

The Australian and New Zealand Cardiac Implantable Electronic Device Survey, Calendar Year 2021: 50-Year Anniversary



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Background

A cardiac implantable electronic device (CIED) survey was undertaken in Australia and New Zealand for calendar year 2021. The survey involved pacemakers (PMs) and implantable cardioverter-defibrillators (ICDs). The survey was conducted on the 50th anniversary of the first survey for both Australia and New Zealand in 1972; that initial survey being conducted by two of the current authors.

Results and Conclusions

For 2021, there were 19,410 PMs (17,971 in 2017) sold in Australia for new implants and 2,282 (1,811 in 2017) sold in New Zealand. The number of new PM implants per million population was 755 for Australia (745 in 2017) and 446 for New Zealand (384 in 2017). Unlike previous recent surveys, the percentage of PM replacements compared to total sales in both Australia and New Zealand rose. Pulse generator types implanted were predominantly dual chamber; Australia 77% (73% in 2017) and New Zealand 70% (68% in 2017). There were 1,509 biventricular PMs implanted in Australia (1,247 in 2017) and 172 in New Zealand (118 in 2017). Transvenous pacing leads were >90% active fixation in the atrium and ventricle. There was an increase in ICD usage with Australia 4,519 new implants (4,212 in 2017) and New Zealand 449 (396 in 2017). New ICD implants per million population were 187 for Australia (175 in 2017) and 88 for New Zealand (90 in 2017). For the first time the survey included implantable event monitors with 6,933 being implanted in Australia. However, for proprietary reasons, survey figures for subcutaneous implantable defibrillators, leadless pacemakers and conduction system pacing have not been included.

Both Australia and New Zealand have high PM and ICD implant numbers compared to the rest of the Asia Pacific region.

Keywords

Australia and New Zealand Survey 2021 • Implantable cardiac pacemakers • Implantable cardioverter-defibrillators

Introduction

Cardiac pacemakers (PMs) have been implanted in Australia and New Zealand since 1961. Implantable cardioverter-defibrillators (ICDs) were first used in Australia in 1984 and in New Zealand in 1988 with more recently, biventricular models for cardiac resynchronisation therapy. Each 3 or 4

years, an Australian and New Zealand cardiac implantable electronic device (CIED) survey has been undertaken and, to coordinate with previous surveys, the calendar year 2021 was selected. For the first time, implantable event monitors are included. This CIED survey was conducted on the 50th anniversary since the initial survey in 1972, with two of the authors (HGM, JGS) involved with both surveys.

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Methods

Survey Questionnaire

Previous comprehensive PM surveys have been conducted in Australia for calendar years 1972 [1,2], 1975 [3,4], 1978 [5], 1989, 1993 [6], 1997 [7], 2001 [8], 2005 [9], 2009 [10], 2013 [11] and 2017 [12]. New Zealand conducted surveys in 1972 [1,2], 1978 [5], 1981, 1993 [6], 1997 [7], 2001 [8], 2005 [9], 2009 [10], 2013 [11] and 2017 [12]. ICDs were included in the survey for the first time in 1993 [6] and biventricular models for cardiac resynchronisation therapy in 2001 [8]. Newer CIEDs, including leadless pacemakers and subcutaneous defibrillators are not separately listed as they are limited to few manufactures and, for proprietary reasons, the implant numbers are not available for publication. Leadless pacemakers, however, are included in the single chamber PM figures. Implantable loop recorders are reported for the first time.

With significant increases in the number of Australian implanting centres over the last 30 years, it became obvious that the collection of separate data from each implanting institution had become impossible. Consequently, it was decided that for the surveys after 1993, all CIED information would be obtained through pacing company records. Data from each Australian state was requested. Because small numbers of CIED implants are performed in the Australian Capital, the figures are grouped with New South Wales. For the first time sales figures for the Northern Territory are documented separately rather than combined with South Australia.

The companies were sent a questionnaire on CIEDs sold and registered in Australian States and New Zealand during calendar year 2021. In some hospitals, there is pacemaker and lead inventory remaining on the shelves from the previous calendar year. However, this figure would remain relatively constant for all surveys since 1992 making the stated units sold essentially the same as those implanted. Although the data for biventricular and ICD devices are stated as units sold, nevertheless, they reflect the implant numbers because company representatives are generally present at all implants and complete the registration requirements. No attempt was made to determine individual hospital implant numbers.

For Australia, the individual company data were received in plain sealed envelopes, transcribed to a working sheet and individual forms destroyed after the data were collated and transferred to a separate unmarked sheet. All pacing companies cooperated with the survey and are listed in the acknowledgements. The data collection and analysis was performed without influence from any of the companies involved and all companies provided all the information asked in the survey form. The information obtained from each company was destroyed after the data was collated. For the New Zealand survey, data was extracted from the ANZACS-QI registry which collects implant data from all public implanting centres, and all but one of the private implanting centres. Data was provided directly from the

remaining private centre. Assistance from pacing companies was also obtained.

For each survey, an accurate number of the CIEDs sold or implanted was obligatory. For PMs and ICDs, this was divided into new implants, replacements, and types. Information on PM leads and the number of implanting institutions in each country was required. Only bipolar leads are used in Australia and New Zealand. No attempt was made to obtain clinical and demographic information.

Results

During 2021, there were ~140 Australian and 14 New Zealand centres implanting PMs. The breakdown of pacing numbers in each Australian state and the corresponding 2017 results for both Australia and New Zealand are listed in [Table 1](#). As stated, sales data reflect implant numbers and companies with improved company registration procedures are now able to more accurately differentiate between new implants and replacements [9,10].

In comparison with the 2017 survey, there was a rise in the total PM sales in Australia from 21,433 to 25,190 (15% rise) and New Zealand from 2,196 to 2,867 (23%). For Australia and New Zealand, the increases in PM usage were for both new implants, Australia 17,971 to 19,410 (7%) and New Zealand 1,811 to 2,282 (21%), and replacements, Australia 3,462 to 5,780 (40%) and New Zealand 385 to 585 (34%). When compared to the total PM units sold, there was a rise in the percentage of PM replacements from 16% to 23% in Australia and 18% to 20% in New Zealand.

As with recent surveys, there was a modest increase in the number of new PM implants per million population, Australia from 745 to 755 (1%) and New Zealand from 384 to 446 (14%). The changes in the Australian and New Zealand markets since the first PM survey in 1972 are graphed in [Figure 1](#). Surveys were not conducted in Australia for 1981 and 1985 and in New Zealand for 1985 and 1989. For the 2021 survey, the individual states of Australia have been separately analysed and reported, but the numbers for New Zealand were too small to allow this. All Australian states had an increase in new PM sales, new implants, and replacements. Once again, New South Wales had the largest number of sales. Apart from Victoria and Tasmania, new implants per million population increased for all Australian states and with 1,018 new implants per million population, South Australia once again had the highest implant rate per population.

[Table 2](#) details the type of PM pulse generators sold in Australia and New Zealand in 2021. All pulse generators sold in Australia and New Zealand are programmable and rate adaptive (R). Single chamber models designated SSI(R) are implanted almost exclusively in the ventricle and rarely in the atrium. They represent 17% of sales in Australia (21% in 2017) and 24% (26% in 2017) of implants in New Zealand. The main pulse generator type sold or implanted were the dual chamber DDD(R) models with 77% (73% in 2017) for

Table 1 Pacemaker sales Australia and New Zealand 2021.

	Total sales	New	Replacement	Popn.	NIMP	Centres
AUSTRALIA						
New South Wales/ACT	7,666 {6,615	6,145 5,467	1,521 (20%) 1,148 (17%)	8.18 7.81	751 700	~45 48}
Victoria	6,593 {5,721	4,936 4,736	1,657 (25%) 985 (17%)	6.65 6.24	742 759	~37 41}
Queensland	5,125 {4,184	3,787 3,528	1,338 (26%) 656 (16%)	5.21 4.88	728 722	~29 24}
Western Australia	2,668 {2,289	2,261 1,997	407 (15%) 292 (13%)	2.68 2.57	844 777	10 12}
South Australia	2,497	1,801	696 (28%)	1.77	1018	9
Northern Territory	74	56	18	0.25	224	2
South Australia/Northern Territory	{2,127	1,829	298 (14%)	1.96	933	12}
2017						
Tasmania	567	424	143 (25%)	0.54	785	5
Total	25,190	19,410	5,780 (23%)	25.7	755	~140
Total 2017	{21,433	17,971	3,462 (16%)	24.13	745	141}
NEW ZEALAND						
Total 2021	2,867	2,282	585 (20%)	5.12	446	14
Total 2017	{2,196	1,811	385 (18%)	4.71	384	10}

Legend:

{ } = 2017 survey

() = Percentage of total sales

Abbreviations: ACT, Australian Capital Territory; Popn., estimated population/millions; NIMP, new implants per million population.

Australia and 70% (68% in 2017) for New Zealand. An important pulse generator type is the biventricular PM for cardiac resynchronisation therapy which has been surveyed since 2001. Compared to the 2017 survey, there was an increase from 1,247 to 1,509 (17%) implanted in Australia and 118 to 172 (31%) in New Zealand. This represents 6% (6% in

2017) of all the pulse generators sold in both Australia and New Zealand. The numbers sold in individual states were very similar for each type.

Previously, a major limitation of the pacing survey in Australia was the distribution of lead usage in the atrium or ventricle. Today, with improved implant registrations

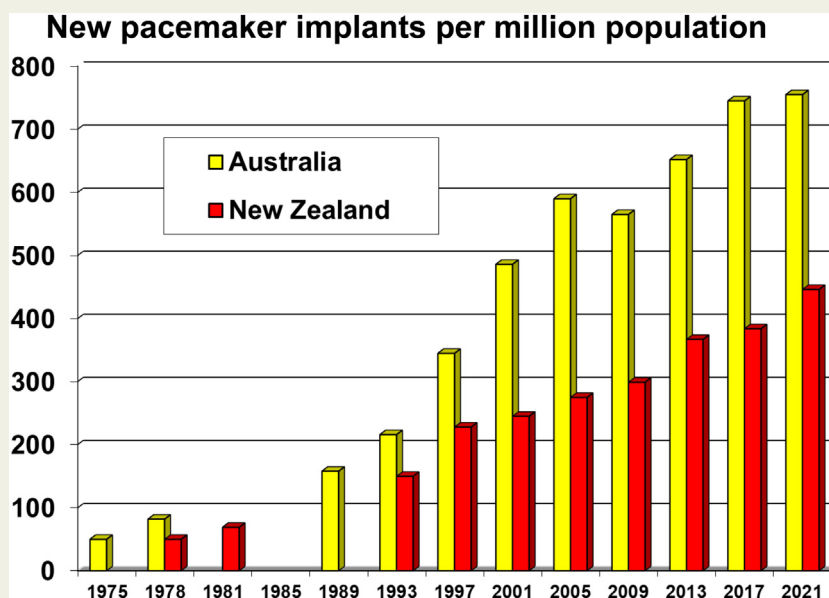


Figure 1 Number of new pacemaker (PM) implants per million population from all the Australian and New Zealand surveys since 1972.

Table 2 Pulse generator type (new and replacement), 2021.

	SSI(R)	DDD(R)	BiVP
AUSTRALIA			
New South Wales/ACT	1,338 (17%) {1,464 (22%)}	5,948 (78%) 4,819 (73%)	380 (5%) 332 (5%)
Victoria	1,054 (16%) {1,063 (19%)}	5,030 (76%) 4,229 (74%)	509 (8%) 429 (7%)
Queensland	793 (15%) {788 (19%)}	4,100 (80%) 3,183 (76%)	232 (5%) 213 (5%)
South Australia	484 (19%)	1,850 (74%)	163 (7%)
Northern Territory	11 (15%)	61 (82%)	2 (3%)
South Australia/Northern Territory 2017	{530 (25%)}	1,468 (75%)	129 (6%)
Western Australia	484 (18%) {521 (13%)}	2,043 (77%) 1,651 (72%)	141 (5%) 117 (5%)
Tasmania	80 (14%) {98 (20%)}	405 (72%) 372 (75%)	82 (14%) 27 (5%)
Total 2021	4,244 (17%)	19,437 (77%)	1,509 (6%)
Total 2017	{4,464 (21%)}	15,722 (73%)	1,247 (6%)
NEW ZEALAND			
Total 2021	688 (24%)	2,007 (70%)	172 (6%)
Total 2017	{518 (26%)}	1,351 (68%)	118 (6%)

Legend:

{ } = 2017 survey

() = Percentage of total sales

Abbreviations: ACT, Australian Capital Territory; SSI(R), atrial or ventricular pacing/sensing (rate adaptive); DDD(R), dual chamber pacing/sensing (rate adaptive); BiVent, biventricular pacemaker.

the figures are more accurate. As all leads sold are now bipolar, lead polarity was not surveyed. For accuracy, only percentages of passive and active fixation leads are presented in Table 3. The percentage of passive fixation leads

continues to fall for both the atrium and ventricle in Australia and New Zealand. For active fixation leads in Australia, there was a 91% (89% in 2017) atrial usage and 95% (91% in 2017) ventricular usage. The higher use of

Table 3 Lead type implanted 2021 {2017}.

	Atrial Fixation		Ventricular Fixation	
	Active	Passive	Active	Passive
AUSTRALIA				
New South Wales/ACT	83% {81%}	17% {19%}	90% {86%}	10% {14%}
Victoria	94% {96%}	6% {4%}	99% {97%}	1% {3%}
Queensland	94% {91%}	6% {9%}	99% {90%}	1% {10%}
*South Australia	93%	7%	92%	8%
*Northern Territory	100%	0%	100%	0%
Western Australia	93% {89%}	7% {11%}	97% {92%}	3% {8%}
Tasmania	98% {98%}	2% {2%}	100% {92%}	0% {8%}
Total 2021 {2017}	91% {89%}	9% {11%}	95% {91%}	5% {9%}
NEW ZEALAND				
Total 2021 {2017}	99% {91%}	1% {9%}	96% {93%}	4% {7%}

Atrial and ventricular active fixation 90%.

Legend:

{ } = 2017 survey

*2017 survey, South Australia and Northern Territory combined.

Abbreviation: ACT, Australian Capital Territory.

Table 4 ICD implants 2021 (2017).

	Total	New	Rep.	NIMP	ICD	ICD Type (%)		Centres
						DCCD	Bi V CD	
AUSTRALIA								
New South Wales/ACT	2,219	1,632	587	200	544 (25%)	668 (30%)	1,007 (45%)	35
	{2,067}	1,407	660	172	614 (30%)	723 (35%)	730 (35%)	39}
Victoria	1,487	1,085	402	193	337 (23%)	485 (33%)	665 (44%)	41
	{1,548}	1,030	518	165	409 (26%)	504 (33%)	635 (41%)	34}
Queensland	1,389	921	468	177	260 (19%)	508 (37%)	621 (44%)	26
	{1,291}	885	406	181	404 (31%)	512 (40%)	375 (29%)	23}
Western Australia	531	355	176	132	145 (27%)	147 (28%)	239 (45%)	9
	{521}	394	127	153	144 (28%)	170 (33%)	207 (39%)	11}
South Australia	548	360	188	203	157 (29%)	180 (32%)	211 (39%)	9
Northern Territory	49	41	8	164	16 (33%)	10 (20%)	23 (47%)	2
<i>South Australia/NT 2017</i>	{580}	407	173	208	221 (38%)	155 (27%)	204 (35%)	12}
Tasmania	198	125	73	231	25 (13%)	66 (33%)	107 (46%)	2
	{118}	89	29	171	26 (22%)	48 (41%)	44 (37%)	4}
Total 2021	6,421	4,519	1,902 (30%)	187	1,484 (23%)	2,064 (32%)	2,873 (45%)	124
<i>{Total 2017</i>	{6,125}	4,212	1,913 (31%)	175	1,818 (30%)	2,112 (34%)	2,195 (36%)	122}
*NEW ZEALAND								
Total 2021	662	450	212 (32%)	88	189 (42%)	107 (24%)	112 (25%)	6
Total 2017	576	396	180 (31%)	90	267 (56%)	101 (21%)	111 (23%)	7

Legend:

{ } = 2017 survey

() = Percentage of total sales

*New Zealand 40 (9%) subcutaneous ICDs.

Abbreviations: ACT, Australian Capital Territory; NT, Northern Territory; Rep., replacements; ICD, implantable cardioverter defibrillator; NIMP, new implants per million population; CD, cardioverter defibrillator; DCCD, dual chamber cardioverter defibrillator; Bi V CD, biventricular cardioverter defibrillator.

passive fixation leads in some states such as New South Wales, suggested a preference by some individuals or centres for this form of lead fixation. For New Zealand, active fixation leads were used 99% (91% in 2017) in the atrium and 96% (93% in 2017) in the ventricle. There was an attempt to survey coronary sinus leads for biventricular pacing, but owing to an error on the survey form, accurate figures could not be obtained.

There was only a modest increase in the use of ICDs in both Australia and New Zealand (Table 4). The units sold accurately reflect the implant numbers as company representatives are generally present at each implant and are responsible for the implanted hardware registration. For 2021, there were 4,519 new ICDs implanted in Australia (4,212 in 2017) and 449 ICDs in New Zealand (396 in 2017). The number per million population was 187 (175 in 2017) for Australia and 88 (90 in 2017) for New Zealand. Figure 2 illustrates the number of new ICD implants per million population in Australia and New Zealand since the first survey in 1993.

For both Australia and New Zealand, the number of ICD replacements remains high at about one third of all implants and therefore a significant proportion of the ICD hardware budget. For Australia, the usage of single chamber ICDs continues to fall at the expense of increased implant numbers

of biventricular ICDs. The number of centres implanting ICDs remains almost the same for Australia (124) and New Zealand (6).

The combined biventricular PM and ICD market for cardiac synchronisation therapy continues to grow with 4,382 implants in Australia (3,442 in 2017) and 284 implants in New Zealand (229 in 2017). For Australia, the biventricular ICD was preferred (66%), whereas for New Zealand it was the PM (61%). These preferences were also noted in the 2017 survey.

For the first time, the use of implantable event monitors was included in the survey (Table 5). In 2021, there were 6,933 monitors implanted, with New South Wales the largest implanting state with 2202. It was not possible to conduct a survey in New Zealand.

Discussion

With ongoing hospital budget constraints, surveys of medical procedures are becoming increasingly important to hospital administrators and government bureaucrats. When compared to previous surveys, the 2021 cardiac PM and ICD survey demonstrates once again an increase in the numbers of cardiac implanted electronic devices in Australia and New Zealand.

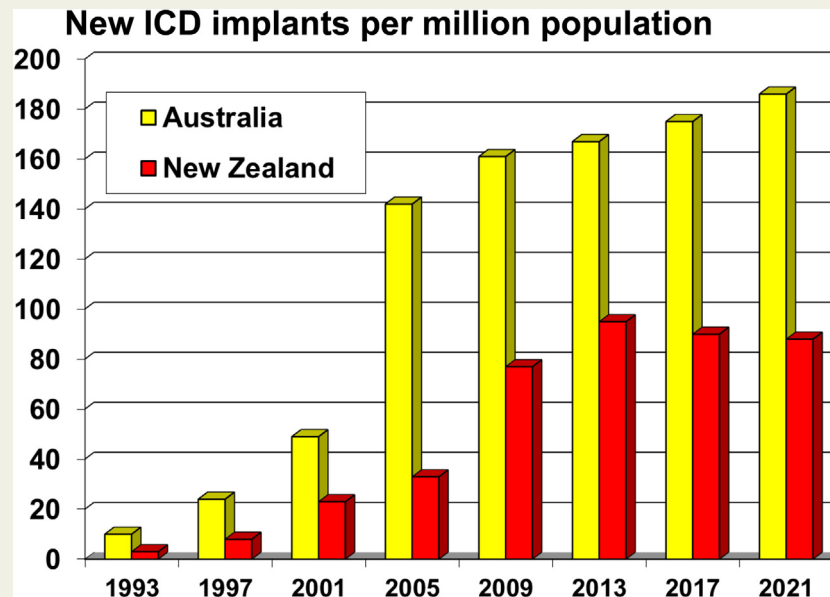


Figure 2 Number of new ICD implants per million population from all the Australian and New Zealand surveys since 1993. Abbreviation: ICD, implantable cardioverter-defibrillators.

Previous surveys have shown a decrease in the percentage number of PM replacements in both Australia and New Zealand as compared to new implants [11,12], and attributed to improved longevity of power sources [13] as well as a concerted effort at PM testing to optimise settings to extend power source life. In comparison, the 2021 survey has shown an increase in the percentage number of PM replacements in both Australia (23%) and New Zealand (20%) as compared to total implants. Although unexplained, this probably represents a plateauing of new PM implants together with a replacement “catch up” as long-term implants reach elective replacement time. In contrast, ICD replacements, which have a shorter service life remain at about one third of all implants in both Australia and New Zealand.

As shown in Table 4, the ICD market has now matured and implant numbers in Australia and New Zealand have plateaued. In both countries, the use of single chamber ICD has fallen, whereas biventricular models, particularly in Australia, have risen both in number of implants and

proportion of the ICD model mix; Australia 45% (36% in 2017) and New Zealand 25% (23% in 2017).

There is a marked difference between Australia and New Zealand in the use of biventricular CIEDs. Most of these devices in New Zealand are PM rather than ICDs. As most biventricular PM recipients would qualify for an ICD, it would have been expected that, as the market matured, the more expensive biventricular ICD would have been preferred. This has not occurred in New Zealand, maybe because of cost or patient/physician preferences.

There has been an increase in the proportion of active fixation leads in both the atrium and ventricle. These leads provide a more secure fixation, without a deterioration in stimulation thresholds or sensing. Ventricular leads have the added advantage of being able to reliably pace in non-apical positions [14].

There has been very little change in the number of centres implanting CIED devices in Australia (PM ~140, ICDs 127) and New Zealand (PM 14, ICDs 6). In previous surveys it was difficult to obtain accurate information on implanting centres for many reasons. Some hospitals implant only a handful of devices a year, whereas others may be private hospitals next to a public centre and patients from both hospitals are implanted in the same laboratory. In some cases, the hospital may be a regional centre which conducts follow-up clinics but does not implant. The centre numbers were obtained from the manufacturers and are now more reliable than previously, although there may still be minor errors in the larger Australian states.

How does Australian and New Zealand usage of CIEDs compare with other countries? Previously, a PM and ICD world survey was conducted by one of the authors (HM) for the same calendar year, but because of increasing difficulty receiving information, this was ceased in 2009 [15]. Europe, via the

Table 5 Implantable event monitors Australia 2021.

Australia	
New South Wales/ACT	2,202
Victoria	1,348
Queensland	1,319
Western Australia	834
South Australia	998
Northern Territory	40
Tasmania	192
Total 2021	6,933

Table 6 Comparative implant data 2020–2021 {2017}.

	New PMs		New ICDs	
	Implanted	NIMP	Implanted	NIMP
Australia	25,190 {21,433}	755 {745}	6,394 {6,125}	186 {175}
New Zealand	2,867 {2,196}	446 {384}	662 {576}	88 {90}
China	85,552 {62,508}	62 {45}	7,325 {2,986}	5 {2}
India	45,963 {39,754}	33 {31}	5,489 {3,114}	4 {2}
Japan	65,897 {40,318}	523 {318}	9,634 {4,208}	76 {33}
Singapore	958 {821}	168 {146}	486 {398}	86 {71}
South Korea	4,631 {5,697}	89 {110}	1,430 {1,458}	28 {28}
Taiwan	7,213 {6,455}	306 {274}	956 {780}	41 {33}

Legend:

{ } = 2017 survey

Abbreviations: PMs, pacemakers (new and replacements); ICDs, implantable cardioverter defibrillators (new and replacements); NIMP, new implants per million population.

European Heart Rhythm Association conducted annual surveys up to 2017 but ceased because of funding issues. The Asian Pacific region, however, conducts annual CIED surveys through the Asia Pacific Heart Rhythm Society with the most recent published data for 2020 [16]. Unlike previous survey reports, this limits comparative implant data to the Asia-Pacific region.

As with this survey, Table 6 compares CIED implant data for the Asia-Pacific region for the two periods 2017 and 2020/21. Six (6) countries were chosen because of implant numbers and socio-economic circumstances like Australia and New Zealand. Australia had the highest new implants per million population of both PM and ICDs, although China had the largest number of implants. Like Australia and New Zealand, implants in most Asian countries had plateaued over the last 4 years or as in South Korea have fallen. Exceptions were ICD implant numbers in China and Japan. In both these countries, this was probably related to the late availability of ICDs because of delayed regulatory approvals, compared with the rest of Asia.

Survey Limitations

In this CIED survey, the Australian data is critically dependent on all companies participating and providing accurate data. A single company rejection would completely invalidate the report. A company based CIED, although generally accurate in numbers, lacks important clinical, demographic and outcomes information. For New Zealand, the data is derived from a database that collects implant data from all but one centre, that should provide accurate implant data. CIEDs are very expensive implantable devices and data on usage and outcomes are very important in allocating future resources, particularly for the rapidly growing biventricular models. Comprehensive surveys and registries to address this are complicated, require public and private hospital cooperation

and are extremely expensive. Hence the failure of the European surveys. They best require a concerted state or federal government initiative, possibly linked to legislation allowing public hospital or private health benefit funding to be dependent on registry information. In the meantime, the responsibilities for use of this expensive therapy lie with the individual cardiology department and implanter.

A minor limitation, particularly with PMs, is that the Australian part of the survey depends on the hardware units sold rather than implanted. Today, probably all implanted devices are registered and therefore the units sold reflect the actual implant numbers.

For proprietary reasons, this survey failed to report on the use of subcutaneous defibrillators, leadless pacemakers and the recent introduction of His-bundle and left bundle branch pacing. Like implantable event monitors, it is hoped that, as more manufacturers enter this market, there will be less resistance to providing data on these new, important, emerging CIED options. Of some concern, is that the failure to survey subcutaneous defibrillators reduces the number of defibrillators actually implanted in Australia and New Zealand.

Conclusions

A CIED survey was undertaken in Australia and New Zealand for calendar year 2021. In comparison to a similar survey in 2017, there were increases in PM implants, but the ICD implant rate has plateaued. The proportion of PM replacements for both Australia and New Zealand have once again risen reflecting a maturing of the market as older implants are now replaced. There is a strong preference for bipolar active fixation leads in both the atria and ventricles.

Declaration

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- Abbott Medical, Macquarie Park, New South Wales.

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- Boston Scientific Australia and New Zealand, Auckland

- Medtel New Zealand, Auckland
- Medtronic New Zealand Limited, Auckland

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