.89)	2.2 (1.42–3.41)
ASA Score	1.53 (1.1–2.12)	1.39 (0.98–1.99)	1.92 (1.46–2.53)	2.04 (1.31–3.18)

reduces the opportunity for disparities to occur. Conversely, there are more opportunities in an elective/waiting list setting for differential access to best-practice care prior to surgery to impact on outcomes: this would include disparities in access to prehabilitation and other preparatory care (including primary care of existing conditions). This lack of access is congruent with evidence suggesting that Indigenous peoples, including Māori, have poorer access to primary care than non-Indigenous peoples.[40–43] With this in mind, we recommend (a) that further investigation regarding ethnic/Indigenous disparities in access to elective/waiting list care, as well as access to preparatory care including prehabilitation, is undertaken as a matter of priority, (2) that this access is measured and monitored at a national/regional level by ethnicity or Indigeneity on an ongoing basis and (3) that these data are used as quality performance indicators for best-practice care provision within regions and hospitals.

Differences in access to best-practice surgical care. The inverse care law states that, in spite of having greater need, socially disadvantaged peoples receive less (and lower-quality) healthcare.[44] Furthermore, the disproportionate care law states that those at a social disadvantage may receive relatively more healthcare than other groups due to increased disease burden, but this care is of poorer quality and still insufficient quantity.[45] In New Zealand, there is evidence that Māori wait longer for treatment, and that when treatment is provided, it is of poorer quality than that delivered to non-Māori ethnic groups.[46] For example, we have previously observed in the context of stomach cancer treatment that Māori patients were less likely to have their resection performed in a main treatment hub and less likely to have a specialist upper-gastrointestinal surgeon perform their gastric resection, even when the surgery was carried out in a major urban centre.[47] Findings in the New Zealand context echo those from other regions: a systematic review of racial disparities in surgical care and outcomes in the United States observed that racial minorities are more likely to be treated in low-volume hospitals or by lower-quality surgeons.[39]

Therefore, the disparities in post-operative mortality that remain after the data are adjusted for factors such as comorbidity and deprivation may, at least partially, reflect differences in the quality of surgical care received by Māori patients compared to European patients. We recommend the centralised, ongoing audit of surgical outcomes for Indigenous (and other minority) patients as a rolling measure of quality performance, to help highlight the extent of disparities within a given country or region and to guide change in those areas where inequities are identified. The recent announcement of the creation of the Māori Health Authority may provide the opportunity for such ongoing quality performance measurement and an impetus for the systemic changes required to improve outcomes for Māori. As Koea and Ronald noted in a recent systematic review, Indigenous patients deserve to be treated by a highly skilled, culturally competent (ideally Indigenous) workforce operating within a surgical care and broader health system that is working with Indigenous communities to review and govern care for their people.[48] The disparities in post-operative outcomes outlined in this study add further urgency to these needs.

Strengths and limitations

This study contributes to a growing body of evidence of international Indigenous disparities in post-operative mortality across Eurocentric healthcare systems. To date, the evidence base has been dominated by studies that have been underpowered, that have poorly articulated methods of identifying Indigenous populations and that have focused on a limited sample of surgical procedures.[7] Our study addresses these limitations and provides evidence of ethnic disparities across a wide range of procedure types. Despite this, there remain several important gaps in our knowledge that warrant further research.

This study focused on measuring post-operative mortality, but it is also important to look at the extent of disparities that may exist for other post-surgical outcomes, such as post-operative morbidity, readmission, functional status and quality of life. Further research should also examine outcomes for those declined surgery, where disparities in outcomes might assist us to understand

and remedy any bias in the surgical prioritisation and selection processes.

Although we are confident in the quality of our national-level data, we may have incompletely adjusted for the impact of severity of illness at time of surgery with our adjustments for comorbidity and ASA score (the latter having a high proportion of missing data). More severe illness at the time of surgery for Māori is a likely contributor to the larger disparities we see in elective/waiting list compared to acute procedures. Greater severity of illness for Māori may result from delays in diagnosis through poorer access to primary care alongside delays to surgery compared to Europeans, who may also be better positioned financially to bypass the public healthcare system and engage with private health providers.

Conclusions

In a national study of nearly 3.9 million surgical procedures, we observed substantial evidence of ethnic disparities in post-operative mortality across procedures, with the clearest disparities occurring between Indigenous Māori and the majority European population. Māori were observed to have higher rates of 30- and 90-day post-operative mortality across most broad procedure categories, with this disparity strongest for elective/waiting list procedures. This evidence provides a robust reinforcement for international findings from our recent systematic review of this topic.[7] Our observed disparities are likely driven by structural factors including institutional racism acting through a combination of healthcare system, process and clinical team factors. As a starting point, we recommend that ethnicity/Indigeneity-stratified monitoring and reporting of access to elective/waiting list procedures, as well as access to pre-operative care, is incorporated into surgical care at a systems level, as part of ongoing quality assurance processes.

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Data sharing statement

The data for this study were provided by the New Zealand Ministry of Health (reference number: 2018-0452) following ethical approval, and may be available to other researchers who meet data access requirements. Code for data processing and analysis is available from JG upon request.

Ethical approval statement

The study received ethical approval from the University of Otago Human Ethics Committee (reference: H18/085).

Supplementary material

- Supplementary Material 1: Number of procedures by covariate, separately for acute and elective/waiting list procedures. Apart from age profile, all other percentages are age-standardised to the 2001 total Māori population.
- Supplementary Material 2: Number and rate of 90-day mortality following acute and elective/waiting list procedures by ethnicity, for both the combined procedures and stratified by procedure specialty. Rates are age-standardised to the 2001 total Māori population.
- Supplementary Material 3: Death within 30 days of selected individual procedures, including numbers of deaths, crude and age-standardised death rate for Pacific, Asian and MELAA/Other ethnic groups, as well as hazard ratios (HR) comparing likelihood of death between European/Other patients and other ethnic groups. Results for Māori and European groups are shown in Table 3.

Competing interests:
Dr Ongley is Chair of the Perioperative Mortality Review Committee for HQSC.
Dr McLeod reports grants from HRC during the conduct of this study.

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