Epidemiology and Outcomes of Abdominal Aortic Aneurysms in New Zealand: A 15-Year Experience at a Regional Hospital

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Introduction: Abdominal aortic aneurysms (AAA) account for approximately 400 deaths per year in New Zealand (NZ). Waikato Hospital caters to a diverse population comprising a high proportion of the indigenous Māori ethnic group considered to be at higher risk of mortality and morbidity. Despite these population factors, there is no screening program for AAA. The aim of this study was to further define the epidemiology and outcomes of AAA repairs in NZ to investigate the utility of implementing a population-specific screening program.
Methods: A retrospective study of all AAA repairs at Waikato Hospital between July 1996 and November 2010 was performed comparing long-term outcomes between Europeans and Māori considering acuity of presentation, age, gender, and type of repair. Perioperative and overall mortality data were obtained to generate Kaplan-Meier survival curves.
Results: 1,036 AAA repairs were performed. Māori presented younger (69.1 vs. 74.5, $P < 0.001$), had lower male predominance (1.6:1 vs. 3.5:1, $P < 0.001$), less elective repairs (44% vs. 67%, $P < 0.001$), and more ruptured AAA (RAAA) (40% vs. 21%, $P < 0.001$) despite the overall incidence of RAAA decreasing from 26% to 7.8% ($P = 0.01$). Māori had a lower postoperative 10-year survival compared to Europeans (17.4% vs. 36.5%, $P < 0.001$). There was an initial survival benefit for endoluminal over open repair but this converged at 4.9 years post repair.
Conclusions: This study highlights the epidemiological trends and survival outcomes of AAA management in Māori and Europeans over 15 years. It provides further evidence supporting the consideration of a population-specific screening program in future.

INTRODUCTION

Abdominal aortic aneurysm (AAA) accounts for approximately 400 deaths per year in New Zealand (NZ). Over half of these are attributable to a ruptured abdominal aortic aneurysm (RAAA).[1] National data shows a 30-day mortality rate of 31.5% following surgical repair of AAA in the acute ruptured setting and 2.5% in an elective setting.[2] Despite these statistics, there is no population screening program for AAA in NZ.

Landmark screening programs in the world include the UK National Aneurysm Screening Program, where 1.5% of men aged 65 years and over had aortic diameters of more than 3 cm.[3] Similarly, in the Veteran Affairs (VA) screening study in USA, 4.6% of patients between the age of 50 and 79 years had an AAA of more than 3 cm and 1.4% of more than 4 cm.[4] Typically, the aneurysm sac size threshold for consideration of surgical intervention is around 5 cm with an annual rupture risk of approximately 5% if left untreated.[5]

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Meta-analysis showed that screening is cost-effective and reduces AAA-related mortality by 40% in males aged 65−79 years.[6,7] However, there are some concerns about the efficiency of implementing and maintaining a screening program including the risk of overtreatment, the benefit-harm balance of an elective repair, and the capacity of the health care system to deal with increased patient workloads.

Recent epidemiological studies on patients with AAA in NZ by Sandiford et al. and Nair et al. concluded that Māori, in particular women, have a higher incidence and poorer outcomes with higher mortality rates compared to Europeans.[1,8,9] In addition, Māori present on average 8 years younger than Europeans, typically with symptoms and therefore have a higher prevalence of acute surgical management. AAA in younger patients is often symptomatic, familial, and on average 1 cm larger at initial evaluation than that in older patients.[10] Nair et al. advocated for the introduction of a population screening program using ultrasound scanning. They proposed that its introduction would lead to an increase in elective repairs, and thereby improve postoperative outcomes compared to acute intervention for symptomatic AAA. Of note, the authors suggested further investigation was required into the epidemiological data relating to the Māori population.[11,12]

Khashram et al. simulated regional screening in Canterbury, NZ by studying patients who had a CT colonography.[13] AAA of more than 3 cm was detected in 6.1% of the patients older than 55 years where 10.3% of patients had an aneurysm sac size greater than 5 cm. Being Māori was not identified as a risk factor in prevalence and survival; however, they represented only 1.8% of the study population.

According to the Census in 2013, Māori accounts for 599,000 people of the 4.2 million national population.[14] Waikato Hospital is a tertiary center that serves 14.0% of the national Māori population, which is equivalent to nearly 20% of the regional population in NZ. In addition, it covers 4 adjacent regions that cumulatively consist of approximately 40% of the entire Māori population.

Although previous studies by Sandiford and Nair et al. focused on the mortality associated with AAA, there remains a lack of information on the long-term outcomes following surgical intervention. This article aims to expand the current knowledge of epidemiology and outcomes of AAA repairs in NZ, investigate the utility of a population-specific screening program and consider the disparity between the ethnic groups.

METHODS

A retrospective review of all patients who underwent surgical repair of AAA between July 1996 and November 2010 at Waikato Hospital was conducted. Those that had hybrid repairs of thoracoabdominal pathologies or who had only secondary operations because of a complication from the initial surgery, such as limb extensions for endoleaks, were excluded. Patients who did not undergo operative management of AAA were also excluded.

Patients were identified from hospital records, and perioperative data were verified using discharge summaries, operating theater records, the Otago Audit, and the Australasian Vascular Audit. Basic demographic data were obtained. Ethnicity was recorded as per patients' belief during their presentation. The type of operation (open or endovascular repair [EVAR]) and acuity of presentation (ruptured or nonruptured and elective or acute) was recorded. For patients who were found to be deceased, the date and cause of death were determined either from clinical notes or review of death certificates obtained from the Ministry of Health (NZ). Follow-up was completed in November 2011. To calculate incidences of AAA repairs in the Waikato region, regional population estimates were extracted from the NZ Census 2006, and their summary tables based on district health board area.[14]

Statistical Analyses

Data were collected in Excel®. Statistical analyses were performed using SPSS, version 22 software (IBM Corporation, Armonk, NY, USA). A type I error of 5% ($P \leq 0.05$, two-tailed) was considered as statistically significant.

Descriptive statistics were described in terms of the range, mean, and standard deviation (SD). When comparing the means of 2 groups of continuous variables, parametric analysis (the Student's *t*-test) was used assuming the data followed a normal distribution. Chi-squared and Fisher's exact tests were applied for discrete variables depending on the sample size. Survival analysis was performed using Kaplan-Meier curves. Confounding factors were detected using logistic regression models.

RESULTS

Overall Demographics

1,036 AAA repairs were performed in the study period of 172 months (14.3 years). Table I summarizes the demographics and clinical presentation of

Table I. Basic demographics of the study population.

	European	Māori	Pacific Island	Other	Not stated
Number (%)	900 (87)	95 (9)	4 (0.3)	19 (1.8)	18 (1.7)
Mean age (Range)	74.7 (48.0–96.7)	69.1 (44.2–88.5)	70.0 (64.4–75.7)	74.6 (43.8–88.9)	71.8 (59.8–86.6)
Male (%)	698 (78)	58 (61)	3	12	15
Male:female	3.5:1	1.6:1	3.0:1	1.7:1	5.0:1
Open repair (%)	594 (66)	67 (70)	4	16	11
Elective repair (%)	606 (67)	42 (44)	2	12	10
Symptomatic (%)	106 (12)	15 (16)	1	1	3
Ruptured (%)	188 (21)	38 (40)	1	6	5
OT time (mins, SD)	195 (66)	208 (77)	177 (32)	169 (60)	193 (87)
LOS (days, SD)	9.0 (7.7)	10.1 (9.9)	7.3 (1.0)	9.4 (14.1)	8.8 (10.8)

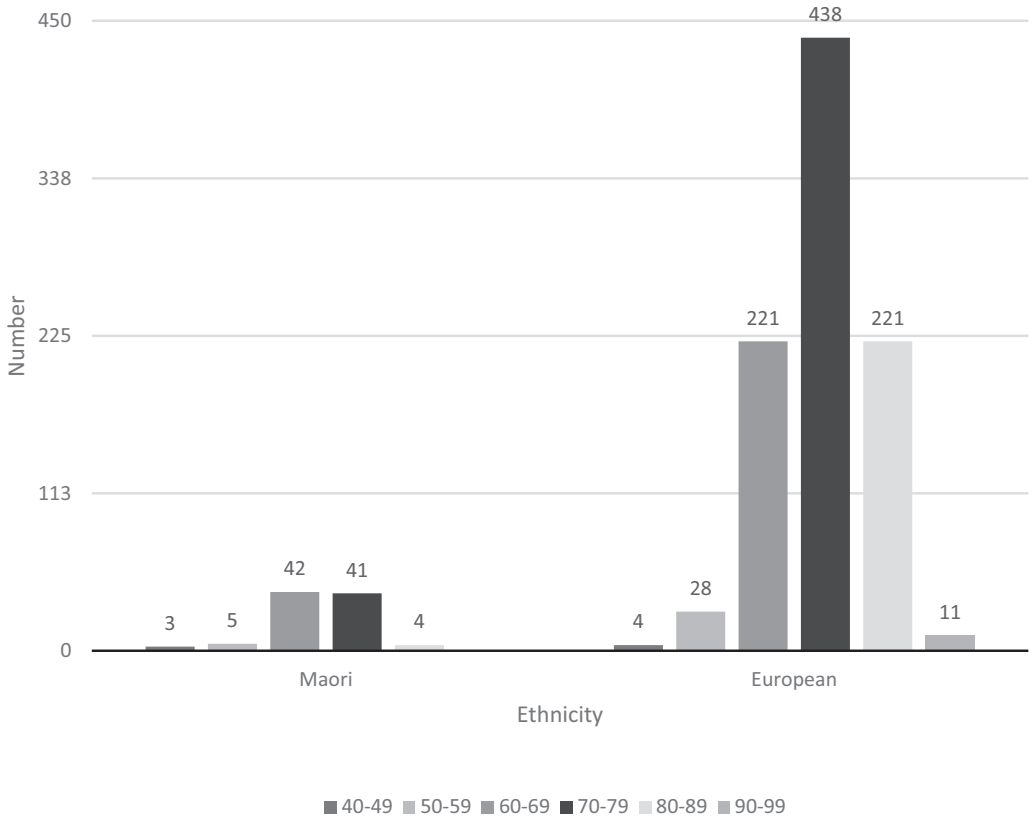

Fig. 1. Bar chart to demonstrate the variation of AAA repairs across different age groups.

the different ethnic groups. For the remaining study, only Europeans and Māori were compared.

Māori presented at a younger age for AAA repair (Fig. 1, 69.1 vs. 74.5 years, $P < 0.001$) and had a lower male predominance than Europeans (1.6:1 vs. 3.5:1, $P < 0.001$). Māori were less likely to undergo elective AAA repairs (44% vs. 67%, $P < 0.001$); and were more likely to have surgery for RAAA (40% vs. 21%, $P < 0.001$). Māori women were more likely to undergo RAAA repairs than European women (odds ratio = 4.1; risk ratio = 3.0; $P < 0.001$). There was no difference between Māori and Europeans with regards to method of repair (open vs. EVAR).

Incidences of AAA Repair in the Region

All patients who presented to hospital from outside the Waikato region were excluded in this subanalysis. Patients were stratified into 3 age groups: ''45 to 59''; ''60 to 69'' and ''over 70''. Tables II–IV show

Table II. Incidence of AAA repairs of patients between the age 45 and 59

	European		Māori	
Age 45–59	Male	Female	Male	Female
Population	21,453	22,617	4,038	4,722
Number of AAA repairs	19	2	5	0
AAA repairs/year	1.3	0.1	0.3	0
AAA/100,000 ppl/year	6.2	0.6	8.7	0
Number of RAAA repairs	6	0	3	0
RAAA repairs/year	0.4	0	0.2	0
RAAA/100,000 ppl/year	2.0	0	5.2	0

Table III. Incidence of AAA repairs of patients between the age 60 and 69

	European		Māori	
Age 60–69	Male	Female	Male	Female
Population	10,110	10,752	1,356	1,419
Number of AAA repairs	113	36	12	7
AAA repairs/year	7.9	2.5	0.8	0.5
AAA/100,000 ppl/year	78.2	23.4	61.9	34.5
Number of RAAA repairs	30	5	2	2
RAAA repairs/year	2.1	0.3	0.1	0.1
RAAA/100,000 ppl/year	20.8	3.3	10.3	9.9

Table IV. Incidence of AAA repairs of patients aged greater than 70 years

	European		Māori	
Age >70	Male	Female	Male	Female
Population	10,839	14,019	693	912
Number of AAA repairs	353	110	5	10
AAA repairs/year	24.7	7.7	0.3	0.7
AAA/100,000 ppl/year	227.7	54.9	50.5	76.7
Number of RAAA repairs	79	17	1	3
RAAA repairs/year	5.5	1.2	0.1	0.2
RAAA/100,000 ppl/year	51.0	8.5	10.1	23.0

the incidence of AAA and RAAA repairs subdivided by gender and age group between the European and Māori. The overall incidence of AAA repairs from the Waikato region was 0.45 per year per 100,000 people aged greater than 45 years.

Repairs of AAA were uncommon below the age of 59. The incidence of AAA repairs increased dramatically in the 60–69 age group compared to the 45–59 age group; and the incidence further increased in the over 70 age group for Europeans. Interestingly, Māori women were more likely to have AAA repairs than European women, and more importantly, Māori women were twice as more likely to present with RAAA than Māori men. The ratio of RAAA to all AAA repairs was similar across both ethnicities and genders.

Outcome of AAA Repairs

692 (65%) patients had an open repair (OR). Although the total number of repairs per year remained consistently around 70, the proportion of EVAR increased over the study period (Fig. 2, 7.6–72%, $P < 0.001$).

364 patients (35%) presented acutely, of which 238 (23%) had an RAAA. Over the study period, the proportion of patients presenting with an RAAA decreased from 26% to 7.8% (Fig. 3, $P = 0.01$).

Table V shows patients stratified into 2 age groups (45–69) and (>70). Māori were found to present for AAA repairs at a younger age and more likely to undergo an open repair (76.8% vs. 62.5%, $P < 0.001$). Patients under the age of 70

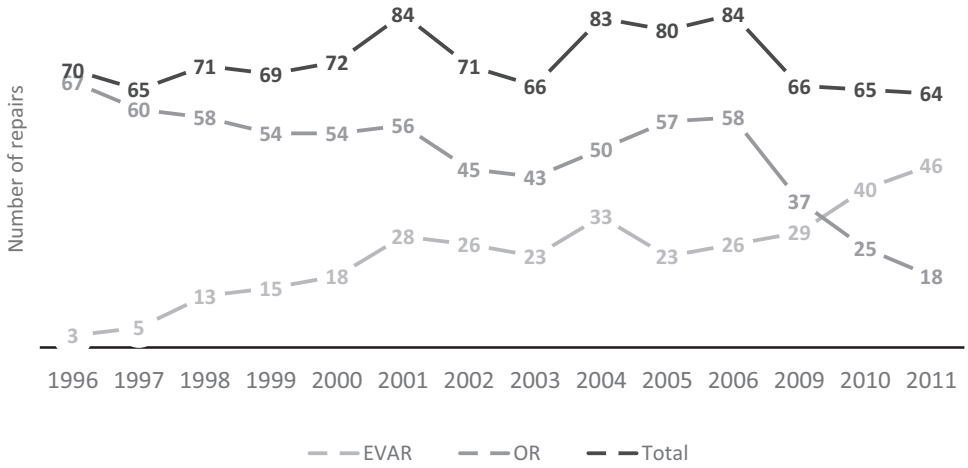

Fig. 2. Number of AAA repairs and the method of repair over time.

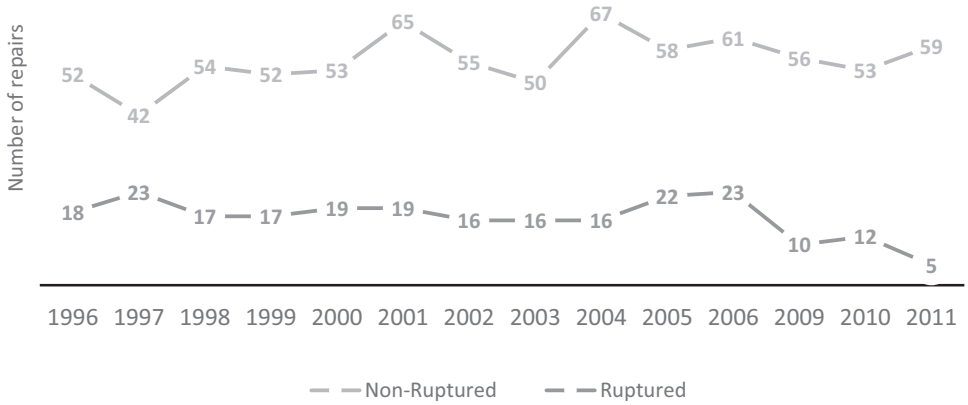

Fig. 3. Graph comparing the number of ruptured and nonruptured AAA over time.

Table V. Descriptive analyses of patients under and over the age of 70 undergoing AAA repairs

Age group	45–69 ($n = 311$)	>70 ($n = 725$)	*P*-values
Male (%)	238 (76.5)	548 (75.6)	0.81
Māori (%)	50 (16.1)	45 (6.2)	0.0001
Acute (%)*	127 (40.8)	237 (32.7)	0.01
RAAA (%)	83 (26.7)	155 (21.4)	0.07
OR (%)	239 (76.8)	453 (62.5)	0.0001

*Acute repairs: included symptomatic and ruptured.

were also more likely to present acutely for AAA repairs either in the form of RAAA or symptomatic but nonruptured AAA.

Survival Analyses

Māori had poorer outcomes with a 10-year survival rate of 17.4% compared to 35.6% in Europeans (Table VI and Fig. 4, $P < 0.001$). Poor outcomes for Māori remained consistent irrespective of the gender, type of presentation, and age. The 5-year and 10-year mortality rates were similar irrespective of the acuity associated with the repair. Similarly, for the Māori population, women of both age groups (under and over the age of 70), had poorer long-term survival following surgery.

Table VI. Kaplan-Meier survival analyses demonstrating mortality rates up to 10 years

Mortality rate (%)	30 days	1 year	5 year	10 year	*P* value
Overall	88.3	82.1	60.2	34.3	
Open repairs	83.5	77.2	59.2	33.4	0.03
EVAR	98.0	91.8	60.1	34.7	
European	89.1	83.3	61.3	35.6	<0.001
Māori	83.2	72.2	45.2	17.4	
European					<0.001
Male	89.1	83.3	61.1	37.7	
Female	89.1	83.1	62.0	30.0	
Maori					
Male	84.5	72.3	46.8	20.1	
Female	81.1	72.3	43.2	12.3	
European					<0.001
Elective	96.4	91.1	65.4	38.8	
Symptomatic	93.4	86.7	67.0	39.2	
RAAA	62.9	55.8	44.3	23.1	
Māori					
Elective	95.3	87.8	42.0	12.0	
Symptomatic	93.3	73.3	64.2	32.1	
RAAA	64.9	54.1	39.2	16.0	
European					<0.001
Under age 70	93.4	89.0	77.7	57.7	
Over age 70	87.6	81.3	55.3	27.4	
Māori					
Under age 70	92.0	77.8	58.8	23.7	
Over age 70	73.3	66.2	30.5	10.2	

Of note, EVAR had more favorable outcome than OR. After an initial survival advantage with EVAR, the curves converged at 4.9 years following surgery (Fig. 5).

Using a logistic regression model, age ($P < 0.001$) and operation length ($P = 0.04$) were found to be confounding factors influencing mortality when comparing the 2 ethnic groups. With the age and operation time adjusted, Māori still had worse outcome in terms of mortality ($P < 0.001$ for age, $P = 0.045$ for operation time).

Causes of Death

513 patients died during the study period. Primary causes of death were found in 498 patients (97%) and categorized accordingly. Figure 6 summarized the causes of deaths subdivided into early (≤30 days) and late (>30 days) deaths. Sixteen (3.2%) deaths were a complication of the repair, categorized as ''AAA complications''. Of these, 7 died within 30 days and were associated with post-operative bleeding. Of the 9 late complications associated with mortality, 4 were secondary to graft or endograft stent bleeding. Two of the 3 patients that had an infected graft explanted during additional surgery died (1 patient died from aortoenteric fistula and another from a blocked aortic graft).

''Ruptured AAA'' was the only primary cause of death that was significantly more prevalent proportionally between Māori than Europeans ($P = 0.014$, Table VII). Subanalyses of early and late deaths between the 2 ethnic groups did not yield any significant findings.

DISCUSSION

This study describes the epidemiological and mortality data on over 1,000 aneurysm repairs in a single center over 15 years. The study population comprised a large proportion of the indigenous Māori population who are considered ''high-risk'' in suffering from AAA, especially women. Analysis of the data collected shows Māori are more likely to present at a younger age, with an RAAA and have poorer mortality rates and perioperative outcomes. Typically, AAA is a disease known to affect males in a higher proportion compared to females.[15] However, the Māori population did not demonstrate the same male preponderance as Europeans. These findings suggest a probable genetic

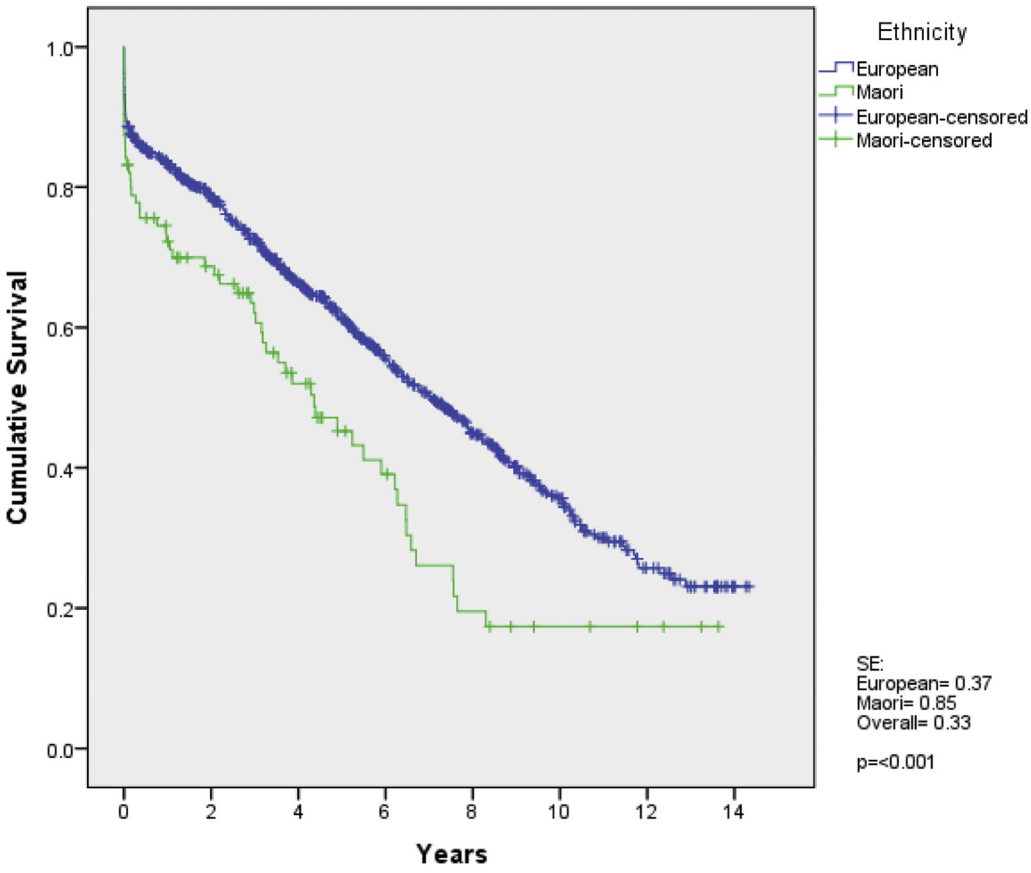

Fig. 4. Kaplan-Meier curve comparing survival of Māori versus Europeans.

disposition behind Māori developing aneurysmal disease.

Although a high proportion of the repairs were performed in acute presentations of AAA, data across the study period showed a downward trend in the proportion of RAAA presentations. This was noted in both the Māori and European populations irrespective of age groups. Explanations for this include the advent of imaging technologies like computed tomography (CT) in recent years, allowing for an increasing number of AAA's to be detected early without any specific population screening programs. In addition, AAA's are typically found incidentally, and the growing use of abdominal imaging for other pathologies is also a likely contributor. Lower rates of smoking and the general improvement in medical management of risk factors such as hypertension may also have had an impact.

The overall mortality data suggest that Māori experienced worse outcomes from AAA repair than Europeans postoperatively. Although this could be partly attributed to ethnic inequalities associated with health outcomes, the reasons are likely multifactorial where the indigenous population typically have multiple comorbidities resulting in a shorter life expectancy, less access to health care and poorer health literacy.[14,16–20] Māori and Pacific Islanders have a higher prevalence of diabetes and related risk factors (e.g., obesity, physical inactivity, insulin resistance, and metabolic syndrome) when compared with Europeans.[21–23] There is a higher prevalence of smoking among Māori with diabetes than in their non-Māori counterparts.[24] The age-adjusted mortality rates for cardiovascular disease, cancer, and renal disease, are higher in Māori, especially in women.[17] According to the Ministry of Health (NZ), the prevalence and mortality rate of cardiovascular disease are similar between the 2 gender groups in the Māori population.[25] These factors may explain the near-equal sex distribution of AAA in Māori.

Cultural and ethnic factors also have an influence in the attitude of Māori toward the treatment for AAA. Māori have a different approach to health care. As well as physical health, Māori have a strong philosophical emphasis on familial, spiritual, mental

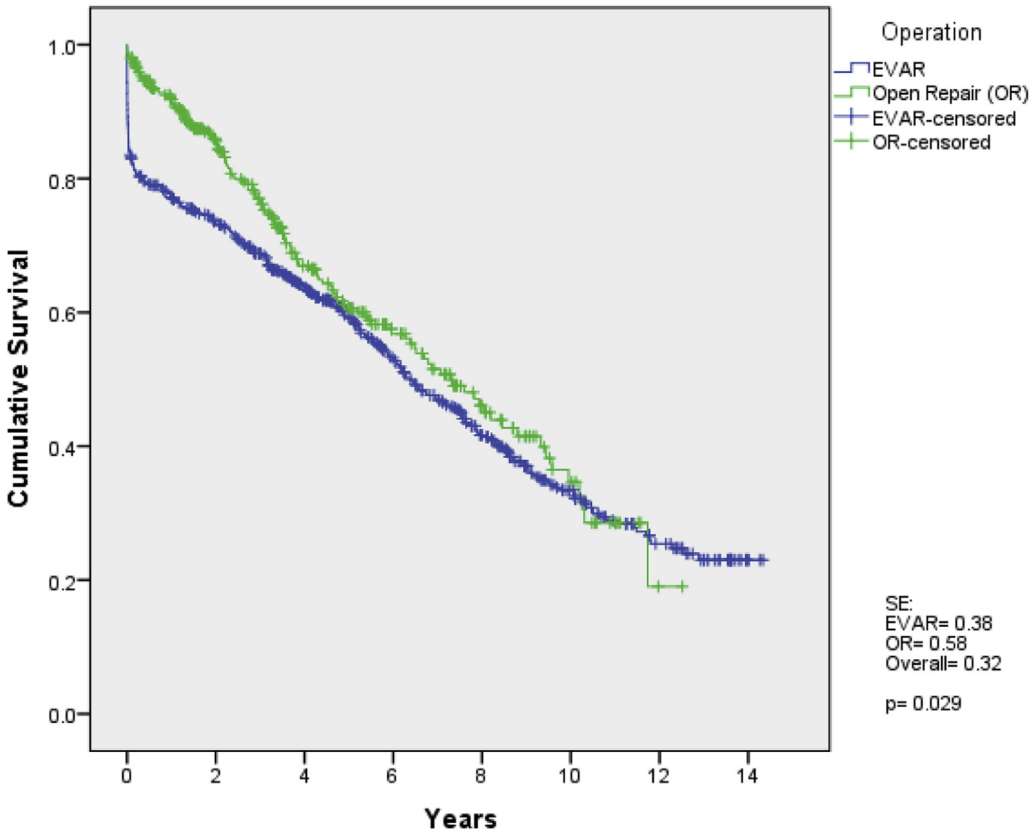

Fig. 5. Kaplan-Meier curve comparing survival of EVAR versus open repairs.

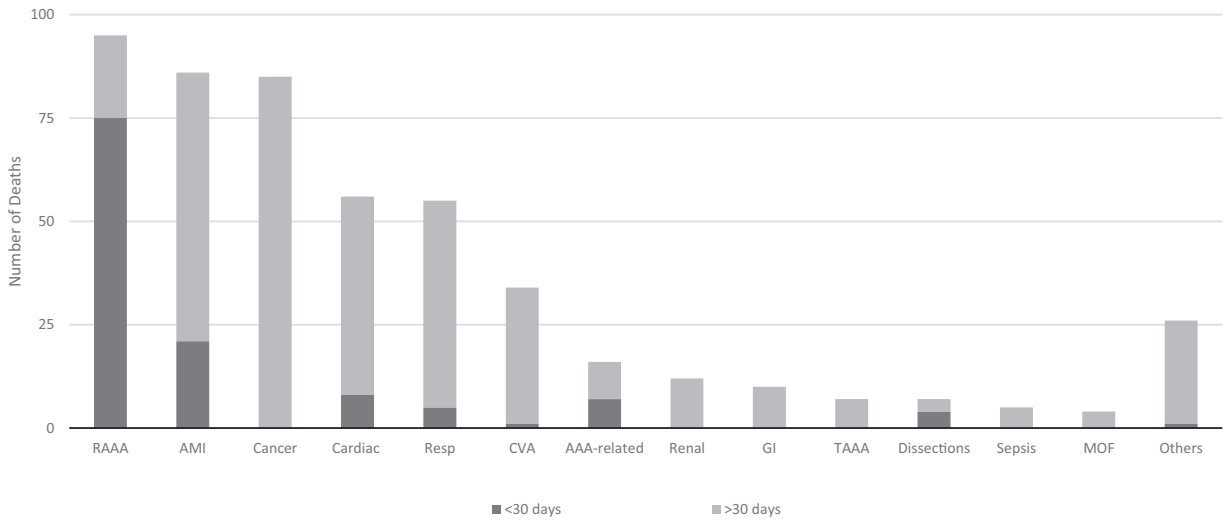

Fig. 6. Bar chart to show the distribution of causes of death categorized by early (≤30 days) and late (>30 days). RAAA, ruptured abdominal aortic aneurysm; AMI, acute myocardial infarction; Resp, respiratory; CVA, cerebrovascular events; GI, gastrointestinal; TAAA, thoracic or thoracoabdominal aneurysm; MOF, multiorgan failure.

Table VII. Summary of the primary causes of deaths

Cause of death	European	Māori	*P* value
Ruptured AAA	76	16	0.014
Malignancy	71	12	0.11
Acute MI	77	6	0.56
Cardiac (not MI)	46	8	0.23
Respiratory	48	6	0.63
Cerebrovascular	32	1	0.35
AAA complications	15	1	1.00
Renal	9	3	0.10
GI (not malignancy)	10	0	0.61
TAAA	6	1	0.50
Sepsis	4	1	0.39
Aortic dissections	4	1	0.39

MI, myocardial infarction; GI, gastrointestinal; TAAA, thoracic or thoracoabdominal aneurysm; MOF, multi-organ failure.

wellbeing, forming the so-called ''4 pillars of Māori Health''. As is historically known, the access to health care among Māori is poorer than non-Māori. A perception of the hospital and medical clinics being unfriendly environments exists.[26] In addition, it is likely the inherent cultural beliefs and mistrust of allopathic medicine lead to reduced primary prevention of cardiovascular risk factors. This aspect has been addressed extensively by the NZ government with the introduction of specialized programs targeting the Māori population through primary care practitioners. It is possible that over time, as the inequality to access and knowledge of primary prevention improves amongz Māori patients, the burden of diseases like AAA will also reduce.

Findings of this study add to the growing evidence of potential benefits associated with the establishment of an AAA screening program specifically targeting the Māori population who have clear differences in disease epidemiology compared to Europeans. Within NZ, there is increasing support for an organized screening program.[11,12] Some private radiology clinics are already offering screening for both men and women, and some health centers are screening opportunistically for AAA. However, there may be a lack of services available in rural areas where Māori live or a reluctance of Māori to access these services.

According to Khashram et al., there was no difference in detecting AAA between Europeans and Māori.[13] The rate of detecting an AAA of more than 3 cm was 6.1% and that of more than 5 cm was 0.6%. Using the population estimates from this study, this equates to a new diagnosis of AAA of more than 3 cm detected in 3,056 patients over the age of 60, and 301 new diagnoses of AAA of more than 5 cm requiring consideration of surgical repairs. There were 45.1 AAA repairs per year in patients over the age of 60 in this study. This may reflect 85% of people who have a large AAA were left undetected due to the lack of a screening program.

The decreasing incidence of ruptured AAA shown in this study and other studies suggests that a generalized screening program might not be as effective and beneficial as a targeted population-specific program. The age-standardized incidence of AAA in both NZ and the UK has been falling steadily in recent years, presumably as a result of the medical and life style interventions that have caused a similar fall in cardiac events.[1,8]

There remains debate over the effectiveness of an AAA screening given the incidence of AAA repairs in this study remains more common in European men, even when considering Māori men and women. In addition, the long-term survival for Māori, in particular women, following AAA repairs is poor, irrespective of elective or RAAA surgery.

One of the main limitations of this study is that the AAA repair data were not updated in the past 5 years. This was due to the amount of time required to formulate and verify the database. How the data output would have been affected is uncertain. In addition, the lack of substantial data on preoperative risk factors precluded their inclusion in the overall analysis.

Young and healthy patients were previously considered to be better managed with open repairs due to its durability, while recognizing the higher early risks. This is evident in this study where more patients had open repairs in the younger age

group. However, the endovascular era has exploded in recent years with improved products; and EVAR has become the preferred option for treating AAA for most surgeons irrespective of the patients' age, comorbidities, and life expectancy. In addition, with the advancements in endovascular techniques, the number of open AAA repairs in most centers has further reduced, often reserved for those that are technically challenging, such as juxtarenal AAA where standard, fenestrated, or branched EVARs are not favorable. These factors may impact on the mortality data with improved long-term outcomes, but it would probably not explain the ethnic disparity that exists in the incidence of AAA (and RAAA) and their long-term outcomes.

Other limitations to consider include the registration of ethnicity which is dependent on the patients' belief. Ethnicity and descent are different concepts. Ethnicity refers to cultural affiliation, whereas decent is about ancestry. The Māori ethnic population consists of people who stated Māori being their sole ethnic group or one of several ethnic groups. The composition of the biological footprint of the indigenous race in terms of genetic predisposition to AAA formation would be heterogenous in both the ''Māori'' and ''European'' patients.

Given the epidemiological perspective of this study, patients who did not undergo operative management of AAA were excluded. The focus of the study was to further define the epidemiological patterns and long-term mortality outcomes of surgical disease management of abdominal aortic aneurysms in relation to population factors such as ethnicity and gender.

CONCLUSION

This study highlights the epidemiological trends and survival outcomes of AAA management in Māori and Europeans over a 15-year study period. It provides further evidence supporting the consideration of a population-specific screening program in the future.

Simone Oldham, who was a medical student in the unit, made significant contribution in the data collection.

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