Ethnic variation in the trends of new implantable cardioverter defibrillator implants in New Zealand 2005–2019 (ANZACS-QI 63)

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ABSTRACT:

AIMS: Ethnic variation in implantable cardioverter defibrillator (ICD) implant rates have been reported internationally but have not previously been examined in New Zealand. This study examined trends in new ICD implants by ethnicity over an extended period.

METHODS: All patients who received a new ICD implant between 2005 and 2019 were identified using the National Minimum Dataset, which collects information on all public hospital admissions in New Zealand. Ethnicity was classified using the following standard prioritisation: Māori, Pacific, Asian and European/Other. New ICD implant rates were analysed by ethnicity and age groups.

RESULTS: A total of 5,514 new ICDs were implanted. New ICD implant rates increased from 41.4/million in 2005 to 98.2/million in 2019, an average increase of 5.4%/year (p<0.01). The highest age-standardised implant rates were among Māori, followed by Pacific, Asian and European/Other. New ICD implant rates were analysed by ethnicity and age groups.

RESUL TS: A total of 5,514 new ICDs were implanted. New ICD implant rates increased from 41.4/million in 2005 to 98.2/million in 2019, an average increase of 5.4%/year (p<0.01). The highest age-standardised implant rates were among Māori, followed by Pacific, European/Other and Asian ethnicities. The largest increase was seen in Pacific people at 8.9%/year (p <0.01), followed by Māori and Asian people at 4.7%/year and 4.3%/year respectively (both p<0.01). In European/Other patients, ICD implant rates increased by 10.3%/year (p<0.01) between 2005 to 2012, then plateaued at -0.4%/year (p=0.71) between 2012 to 2019. By 2019, the age-standardised implant rates in Māori and Pacific people were two-fold higher than European/Others.

CONCLUSION: There is marked ethnic variation in ICD implant rates in New Zealand. The higher implant rates in Māori and Pacific parallel known ethnic differences in rates of underlying cardiac disease. The more rapid increase in implant rates in these ethnic groups may represent more equitable treatment over time.

Variation in implantable cardioverter defibrillator (ICD) implant rates by ethnic groups have been identified in the United States and the United Kingdom, with African American and South Asian patients being less likely to receive an ICD compared to White patients. However, there is limited information on ethnic disparity in ICD implant rates elsewhere. In New Zealand, there is variation in cardiovascular and non-cardiovascular risk factors, investigation, management and outcomes by ethnicity. ICD implant rates for Māori, Pacific, Asian and New Zealand Europeans have been reported for a single year, but whether the reported trend has persisted over a longer time-period is unclear. The main ethnic groups in New Zealand also have differing age structures, but the age-specific ICD implant rates by ethnicity are unknown.

The rate of ICD implants has increased globally in recent years. In patients with heart failure with reduced ejection fraction ICDs have an important role in the prevention of sudden cardiac death, in addition to risk factor modification and pharmacological treatment. In New Zealand,
ICDs are indicated for primary prevention of sudden cardiac death in patients <75 years old with symptomatic heart failure with reduced ejection fraction, and for the secondary prevention of sudden cardiac death in patients who have survived a cardiac arrest. ICD implant rates in New Zealand have increased significantly over the past decade, with substantial regional variation. This paper aims to provide an analysis of trends in new ICD implants in New Zealand by ethnicity over the past 15 years.

Methodology
All patients who received a new ICD implant, including cardiac resynchronisation therapy defibrillators, between 1 January 2005 to 31 December 2019 were identified using the National Minimum Dataset, which collects information on all public hospital admissions in New Zealand. The Dataset does not include procedures from private hospitals, but ICD implants were rarely performed in the private sector over the study period, as device costs were not covered by health insurance providers in New Zealand. ICD implants were identified using specific codes from the Australian Classification of Health Interventions (ACCH), which were issued as part of the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD10-AM) procedure coding (Supplementary Table 1). Specific prioritisation and categorisation rules were applied using a previously validated methodology, which had an excellent ability to capture all permanent pacemaker (PPM) and ICD implants nationally, differentiate between PPM and ICD implants and distinguish between new and replacement procedures. Replacement ICD procedures were excluded from this analysis.

Self-identified ethnicity is routinely recorded in all national health databases in New Zealand following a standardised protocol. For patients with multiple ethnic groups recorded, a modified prioritisation of the Ministry of Health's Ethnicity Data Protocols was used to assign each individual to one ethnic group. Prioritisation was performed in the following order: Māori, Pacific (Tokelauan, Fijian, Niuean, Tongan, Cook Island Māori, Samoan, Other Pacific), Asian (Indian, Southeast Asian, Chinese, Other Asian) and European/Other (Middle Eastern, Latin American, African, Other Ethnicity, Other European and New Zealand European). The sole exception were Fijian Indian patients, who were categorised as Indian (in the Asian group) rather than Pacific, as a previous local study demonstrated that these patients have cardiovascular risk profiles that are more similar to Indians than other Pacific groups. As Europeans represent >90% of the European/Other group, this group is referred to as “European” in the rest of this paper. Over the study period, the proportion of the population the main ethnic groups were as follows: Māori: 15.7%, Pacific: 6.4%, Asian: 11.8%, European: 66.1%.

Statistical analysis
Implant rates per million population by ethnicity were calculated using the number of new ICD implants as the numerator and the estimated population of New Zealand for each year as the denominator. The estimated population of New Zealand by ethnicity (the denominator) is prioritised in the same method as described above. These data are available in the 2018 New Zealand Population Projections from Stats NZ. Age-specific rates for the age groups <40, 40–69, 70–79 and ≥80 years by ethnicity were calculated. Due to low implant volumes in some age groups, age-specific rates were also combined for the three years at the beginning and the end of the study period (2005–2007 and 2017–2019) to facilitate comparisons. Implant rates per million population were age-standardised using the direct method with the European Standard Population. Trend analysis of age-standardised implant rates was performed using a “joinpoint” regression model, to accommodate non-linear trends over time. The process fits the simplest model that the data allow and tests whether one or more joinpoints, which indicate a change in slope of the trend, are statistically significant. Annual percentage changes in trend were calculated. Version 4.7.0.0 of the Joinpoint Regression Program was used. Other analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).
Ethics
This is a sub-study of ANZACS-QI, which is part of the wider Vascular Informatics using Epidemiology and the Web (VIEW) programme. The VIEW programme was approved by the Northern Region Ethics Committee Y in 2003 (AKY/03/12/314), with subsequent amendments to include the ANZACS-QI registries, and with annual approvals by the National Multi-region Ethics Committee since 2007 (MEC07/19/EXP).

Results
A total of 5,514 new ICDs were implanted between 2005 and 2019. New ICD implant rates increased by 137% over the 15-year period, from 41.4 per million in 2005 to 98.2 per million in 2019, an average increase of 5.4% per year (95% confidence interval (CI): 4.7–6.1%, p<0.01).

Age-specific trends by ethnicity
In all age groups <80 years, Māori and Pacific people had higher implant rates through most of the study period. Asians consistently had the lowest new ICD implant rates across all age groups, with the lowest rate in patients <40 years. Māori and Pacific people in the 40–59 years and 60–69 years age groups had substantially higher age-specific implant rates compared to Europeans and Asians (Figure 1, Supplementary Figure 1). Of note, at the beginning of the study there were no implants in Pacific people over 70 or Māori and Asians over 80. However, new ICD implants in octogenarians across all ethnicities represented only 2.4% of all new ICD implants over the study period (Supplementary Tables 2 and 3).

Trends in age-standardised new ICD implant rates by ethnicity
Between 2005 to 2019, the highest age-standardised new ICD implant rates were among Māori, followed by Pacific, Europeans and Asians. In 2005, age-standardised new ICD implant rates were higher in Māori and Pacific people than Europeans. Since 2005, the largest increase in new ICD implant rates was seen in Pacific patients at 8.9% per year (95% CI: 6.1–11.7%, p<0.01). New ICD implant rates increased by 4.7% per year (95% CI: 2.2–7.2%, p<0.01) in Māori and increased by 4.3% per year (95% CI: 1.3–7.4%, p<0.01) in Asians. In Europeans, new ICD implant rates initially increased by 10.3% per year (95% CI: 17.1–13.6%, p <0.01) between 2005 to 2012, but then plateaued at -0.4% per year (95% CI: -2.6–1.9%, p=0.71) between 2012 to 2019. By 2019, the age-standardised new ICD implant rate in Māori and Pacific people were approximately double that of Europeans and three- to four-fold higher than Asians (Figure 2).

Discussion
This is the first nationwide description of ICD implant trends by ethnicity in New Zealand over an extended time-period. In 2005 the age-standardised implant rates for Māori were higher than for Europeans, but implant rates among Pacific people were similar to those for Europeans. By 2019, implant rates in Europeans had plateaued, but implant rates for both Māori and Pacific people continued to increase and diverge from Europeans, resulting in Māori and Pacific people having more than twice the implant rates of Europeans.

Wilson et al have previously shown that Māori patients had a higher crude ICD implant rate compared to Europeans in 2010, but the crude implant rates in Pacific patients lagged behind Europeans despite their known higher incidence of ischaemic heart disease.20 We have shown that, although the age-standardised ICD implant rates plateaued in European patients in recent years, rates have continued to increase for both Māori and Pacific people.

Are ICD implant rates in New Zealand equitable?
In New Zealand, there is evidence of inequitable distribution of risk factors, investigation, management and outcomes for both cardiac and non-cardiac disease.5–19 Although we have reported higher and increasing rates of ICD implantation in Māori and Pacific people relative to Europeans, a key question arising from this work is what the ideal rate of ICD implants should be if clinical guidelines for implantation were strictly adhered to.23–26 Any gap between the ideal rate and observed rates may be attributable to unwarranted variation and therefore evidence of inequitable treatment. In this study we cannot
**Figure 1:** Age-specific new ICD implant rate per million population by ethnicity and age groups from 2005–2007 to 2017–2019. Age group ≥80 years not included as they accounted for only 2.4% of all new ICD implants.
give a definitive answer to this question as a full clinical description of the populations eligible to receive an ICD is not available.

We recently performed an analysis using national administrative datasets, which found that the rates of incident heart failure are two-fold higher in Māori and Pacific patients compared with Europeans (Chan et al, submitted for publication). This confirms other data demonstrating that Māori and Pacific had higher rates of prior heart failure and heart failure hospitalisation compared to Europeans.\textsuperscript{3,11,36} We also know that, compared with Europeans, the age-standardised burdens of hospitalisation or death due to ischaemic heart disease for Māori and Pacific people were two-fold greater in 2014–2015, and that the case fatality for acute coronary syndromes in 2014–2017 was two- to three-fold higher.\textsuperscript{11,12} The at least two-fold incidence and mortality of both heart failure and ischaemic heart disease for Māori and Pacific people relative to Europeans is consistent with the higher ICD implant rates observed in this study.

However, further work is required to determine whether implant rates are high enough.

In recent years, the age-standardised ICD implant rates in European patients in New Zealand have plateaued. At the same time, there has been a decline in hospitalisations and deaths due to ischaemic heart disease and heart failure\textsuperscript{12} (Chan et al, submitted for publication). However, this does not take into consideration changes in clinical guidelines for ICD implantation in recent years, level of adherence to clinical guidelines, changes in rates of investigation and risk factor management. Further work is therefore needed to determine whether the appropriate implant rates have been achieved.

Interestingly, our study showed that Asians (including Indians) had substantially lower ICD implant rates compared to other ethnicities, even though Indians have among the highest rates of cardiovascular disease and diabetes in New Zealand.\textsuperscript{5,11} Due to the small number of ICD implants in Asians,
we did not separate Indian and non-Indian Asians in this analysis. Previous research has shown that both Indian and non-Indian Asians had higher overall coronary revascularisation rates in addition to the lowest all-cause mortality after a myocardial infarction compared to other ethnicities.\textsuperscript{3,11,12} Thus, the favourable cardiovascular outcomes and likely lower incidence of ischaemic cardiomyopathy in Asians may partially explain the lower rates of ICD implants in this ethnic group.

**Ethnic variation in ischaemic heart disease and implantable cardioverter defibrillator implants internationally**

Ethnic variation in ICD implants has been reported internationally, but data are predominantly limited to the United Kingdom and the United States and only a small number of ethnicities were compared. In the United States, studies from the late 1990s and early 2000s showed that African American patients were less likely to receive ICD implants compared to White patients, irrespective of primary prevention or secondary prevention indications.\textsuperscript{37,38} However, this disparity may have narrowed in recent years.\textsuperscript{39} Previous studies have also reported that African American patients were less likely to receive coronary angiography and coronary revascularisation than White patients.\textsuperscript{40} Mistry et al reported lower ICD implant rates in South Asian patients compared to White patients, despite a higher burden of coronary artery disease.\textsuperscript{4} In these international studies, poor communication, system-wide failures to address health literacy, a lack of acknowledgement of cultural beliefs and language barriers were hypothesised as reasons for disparity in ICD implant rates.\textsuperscript{2,4} However, in the United States’ Get With The Guidelines – Heart Failure Program, there was still disparity in the rate of ICD use by ethnicity, even among patients who received counselling for ICD therapy.\textsuperscript{41}

To ensure equitable treatment and to improve cardiovascular outcomes for Māori and Pacific patients, it is imperative that unwarranted ethnic differences at every stage of the management of cardiovascular disease, particularly for ischaemic heart disease and heart failure, is addressed: from risk-factor modification to treatment with pharmacologic therapy and coronary procedures, and finally with fair and appropriate patient selection for ICD implants. To achieve this, health services must, among other things, recognise the importance of effective communication, continuity of care and integrated models of care that respect and are aligned with the values of diverse communities.

**Limitations**

This study is a descriptive analysis of ICD implant rates by ethnicity in New Zealand. It has been reported in the context of inequities of underlying disease burden at a population level. However, a detailed patient-level investigation of clinical, geographical or socioeconomic factors that may have impacted on implant rates is beyond the scope of this study.

Self-identified ethnicity may differ between national health databases and the national census. This study uses data from Stats NZ only, but trends in self-identified ethnicity over time is unknown.

Although there have been significant changes in population within each age band as well as age structure by ethnicity over the study period, the calculation of age-specific and age-standardised rates take these changes into account and minimise errors in comparison of implant rates between ethnicities.

Additionally, ICD implants for primary vs secondary prevention indications could not be reliably differentiated in the national level data.

**Conclusion**

There is marked ethnic variation in ICD implant rates in New Zealand. Implant rates have increased in non-European ethnic groups but have plateaued in European patients in the past seven years. The higher implant rates among Māori and Pacific people parallel known differences between ethnic groups in rates of underlying cardiac disease. The more rapid increase in implant rates in these groups may be due to a greater clinical need or more equitable treatment over time. However, further research at an individual patient level is needed to determine whether implant rates are high enough to represent equity in patient selection for ICD implant.
Supplementary Material

• **View Supplementary Table 1:** ICD10-AM codes for permanent pacemaker (PPM) and implantable cardioverter defibrillator (ICD) implants. If codes for ICD and PPM were both present in a single episode of care (EoC), this was categorised as an ICD implant. When codes for a new and replacement procedure were both present in a single EoC, it was categorised as a replacement procedure if replacement codes were present on the same day or earlier than the dates of the new procedure codes. Conversely, if replacement codes were one day or more after the date of new procedure codes, the procedure was categorised as a new implant.

• **View Supplementary Table 2:** Number of implantable cardioverter defibrillator implants by ethnicity and age-groups.

• **View Supplementary Table 3:** Age-specific new ICD implant rate per million population by ethnicity and age groups from 2005-2007 to 2017-2019. *European ethnicity includes European/other after ethnic group prioritisation for Māori, Pacific and Asian ethnicities. CI, confidence interval; ICD, implantable cardioverter defibrillator.

• **View Supplementary Figure 1:** Trends in new ICD implant rates by ethnicity and age groups. Excludes replacement procedures. ICD, implantable cardioverter defibrillator.
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