



ORIGINAL ARTICLE

Implantable cardioverter defibrillator and cardiac resynchronization therapy use in New Zealand (ANZACS-QI 33)

Fang Shawn Foo MBChB^{1,2}  | Mildred Lee BTech, MsC^{1,3} | Khang-Li Looi MBChB²  | Peter Larsen PhD⁴ | Geoffrey C. Clare MBChB^{5,6} | David Heaven MBChB¹ | Martin K. Stiles MBChB, PhD⁷ | Jamie Voss MBChB¹ | Dean Boddington MBChB⁸ | Rod Jackson MBChB, PhD³ | Andrew J. Kerr MBChB, MD^{1,3} |
on behalf of the ANZACS-QI investigators

¹Department of Cardiology, Middlemore Hospital, Auckland, New Zealand

²Department of Cardiology, Auckland City Hospital, Auckland, New Zealand

³University of Auckland, Auckland, New Zealand

⁴Wellington Cardiovascular Research Group, Wellington Hospital, Wellington, New Zealand

⁵Department of Cardiology, Christchurch Hospital, Christchurch, New Zealand

⁶University of Otago, Christchurch, New Zealand

⁷Department of Cardiology, Waikato Hospital, Hamilton, New Zealand

⁸Department of Cardiology, Tauranga Hospital, Tauranga, New Zealand

Correspondence

Fang Shawn Foo, Department of Cardiology, Middlemore Hospital, Private Bag 93311, Otahuhu, Auckland, New Zealand.
Email: shawnfoo@icloud.com

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Abstract

Background: The ANZACS-QI Cardiac Implanted Device Registry (ANZACS-QI DEVICE) collects nationwide data on cardiac implantable electronic devices in New Zealand (NZ). We used the registry to describe contemporary NZ use of implantable cardioverter defibrillator (ICD) and cardiac resynchronization therapy (CRT).

Methods: All ICD and CRT Pacemaker implants recorded in ANZACS-QI DEVICE between 1 January 2014 and 31 December 2017 were analyzed.

Results: Of 1579 ICD implants, 1152 (73.0%) were new implants, including 49.0% for primary prevention and 51.0% for secondary prevention. In both groups, median age was 62 years and patients were predominantly male (81.4% and 79.2%, respectively). Most patients receiving a primary prevention ICD had a history of clinical heart failure (80.4%), NYHA class II-III symptoms (77.1%) and LVEF \leq 35% (96.9%). In the secondary prevention ICD cohort, 88.4% were for sustained ventricular tachycardia or survived cardiac arrest from ventricular arrhythmia. Compared to primary prevention CRT Defibrillators (n = 155), those receiving CRT Pacemakers (n = 175) were older (median age 74 vs 66 years) and more likely to be female (38.3% vs 19.4%). Of the 427 (27.0%) ICD replacements (mean duration 6.3 years), 46.6% had received appropriate device therapy while 17.8% received inappropriate therapy. The ICD implant rate was 119 per million population with regional variation in implant rates, ratio of primary prevention ICD implants, and selection of CRT modality.

Conclusion: In contemporary NZ practice three-quarters of ICD implants were new implants, of which half were for primary prevention. The majority met current guideline indications. Patients receiving CRT pacemaker were older and more likely to be female.

KEYWORDS

cardiac resynchronization therapy, device therapy, implant rates, Implantable cardioverter defibrillator, New Zealand

1 | INTRODUCTION

Cardiac implantable electronic device (CIED) therapy is an important tool in the management of heart failure with reduced ejection fraction. Implantable cardioverter defibrillators (ICD) are indicated for primary prevention of sudden cardiac death in patients with symptomatic heart failure and left ventricular ejection fraction (LVEF) $\leq 35\%$ despite optimal medical therapy.¹⁻¹⁰ They are also indicated for secondary prevention in patients who have survived a cardiac arrest or hemodynamically unstable ventricular arrhythmia.^{1,9-14} Cardiac resynchronization therapy (CRT) is indicated in patients with symptomatic heart failure, sinus rhythm, LVEF $\leq 35\%$, and a wide QRS despite optimal medical therapy.^{9,10,14-18} This can be delivered in the form of a CRT Pacemaker (CRT-P) or a CRT Defibrillator (CRT-D). Most patients who fulfill conventional indications for CRT have overlapping indications for an ICD.

The All New Zealand Acute Coronary Syndrome-Quality Improvement Cardiac Implanted Device Registry (ANZACS-QI DEVICE) is a web-based platform designed to collect data on CIED implanted across New Zealand (NZ). The registry includes permanent pacemaker (DEVICE-PPM) and implantable cardioverter defibrillator (DEVICE-ICD), including both new implants and replacement procedures. It was built upon the ANZACS-QI platform and introduced to NZ public hospitals in 2014 through a grant from the NZ branch of the Cardiac Society of Australia and New Zealand (CSANZ).¹⁹ The ANZACS-QI DEVICE Registry has been used previously to describe the clinical characteristics and implant details of patients receiving new pacemaker implants.²⁰ Our study aims to describe the contemporary NZ use of ICD and CRT, utilizing the ANZACS-QI DEVICE Registry.

2 | METHODS

All ICD implants (including new and replacement procedures) registered in the ANZACS-QI DEVICE between 1 January 2014 and 31 December 2017 were analyzed. For the CRT cohort, new primary prevention CRT-D implants (from DEVICE-ICD) as well as new CRT-P implants (from DEVICE-PPM) over the same study period were analyzed.

Data are entered by cardiac physiologists at the time of the procedure and at the 4- to 6-week follow-up device clinic. All data extracted from the registries for analysis are anonymized. Although participation in the registry is voluntary, seven of 10 PPM implant sites and five of seven ICD implant sites participated by mid-2014, with full participation from all implant sites from early 2016. However, there was a drop in participation in early 2017. Details regarding the operation of the ANZACS-QI registries have been

previously reported.¹⁹ Both DEVICE-ICD and DEVICE-PPM collect procedure numbers, basic patient demographics, symptoms, ECG findings, device indication, device type, implant physician and hospital as well as early complications. Data collected in the DEVICE-ICD registry also include cardiac and medical history, primary and secondary prevention indication, NYHA class and left ventricular systolic function (in those with a history of clinical heart failure). The CRT-P cohort of DEVICE-PPM also has data on NYHA class and left ventricular systolic function as well as additional ECG details.

2.1 | Definitions

Appropriate device therapy was defined as the delivery of antitachycardia pacing (ATP) or shocks for ventricular tachycardia (VT) or ventricular fibrillation (VF). Device therapy in the absence of VT or VF was considered to be inappropriate device therapy.

2.2 | Statistical analysis

Continuous variables were summarized as means with standard deviation (SD) or medians with interquartile range (IQR). The Student's *t* test was used to compare groups. For categorical variables, data were summarized as frequency and percentage and the Chi-square test or Fisher's exact test was used for comparisons between groups where appropriate. All P-values reported were two-tailed and a $P < .05$ was considered significant. Data were analyzed using the SAS statistical package, version 9.4 (SAS Institute). Crude implant rates were calculated using the 2017 Projected New Zealand Population.

2.3 | Ethics

ANZACS-QI is a substudy within the PREDICT study which was approved by the Northern Region Ethics Committee Y in 2003 (AKY/03/12/314) with subsequent annual approval by the National Multi Region Ethics Committee since 2007 (MEC07/19/EXP).

3 | RESULTS

There were 1579 ICD implants during this study period, including 1152 (73.0%) new implants and 427 (27.0%) replacement procedures.

3.1 | New ICD implants

Of the 1152 new implants, there were 565 (49.0%) primary prevention ICDs and 587 (51.0%) secondary prevention ICDs (Table 1). The clinical characteristics of both groups were similar. The median age was 62 years, predominantly male (81.4% vs 79.2%), with European

(63.7% vs 66.8%) and Māori (24.8% vs 21.1%) being the most common ethnicities. The mean BMI was 30.2 vs 29.2 kg/m². Baseline histories of hypertension, diabetes mellitus, and dyslipidemia were similar in the two groups. A history of atrial fibrillation or atrial flutter was reported in 31.0% vs 33.7% of the primary and secondary prevention groups, respectively. The majority (75.2% vs 80.7%) was in sinus rhythm at the time of ICD implant.

Most patients receiving a primary prevention ICD had a history of clinical heart failure (80.4%) with significant heart failure symptoms (NYHA class II-III in 77.1%) and severe LV impairment (LVEF ≤ 35% in 96.9%) of those with heart failure. The etiology of heart failure was ischemic in only 42.5%. The mean QRS duration was 130 milliseconds, with 31.9% having left bundle branch block (LBBB). CRT-D accounted for 27.4% of primary prevention ICD implants.

In the secondary prevention ICD cohort, 88.4% were for VT/VF cardiac arrest or sustained VT. In contrast with the primary prevention ICD cohort, only 39.7% had a history of clinical heart failure, of whom 47.3% had significant heart failure symptoms (NYHA class II-III) and 76.0% had an LVEF ≤ 35%. There was a higher rate of ischemic etiology for heart failure at 55.8%. The mean QRS duration was 113 milliseconds, with only 16.0% having LBBB. CRT-D accounted for only 8.3% of secondary prevention ICD implants.

Overall, the majority of patients had remote monitoring (89.3%), use of standard device programming (74.5%) and use of supraventricular tachycardia (SVT) discriminators (89.1%). Subcutaneous ICDs were implanted in 3.1% of patients. The overall complication rate in the first 6 weeks was 5.7%. Cardiac perforation occurred in 0.2% and pneumothorax in 0.3%. Hematoma occurred in 1.1%, with intervention required in 0.6%. Reoperation was required in 2.1%, including 1.9% for lead-related reoperation. The rate of infection was 1.8%, with 0.3% requiring device removal. Death from any cause at 6 weeks was recorded in three patients (0.3%), but these patients did not have any other device-related complications recorded.

3.2 | Primary prevention CRT defibrillators and CRT pacemakers

The subgroup of new primary prevention CRT-D patients (n = 155) was compared with new CRT-P patients (n = 175). The baseline characteristics are shown in Table 2. NYHA class and LVEF were recorded in all patients with CRT-P, but only available in those with a history of clinical heart failure (92.3%) in the CRT-D group. Most patients in both primary prevention CRT-D and CRT-P groups had symptomatic heart failure (NYHA ≥ II in 89.0% vs 89.2%, *P* = .492), LBBB (87.7% vs 89.1%, *P* = .319), and QRS duration >120 milliseconds (120-150 milliseconds in 19.4% vs 25.7%; >150 milliseconds in 76.8% vs 68.0%; *P* = .195). Patients who received a CRT-P were older (median age 74 years vs 66 years, *P* < .001) and more likely to be female (38.3% vs 19.4%, *P* < .001). Patients receiving a new primary prevention CRT-D had longer mean QRS duration (169 milliseconds vs 161 milliseconds, *P* = .005) and poorer LV systolic function (mean LVEF 24.2% vs 28.7%, *P* < .001).

The overall complication rate in the first 6 weeks was 9.1%. Pneumothorax occurred in 1.2% and coronary sinus dissection in

1.2%. Hematoma occurred in 0.6%, with intervention required in 0.3%. The rate of infection was 3.3%, with 0.3% requiring device removal. Reoperation was required in 2.4%, including 2.1% for lead-related reoperation. Death from any cause at 6 weeks was recorded in one patient (0.3%), but this patient did not have any other device-related complications recorded.

3.3 | ICD replacements

In the 427 ICD replacements, 72.6% were for elective replacement indicators and 9.6% were for system upgrades (Table 3). Five (1.2%) were for infection. Over a mean duration of 6.3 ± 2.7 years, 46.6% had received appropriate device therapy (38.4% had shocks or ATP with shocks) while 17.8% had inappropriate device therapy (including ATP and/or shocks) with a mean number of shocks of 3.7 ± 8.2.

3.4 | ICD and CRT national and regional implant rates in 2016

As there was participation from all implant sites in 2016, this provided an opportunity to examine implant rates at a national and regional level (Figures 1 and 2). The completeness of data within the ANZACS-QI DEVICE Registry in 2016 has been validated previously.²¹ In 2016, there were 560 ICD implants, including new and replacement procedures. This included 122 CRT-D implants. In comparison, there were 112 CRT-P implants. This translates to implant rates per million population of 119 for all ICD, 93 for ICD (excluding CRT-D) and 50 for all CRT (26 CRT-D and 24 CRT-P). Primary prevention ICD implants accounted for 52% of new implants.

There was significant variation in implant rates and implant practice across the four regions in NZ. The Midlands region had the highest ICD implant rate (163) while the Central region had the lowest ICD implant rate (74) but had the highest CRT-D to CRT-P implant ratio (2.7:1). In contrast, the Southern region had the highest rate of CRT-P implantation (52) and the highest CRT-P to CRT-D implant ratio (1.6:1). The Midlands region had the highest new primary prevention ICD implant ratio (62%) while the Southern region had the lowest (39%).

4 | DISCUSSION

This is the first study to describe individual level data on ICD and CRT patient characteristics and implant practice at a national level. Implant volumes and types of pacemakers and ICDs have been surveyed regularly across Australia and NZ previously.²² In patients who receive ICD and CRT-D, previous reports have examined the impact of geographic, ethnic, and socioeconomic impact on implant rates at a national level, while the long-term outcomes of patients have only been examined at a regional level.^{23,24}

Three-quarters of ICD implant procedures in contemporary NZ practice are new implants. Of these, half were for primary prevention indications. The majority of patients receiving a primary

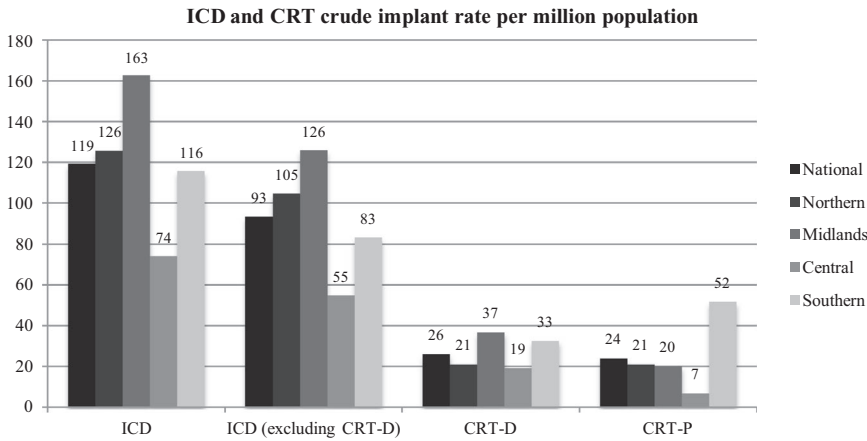


FIGURE 1 Regional variation in ICD and CRT implant rate per million population in 2016. ICD, implantable cardioverter defibrillator; CRT, cardiac resynchronisation therapy

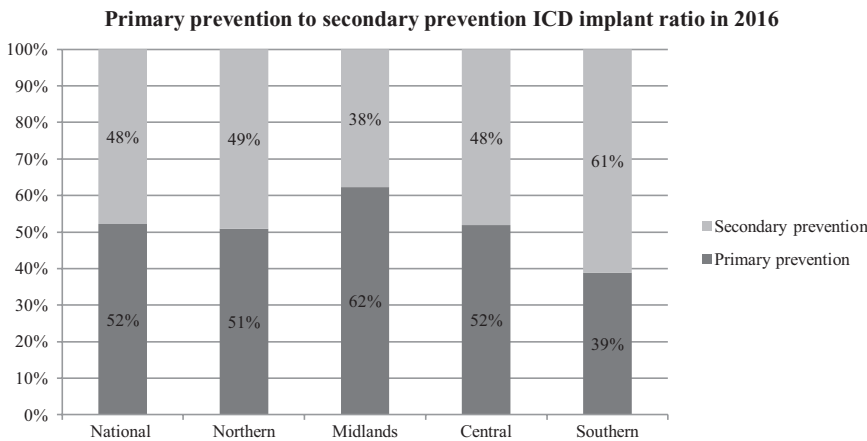


FIGURE 2 Regional variation in new primary prevention to secondary prevention ICD implant ratio in 2016. ICD, implantable cardioverter defibrillator

prevention ICD had a history of clinical heart failure with significant heart failure symptoms and poor LV systolic function. Most patients receiving secondary prevention ICD were for VT/VF cardiac arrest or sustained VT. CRT-D was the device type in a quarter of patients receiving an ICD for primary prevention indications but fewer than one-tenth of those for secondary prevention indications. Of the ICD replacement procedures, nearly three-quarters were for an elective replacement indication. Nearly half of the patients presenting for an ICD replacement had received at least one appropriate device therapy during the life of the device, and almost a fifth received inappropriate device therapy. There is also significant variation in implant rates and implant practice across the NZ regions, particularly with primary prevention ICD implant ratios and selection of CRT modality.

4.1 | New implants—primary vs secondary prevention

The ratio of new primary prevention ICD implants to secondary prevention ICD implants in our cohort was just under 50%. This is essentially unchanged from the last analysis of national ICD implant practice in NZ in 2010.²³ The primary prevention ICD implant ratio reported in several international registries over the past decade is as follows: 46% in Denmark, 55% in Germany, 57% in the United Kingdom, 59% in Sweden, 62% in Spain, 63% in France,

73% in Canada, 75% in the United States, and 82% in Italy.^{25–32} The proportion of ICDs implanted in NZ for primary prevention indications is thus on the lower end of the range of contemporary international implant practice. There is also variation in primary prevention ICD implant ratio of 39%–62% across NZ regions. This suggests that we are relatively conservative with our patient selection, which is likely because of the resource constraints, work force limitations and varying interpretation of the evidence and guidelines by implanting centers in NZ. In accordance with international guideline recommendations, most of the patients receiving a primary prevention ICD in our cohort had a history of clinical heart failure, significant heart failure symptoms and LVEF \leq 35%. The clinical characteristics of the patients in our cohort were similar to those described in international registries.^{27,30} The mean LVEF in the primary prevention group was 25.1%, which was similar to several major primary prevention ICD and CRT-D trials that had a mean LVEF of 21.4%–28.0%.^{2–7,15,16,18} Interestingly, ischemic etiology for heart failure accounted for only 42.5% of primary prevention ICD implants and 55.8% of secondary prevention ICD implants in our cohort. This is in contrast to other international studies that have reported ischemic etiology for heart failure at rates of 54.0%–93.0%.^{25,28–30} This trend may change in the coming years following the results of the DANISH study, which has shown no mortality benefit in primary prevention ICD implantation in nonischemic cardiomyopathy.³³

TABLE 1 New primary and secondary prevention ICD implant patient characteristics

	Primary (n = 565)	Secondary (n = 587)	P
Demographics			
Age, years			.386
Median (IQR)	62 (54-68)	62 (53-70)	
Gender, n (%)			.348
Male	460 (81.4)	465 (79.2)	
Female	105 (18.6)	122 (20.8)	
Ethnicity, n (%)			.337
European	360 (63.7)	392 (66.8)	
Māori	140 (24.8)	124 (21.1)	
Others	65 (11.5)	71 (12.1)	
BMI (kg/m ²)			.059
Mean ± SD	30.2 ± 6.5	29.6 ± 6.5	
Smoking, n (%)			.038
Never	248 (43.9)	257 (43.8)	
Ex-smoker	252 (44.6)	243 (41.4)	
Current smoker	65 (11.5)	87 (14.8)	
Medical history			
AF/ AFL			.317
Paroxysmal AF	56 (9.9)	89 (15.2)	
Persistent AF	31 (5.5)	21 (3.6)	
Permanent AF	74 (13.1)	71 (12.1)	
Atrial flutter	14 (2.5)	17 (2.9)	
Hypertension, n (%)	274 (48.5)	288 (49.1)	.847
Diabetes, n (%)	133 (23.5)	107 (18.2)	.027
Dyslipidaemia, n (%)	291 (51.5)	301 (51.3)	.939
Coronary artery disease, n (%)	279 (49.4)	336 (57.2)	.008
of which Prior MI , n (%)	191 (68.5)	254 (75.6)	.049
Valvular heart disease, n (%)	170 (30.1)	124 (21.1)	.001
Other cardiovascular conditions, n (%)			—
Hypertrophic cardiomyopathy	34 (6.0)	19 (3.2)	
Sarcoidosis	11 (1.9)	6 (1.0)	
Congenital heart disease	8 (1.4)	10 (1.7)	
Long QT	6 (1.1)	11 (1.9)	
Brugada	4 (0.7)	3 (0.5)	
ARVC	3 (0.5)	13 (2.2)	
Idiopathic VF	0 (0)	8 (1.4)	
CPVT	0 (0)	1 (0.2)	
Other comorbidities, n (%) ^a			—
Peripheral vascular disease	16 (2.8)	18 (3.1)	
TIA/stroke	37 (6.5)	41 (7.0)	
Chronic lung disease	48 (8.5)	48 (8.2)	
Chronic renal impairment	43 (7.6)	38 (6.5)	
Anxiety/depressive disorder	26 (4.6)	23 (3.9)	
Sleep apnoea	46 (8.1)	31 (5.3)	
Clinical heart failure, n (%)	454 (80.4)	233 (39.7)	<.001

(Continued)

TABLE 1 (Continued)

	Primary (n = 565)	Secondary (n = 587)	P
NYHA Class			<.001
I	80 (17.6)	84 (36.1)	
II	258 (56.8)	84 (36.1)	
III	92 (20.3)	26 (11.2)	
IV	4 (0.9)	2 (0.9)	
Unknown	20 (4.4)	37 (15.9)	
LVEF (%)			
Mean ± SD	25.1 ± 6.7	30.3 ± 9.3	<.001
≤35%	440 (96.9)	177 (76.0)	<.001
Aetiology of heart failure			
Ischaemic	193 (42.5)	130 (55.8)	
Non-ischaemic	261 (57.5)	103 (44.2)	
Estimated GFR (ml/min/1.73 m ²)			<.001
>60	406 (71.9)	480 (81.8)	
30-60	148 (26.2)	105 (17.9)	
<30	11 (1.9)	2 (0.3)	
ECG Features			
ECG at time of implant, n (%)			
Sinus Rhythm	429 (75.2)	474 (80.7)	
2nd degree AVB type 1	1 (0.2)	3 (0.5)	
2nd degree AVB type 2	1 (0.2)	2 (0.3)	
Complete heart block	12 (2.1)	3 (0.5)	
Atrial fibrillation/ flutter	110 (19.5)	92 (15.7)	
Ventricular paced	10 (1.8)	7 (1.2)	
Atrial paced	2 (0.4)	0 (0)	
Other	4 (0.7)	6 (1.0)	
QRS duration (msec)			<.001
Mean ± SD	129.9 ± 36.4	113.4 ± 31.5	
QRS duration (msec), n (%)			<.001
<120	265 (46.9)	383 (65.3)	
120-150	121 (21.4)	119 (20.3)	
>150	179 (31.7)	85 (14.5)	
Bundle Branch Block, n (%)			
LBBB	180 (31.9)	94 (16.0)	<.001
RBBB	43 (7.6)	40 (6.8)	.018
Fascicular Block	13 (2.3)	15 (2.6)	
Secondary prevention ICD Indication, n (%) ^a			
VT/VF Cardiac Arrest	N/A	371 (63.2)	—
Sustained VT		148 (25.2)	
Non sustained VT		56 (9.5)	
Syncope		54 (9.2)	
Presyncope		22 (3.7)	
Non VT/VF cardiac arrest		7 (1.2)	

(Continued)

TABLE 1 (Continued)

	Primary (n = 565)	Secondary (n = 587)	P
Implant details			
Device type, n (%)			<.001
Single	291 (51.5)	369 (62.9)	
Dual	101 (17.9)	151 (25.7)	
CRT	155 (27.4)	49 (8.3)	
Subcutaneous	18 (3.2)	18 (3.1)	
Remote monitoring, n (%)	495 (87.6)	534 (91.0)	.065
Device testing, n (%)	50 (8.8)	144 (24.5)	<.001
Number of programmed therapy zones, n (%)			.002
1	122 (21.6)	81 (13.8)	
2	257 (45.5)	277 (47.2)	
3	186 (32.9)	228 (38.8)	
NZ Standard Device Programming, n (%)	450 (79.6)	408 (69.5)	<.001
SVT discriminators used, n (%)	491 (86.9)	536 (91.3)	.016
Complications (up to 6 weeks), n (%)	43 (7.6)	23 (3.9)	—
Death from any cause	1 (0.2)	2 (0.3)	
Cardiac perforation	2 (0.4)	0	
Pneumothorax	3 (0.5)	0	
Haematoma	8 (1.4)	5 (0.9)	
Intervention	4 (0.7)	3 (0.5)	
No intervention	4 (0.7)	2 (0.3)	
Re-operation	13 (2.3)	11 (1.9)	
Lead-related re-operation	12 (2.1)	10 (1.7)	
Infection	16 (2.8)	5 (0.9)	
Antibiotics	13 (2.3)	5 (0.9)	
Device removal	3 (0.5)	0	

Abbreviations: AF, atrial fibrillation; AFL, atrial flutter; ARVC, arrhythmogenic right ventricular cardiomyopathy; BMI, body mass index; CPVT, catecholaminergic polymorphic ventricular tachycardia; GFR, glomerular filtration rate; LBBB, left bundle branch block; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NYHA, New York Heart Association; RBBB, right bundle branch block; SVT, supraventricular tachycardia; TIA, transient ischaemic attack; VF, ventricular fibrillation; VT, ventricular tachycardia.

^aMore than one option may be selected.

4.2 | CRT

Patients who received CRT-P were older and more likely to be female while patients receiving CRT-D had longer mean QRS duration and poorer LV function. There has been limited evidence directly comparing CRT-P to CRT-D, thus current international guidelines do not advocate one modality over the other. In NZ, while the decision to offer CRT-P or CRT-D varies across implant centers, it has been our general practice to limit primary prevention ICD implantation in patients >75 years old.¹⁰ Female gender has been associated with a “super-response” to CRT in previous studies, thus women are also more likely to be offered a CRT-P in NZ.^{34–39} This trend is consistent with several contemporary international registries and studies.^{40–43} Of note, those studies have shown very similar LV systolic function between the CRT-P and CRT-D cohorts, with CRT-P having a longer mean QRS duration. The longer mean QRS duration and poorer LV

systolic function in our CRT-D cohort compared to our CRT-P cohort suggests that we are selecting patients with a higher perceived risk for CRT-D.

4.3 | ICD replacements

Of those who came for an ICD replacement, over a mean duration of 6.3 years, 46.6% had received appropriate device therapy (including 38.4% appropriate shocks), while 17.8% had received inappropriate device therapy. Data from the seven major ICD trials in the late 1990s to early 2000s demonstrated the rate of appropriate ICD therapy was 17%–64% and inappropriate ICD therapy was 10%–24% over the 20 to 45 month follow-up period.^{2–7,13,44,45} Contemporary device programming to reduce inappropriate shocks, combined with broader indications for primary prevention ICD implantation, have lowered the rate of appropriate and inappropriate device therapy.⁴⁵ The rate

TABLE 2 New primary prevention CRT-D and CRT-P patient characteristics

	CRT-D (n = 155)	CRT-P (n = 175)	P
Demographics			
Age, years			<.001
Median (IQR)	66 (59-71)	74 (66-77)	
Gender, n (%)			<.001
Male	125 (80.6)	108 (61.7)	
Female	30 (19.4)	67 (38.3)	
Ethnicity, n (%)			.071
European	120 (77.4)	152 (86.9)	
Māori	25 (16.1)	15 (8.6)	
Others	10 (6.5)	8 (4.6)	
AF/AFL, n (%)			.699
Paroxysmal	21 (13.5)	31 (17.7)	
Persistent AF	9 (5.8)	12 (6.9)	
Permanent AF	21 (13.5)	23 (13.1)	
Atrial flutter	10 (6.5)	8 (4.6)	
NYHA, n (%) ^a			.492
I	15/136 (11.0)	19 (10.9)	
II	74/136 (54.4)	84 (48.0)	
III	45/136 (33.1)	71 (40.6)	
IV	2/136 (1.5)	1 (0.6)	
ECG findings			
QRS duration (msec)			.005
Mean ± SD	169.2 ± 27.9	160.8 ± 25.9	
QRS duration (msec), n (%)			.195
<120	6 (3.9)	11 (6.3)	
120-150	30 (19.4)	45 (25.7)	
>150	119 (76.8)	119 (68.0)	
Bundle Branch Block, n (%)			.319
LBBB	136 (87.7)	156 (89.1)	
RBBB	7 (4.5)	8 (4.6)	
IVBB	4 (2.6)	11 (6.3)	
LVEF ^a			
Mean ± SD	24.2 ± 7.0	28.7 ± 10.7	<.001
≤35%	138/143 (96.5)	144 (82.3)	<.001
Complications (up to 6 weeks), n (%)	17 (11.0)	13 (7.4)	–
Death from any cause	1 (0.6)	0	
Pneumothorax	2 (1.3)	2 (1.1)	
Haematoma	2 (1.3)	0	
Intervention	1 (0.6)	0	
No intervention	1 (0.6)	0	
Infection	9 (5.8)	2 (1.1)	
Antibiotics	8 (5.2)	^b	
Device removal	1 (0.6)	^b	
Re-operation	3 (1.9)	5 (2.9)	
Lead-related re-operation	3 (1.9)	4 (2.3)	
Coronary sinus dissection	0	4 (2.3)	

^aIn the CRT-D group, NYHA and LVEF was only recorded in those with a history of heart failure (n = 143, 92.3%).

^bData not available.

TABLE 3 ICD replacement cohort characteristics

Device replacement	n = 427
Duration of device (in years)	n = 406
Mean ± SD	6.27 ± 2.65
Reason for replacement, n (%)	
Elective replacement indicator	310 (72.6)
System upgrade	41 (9.6)
Infection	5 (1.2)
Device recall	2 (0.5)
System malfunction	10 (2.3)
Other	59 (13.8)
Appropriate therapy from device, n (%)	199 (46.6)
Shocks	71 (35.7)
ATP	35 (17.6)
ATP and shocks	93 (46.7)
Inappropriate therapy from device	76 (17.8)
Total number of shocks from device	
Mean ± SD	3.69 ± 8.23
Range	0-98

Abbreviations: ATP, anti-tachycardia pacing.

of appropriate and inappropriate device therapy in our cohort is comparable to contemporary data from United States, Canada, and Denmark.^{30,46,47}

4.4 | Implant rates and regional variation

Our national ICD implant rate of 119 per million in 2016 has increased over time with previous rates of 81 per million in 2010 and 95 per million in 2013.^{23,48} Our overall ICD implant rate in 2016 is second only to Australia in the Asia-Pacific region.^{22,49} However, our ICD implant rates (excluding CRT-D) are just below the mean of European Society of Cardiology (ESC) member countries.⁵⁰ The implant rates are comparable to the United Kingdom, but lag significantly behind countries with similar gross domestic product and healthcare spending such as Italy and Finland. Our overall CRT implant rate is again second only to Australia in the Asia-Pacific region, but lies only in the second quartile of implant rates of ESC member countries. The CRT-P implant rates are on par with the mean ESC implant rate, but our CRT-D implant rate is less than half that of the mean ESC implant rate.^{22,49,50}

There is significant regional variation in implant practice across NZ. This is likely to be influenced by physician preference and resource constraints at a local and regional level.

5 | LIMITATIONS

This study is a descriptive analysis of the data within the DEVICE Registry. As a number of implant sites joined and left the registry

during the period of analysis, the registry does not contain data of all patients in NZ receiving an ICD or CRT during this study period. Despite this, we believe this to be a representative cohort, as the age, gender, and ethnicity distribution is very similar compared to patients receiving an ICD who are identified from the National Hospitalisation Dataset, which collects all public hospital admissions in NZ using International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD10-AM) coding (Appendix S1). While there is no routine audit of data accuracy of the registry at present, our recent validation analysis of the registry data quality in 2016 (when all implant sites participated in the registry) demonstrated a good capture rate and excellent agreement of basic demographic and procedural data items with the national dataset. However, the implant volumes and rates for 2016 are likely to be slightly underestimated as only 94.6% of DEVICE-PPM forms and 87.7% of DEVICE ICD forms were completed in 2016.

At present, NYHA class and LVEF are only recorded in the cohort of ICD patients with a previous history of clinical heart failure, which is less than 40% in those receiving a secondary prevention ICD and only 60% of all new ICD implants. The ICD indications currently include syncope, presyncope and nonsustained ventricular tachycardia in both primary prevention and secondary prevention indications, therefore some patients may have been misclassified. The ANZACS-QI registry is currently being updated to address these limitations.

6 | CONCLUSION

In contemporary NZ practice three-quarters of ICD implants were new implants, of which half were for primary prevention indications. The majority of patients receiving primary prevention and secondary prevention ICD met current international guideline indications. Our relatively low ratio of primary to secondary prevention ICD implants internationally suggests a conservative patient selection for primary prevention ICD. Compared to new primary prevention CRT-D implants, patients who received a new CRT-P were older and more likely to be female. Of patients receiving a replacement ICD nearly half had received appropriate device therapy over the battery life of the device. There was significant regional variation in ICD and CRT implant rates, ratio of primary prevention ICD implants, and selection of CRT modality.

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ANZACS-QI Governance group: A. Kerr (chair), C. Nunn, D. Boddington, G. Sutcliffe, G. Devlin, H. White, J. Edmond, J. Tisch, S. Riddle, K. Marshall, M. Lund, M. Williams (deputy chair), N. Fisher, T. Scott. ANZACS-QI Project management: K. Sutherland (Project Manager), C. Flynn (Northern coordinator), M. Rhodes (Southern coordinator), A. Rattray (Research Assistant). Data analysis: M. Lee, R. Chan, Y. Jiang. Data management: M. Jenkins, J. Faatui. We acknowledge all the NZ cardiologists, physicians, nursing staff, and physiologists who have supported and contributed to ANZACS-QI. ANZACS-QI hospital cardiac physiologists: Ascot Angiography: M. Lindesay, J. Money, R. Singh, R. Chatburn, R. Kelly, J. Salmon, A. Visser. Intra Healthcare: J. Youbard. Auckland City Hospital (Bay of Islands, Kaitaia, Whangarei, Dargaville): S. Brett, S. Khan, R. Metrick, P. Harris, S. Sinclair, B. Jolly, A. Cheriyan, F. Riddell, H. Finnemore, G. Orsbourn, C. Williams, K. Turner, K. Maas, J. Donald, L. Kitipa, L. Cooper, M. Fowler. Middlemore Hospital: T. Brown, S. Takau, C. Chang, F. McLean, C. Smith. Waikato Hospital (Rotorua, Gisborne, Taranaki, Taumarunui, Te Kuiti, Tokoroa, Taupo, Thames): R. Allen, K. Timmins, K. Coley, P. Jones, N. Anthony-Pudumai, V. Day, V. Stuit, L. Simms, C. Whiteley, A. Wilson. Midland CVS: P. Jones. Tauranga Hospital (Whakatane): K. Hunter, S. Tait, P. Bishop, M. Cookley, T. Cumming, J. Goodson. Christchurch Hospital: O. Thacker. Dunedin Hospital: E. Guglietta, V. Milmine. Hawkes Bay Hospital: J. Cotton. Southland Hospital: L. Wilson. Nelson Hospital: T. Lawson. Palmerston North Hospital: J. White. North Shore Hospital: R. Breakwell, K. Searby, D. Slipper, M. Lipski, A. Sohil, K. Todd, C. Tilsley, K. Harris, A. Clayton, L. Moloney. Wellington Hospital: B. Scott, D. Wylie.

CONFLICT OF INTERESTS

The authors declare no conflict of interests for this article.

ORCID

Fang Shawn Foo  <https://orcid.org/0000-0002-3546-4863>

Khang-Li Looi  <https://orcid.org/0000-0001-6789-9055>

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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