

## ORIGINAL ARTICLE

## Regional differences in echocardiography provision in New Zealand—results from the 2013 SCANZ Workforce Survey

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### Abstract

**Aim** Healthcare may be unevenly distributed based on geographic location. This study aimed to identify whether regional differences in echocardiography provision exist and, if so, to explore key causes.

**Method** In March 2013, 18 public hospitals with a sonographer-led echocardiography service were surveyed, all of which provided data. Questions related to characteristics of the sonographer workforce, echocardiogram volumes and workflows. Information on District Health Board (DHB) population was obtained from public access websites. Multivariable linear regression was performed using the following variables: ethnicity, age, socioeconomic status, type of centre, sonographer full-time equivalent (FTE) and number/proportion of trainees to determine their potential contribution to echocardiogram volume.

**Results** 1748 echocardiograms were performed per 100,000 population (mean) with significant differences seen amongst DHBs but not between tertiary surgical and regional centres (surgical median 1802, regional median 1658,  $p=0.18$ ). Regional disparity in the population-based cardiac sonographer workforce size was observed and the number of scans performed per sonographer was higher in larger centres. In multivariable modelling, the DHB population-based scan volume was predicted by: socioeconomic status (top two quintiles of deprivation status increased scans by 75 per 100,000 population,  $p=0.02$ ) and age (age 20 to 65 years increased scans by 131 per 100,000 population,  $p=0.06$ ).

**Conclusion** Regional differences in echocardiography services in New Zealand exist as evidenced by marked regional disparity in both population-based echo volumes and cardiac sonographer workforce size.

Regional variation in healthcare provision occurs when differences in the access to or the availability of healthcare are dependent on geographic location and unrelated to need.<sup>1</sup>

Echocardiography is a common diagnostic imaging test that plays a crucial role in the provision of patient care for cardiovascular conditions,<sup>2</sup> yet studies in the United States of America (USA), the United Kingdom (UK) and Canada have demonstrated regional disparity in provision of this essential service.

Significant variation in the use of echocardiography has been demonstrated in the Veterans' Administration (VA) healthcare system<sup>3</sup> that was unrelated to population size or differences in healthcare or funding. In the UK significant differences across the four nations (England, Wales, Scotland, and Northern Ireland) has been observed.<sup>4,5</sup> And lastly, large variability in echocardiography provision throughout Canada has also been described.<sup>2</sup>

Similar regional differences in echocardiography services were described in New Zealand (NZ) in 2005 using a national audit over a 1-week period—Survey of Clinical echocardiography Around New Zealand (SCANZ).<sup>6</sup> That study assessed the entire public DHB echocardiography service at the time and reported “significant regional disparity exists in terms of the rate of utilisation of echocardiography across district health boards (DHBs) on a population basis”.<sup>6</sup> The utilisation of echocardiography for risk assessment in Acute Coronary syndrome (ACS) patients has also been investigated within NZ (in 2002 and 2007) and regional disparity was demonstrated comparing centres with or without interventional facilities.<sup>7,8</sup>

One suggested cause of the regional differences in echocardiography services is the size of the cardiac sonographer workforce. In the UK a strong correlation has been observed between the numbers of echocardiograms performed within each nation per capita and the number of sonographers per country,<sup>4</sup> suggesting that the availability of sonographers may be a causal factor in the volume of echocardiograms performed.

In Canada, it was reported that the shortage of sonographers represented a resource barrier and that “the dearth of sonographers is generally expected to be one of the main limitations to the access of echocardiographic services”.<sup>2</sup> In NZ the size of the cardiac sonographer workforce was investigated for the first time in 2010<sup>9</sup> and reported a “scarcity of personnel” as a possible factor in the regional differences seen in the 2005 SCANZ audit.<sup>6</sup> However the relationship between sonographer resource and echo utilisation has not been reported.

Therefore, the aim of this study was to determine whether the regional disparity in public echocardiography services in New Zealand previously described<sup>6</sup> still exists and to identify DHB population predictors of the echocardiogram volumes. Additionally the relationship between the cardiac sonographer workforce size, demographics of the regional population and echocardiography utilisation will be investigated since this relationship has not been previously described in New Zealand.

## Method

### Data sources

In March 2013 surveys were distributed by e-mail to the team leaders of echocardiography at 18 public hospitals. Participants were identified through networks and included all providers of echocardiography using a sonographer-led service. Two hospitals previously surveyed in 2010 were excluded from distribution as they no longer employed sonographers and provided a physician-only echo service. Survey questions related to the cardiac sonographer workforce characteristics, reported echocardiogram volumes and scan duration and were answered by a single respondent.

### Data analysis

Surveys were returned over the period March to July 2013. Return rate was 100%; by e-mail or post from 15 hospitals, 3 hospitals by telephone interview using a single interviewer. Survey responses for the cardiac sonography workforce were entered as both the total number of sonographers and the full time equivalent (FTE) of the echocardiography provision component of the role (based on a 40-hour working week). Annual (2012) echocardiography volumes (actual number of echocardiograms performed per centre) and workflow for each procedure type were entered separated by centre; centres were identified as either surgical (tertiary providers of cardiac surgery) or regional. Entered data were coded and checked for accuracy. Information on DHB population was obtained from the Statistics New Zealand and Ministry of Health public access websites.<sup>10,11</sup>

The median number of scans performed were compared using the Wilcoxon rank sum test. Multivariable linear regression was performed to estimate the associations between DHB population-based scan volume and available population descriptors, which were: age group (represented as percentage aged <20 years compared to ≥20 years and percentage aged +20–65 years compared to <20 or >65 years), percentage of Māori/Pacific ethnicity (compared to non-Māori/Pacific), and percentage in quintile 4 and 5 (most deprived) of the deprivation index compared to quintiles 1–3 (least/less deprived). The number of variables that can be included in the model is limited by the small sample size (16 DHBs) and these age groups were selected as being relevant to the major indications for echocardiography.

Two multivariable linear regression models were developed to investigate how factors associated with the cardiac sonographer workforce influenced the number of echocardiograms performed per sonographer FTE. Model 1 represented the workforce as the proportion of trainee FTEs, whereas Model 2 represented the workforce as total FTEs, irrespective of whether qualified or trainee. Both models included centre type and median scan time. The co-efficient predicted the increase or decrease in the total number of echocardiograms performed for each variable. R statistical software (v3.0.0) was used for all analyses.<sup>12</sup>

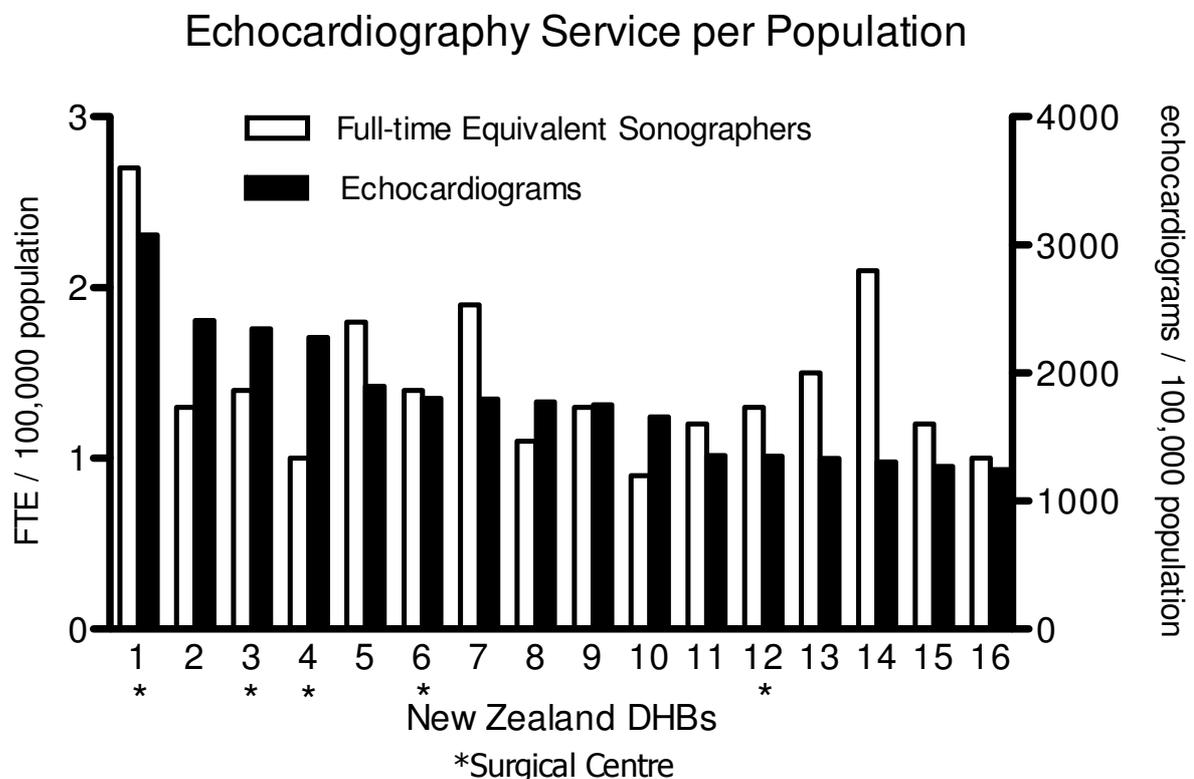
## Results

### Population-based District Health Board (DHB) echocardiogram volumes

A total of 78,900 echocardiograms were performed in public hospitals in 2012; 36,414 echocardiograms (46.2%) were provided by the five hospitals that perform cardiothoracic surgery. An average of 1790 echocardiograms per 100,000 population per annum were performed, with no significant differences seen between tertiary surgical and regional centres (surgical median 1802, range 1352–3077; regional median 1658, range 1246–2409,  $p=0.18$ ).

The average sonographer FTE per 100,000 population is 1.4 with wide differences within centre types and within individual DHBs (surgical median 1.4, range 1.0–2.7; regional median 1.3, range 0.9–2.1).

**Figure 1. Regional echocardiogram service provision by full-time equivalent (FTE) sonographers and echocardiogram scan numbers per 100,000 DHB population**



### DHB population characteristics

A multivariable linear regression model was developed to investigate how factors that describe the DHB population influence the number of echocardiograms performed annually per 100,000 head of population (independent variable).

Every percent increase in the number of people aged 20–65 years in the DHB results in, on average, 131 more echocardiograms performed per 100,000 population per annum. In contrast, 79 fewer echoes are performed per 100,000 people for every 1% increase in those aged <20 years.

Low socioeconomic status (Q4 and Q5) was associated with an increase in the number of echoes performed, which was statistically significant ( $p=0.02$ ).

The proportion of people of Māori and Pacific ethnicity within a DHB population was a negative predictor of echocardiogram volume (35 fewer echocardiograms for each 1% increase in Māori/Pacific population), although this effect was not statistically significant. There was no significant interaction between ethnicity and the different age bands suggesting that the relationship between age and the number of echocardiograms performed is not different for people of Māori/Pacific ethnicity.

**Table 1. Population characteristics by DHB**

District Health Board (DHB)	Total population, N	Age, years (%)			Ethnicity Māori/Pacific (%)	Deprivation status Quintile 4 and 5 (%)
		<20	20–65	>65		
Northland	159795	31	55	16	34.3	56
Waitemata	562970	29	60	11	17.1	26
Auckland*	469400	26	54	20	18.8	39
Counties Manukau	516050	34	57	9	39.4	52
Waikato	373220	30	57	13	24.5	46
Lakes	103170	32	56	12	37.4	51
Bay of Plenty	214910	29	55	16	26.3	45
Tairāwhiti	46753	34	54	12	50.7	65
Taranaki	110258	29	56	15	18.6	41
Hawke's Bay	156490	30	56	14	28.9	47
Mid central	170200	29	57	14	21.7	46
Hutt	145215	30	59	11	26.1	42
Capital and Coast	299720	27	62	11	18.5	28
Nelson Marlborough	141933	26	59	15	10.9	32
Canterbury	509860	27	60	13	10.7	29
Southern*	309028	27	59	14	10.6	32

\* Denotes DHBs who have more than one hospital centre within the catchment.

**Table 2. Model of DHB demographics versus the number of echocardiograms performed per 100,000 population per annum**

Intercept		Coefficient	Standard error	P-value
		<b>-5828</b>	<b>6761</b>	<b>0.41</b>
Age	<20 years	-79	134	0.57
Age	20–65 years	131	62	0.06
Ethnicity	Māori /Pacific	-35	40	0.39
Deprivation status	Quintile 4 and 5	75	29	0.02

Data were entered into the model as binary variables; adjusted  $R^2 = 40.5\%$

### Workforce size and demographics

There were 84 cardiac sonographers in NZ, 14 (17%) of which were trainee sonographers; the total workforce FTE is 70.4, with 13.5 of the FTE being trainees and 37% of the total workforce were employed in surgical centres.

The FTE provided nationally to the echocardiographer role is 61.9. The vacant FTE of 3.2 is 4.5% of the total workforce size. Eighteen (25.7%) of 70 qualified cardiac sonographers and three (21.4%) of 14 trainee cardiac sonographers perform cardiac technical duties in addition to performing

echocardiography. Seventy seven % of cardiac sonographers in surgical centres have more than 5 years of experience with 42% having more than 15 years of experience (21% in regional centres).

The average number of echocardiograms performed per cardiac sonographer FTE was 1323 per annum. Sonographers in surgical centres performed on average more scans per FTE than regional centres (1465 versus 1258) but there was wide disparity within DHBs and centre types (surgical median 1319, range 1039–2193; regional median 1218, range 631–1938).

**Table 3. Model 1 – trainee versus qualified workforce**

	Coefficient	Standard error	P-value
<b>Intercept</b>	1885	636	0.01
% of workforce trainees	-9.0	636	0.37
Surgical centre	712	9.6	0.04
Median scan time (minutes)	-11	15	0.48

Adjusted R<sup>2</sup> = 25.5%.

Model 1 demonstrates that, even after adjusting for centre type and median scan time, an increased percentage of trainees in the workforce will negatively impact on the numbers of echocardiograms per FTE.

**Table 4. Model 2 –Total workforce size by FTE**

	Coefficient	Standard error	P-value
<b>Intercept</b>	<b>2131</b>	<b>677</b>	<b>0.008</b>
Total FTE	50	77	0.52
Surgical Centre	561	413	0.20
Median scan time (minutes)	-22	17	0.20

Adjusted R<sup>2</sup> = 42.8%.

Model 2 demonstrates that increasing centre size (measured by total workforce FTE) will positively impact on the number of echocardiograms per FTE.

Both models showed that, independent of other factors, surgical centres performed more echocardiograms per FTE than regional centres and that increasing scan length reduced the number of echocardiograms performed per cardiac sonographer FTE.

## Discussion

General—This study demonstrates that there is marked regional disparity in echocardiogram volumes throughout New Zealand DHBs and although this study and prior studies<sup>6</sup> reported echocardiogram volumes differently the same disparity first identified in 2005 still exists.

This study builds on the earlier work by demonstrating that both the population-based echocardiogram volumes and the cardiac sonographer workforce size (measured by sonographer FTE) are widely different between DHBs and within centre types.

Multivariable regression analysis showed that deprivation, ethnicity, sonographer FTE and centre type affect echocardiogram volumes and that these volumes are not directly related to increasing age in the DHB population, since the age group which had the most influence on increasing volume was the 20 to 65 years age group.

Not surprisingly DHBs with an increased population of those aged less than 20 years were associated with fewer echocardiograms and may reflect the complexity of the caseload. This effect was not

statistically significant however and should not be over interpreted due to the relatively low number of paediatric echocardiograms performed nationally.

Although not statistically significant, the decrease in volume of echocardiograms for DHBs with higher populations of Māori and Pacific suggests the potential for a need versus access imbalance described by the inverse care law<sup>13</sup> since Māori and Pacific are known to have higher prevalence of cardiac disease,<sup>14</sup> much higher prevalence of cardiac risk factors<sup>14</sup> and are therefore more likely to require an echo. Additionally all four of the DHBs with the highest proportion of Māori and Pacific population (greater than 30% of total population) showed median (at one centre) or lower than median (at three centres) population based cardiac sonographer FTE. This suggests that one possibility for the reduced volume for centres with increased Māori/Pacific population is the unequal distribution of cardiac sonographer FTE.

Furthermore, it is interesting that low socioeconomic status was a predictor of increased scan volumes. Since proportionally higher deprivation is known to exist in Māori and Pacific populations,<sup>15</sup> it may be expected that both ethnicity and socioeconomic status would show a reduction in volumes, or perhaps the interaction of the two. This difference is likely multifactorial but may relate to the inclusion of ethnicity in the reported DHB deprivation population characteristics. This warrants further investigation.

There are likely other factors which may impact on differences in the echocardiogram volumes seen that are not included in this study. This level of data is complicated by several factors: surgical centres take patient referrals from outside their geographic catchment area; there are different rural/urban mixes across the DHBs; some DHBs offer outreach services through mobile clinics and travelling clinics.

A further consideration is differing wait list volumes since the number of echocardiograms performed may not equate to demand—*anecdotal evidence suggests wait list volumes vary widely throughout the country and this may account for some of regional volume differences seen. Finally, disease prevalence within the DHB populations may account for some of the regional differences seen.*

Both the wait list and the number of echocardiograms performed could relate to the cardiac sonographer workforce size, as has been suggested in a previous UK study.<sup>4</sup> Although there is regional disparity in cardiac sonographer workforce size (measured by sonographer FTE) and regional variability in the annual number of echocardiograms performed, there does not seem to be a relationship between the two. Possible reasons for this were explored by multivariable analysis, which predicted that both the proportion of trainee to qualified FTE in a DHB and overall workforce size may account for some of the DHB differences seen, but not other factors.

The results show that increasing the proportion of trainees in a workforce will reduce the volume of echoes performed. This is not surprising as training of sonographers is time intensive and requires one on one direct supervision.<sup>16</sup> In NZ, cardiac sonographers are usually trained in an employed (rather than supernumerary) capacity and it is known that this model of training impacts on productivity.<sup>17</sup> More regional than surgical centres have trainees in the workforce (64% versus 36%) and this may reflect the ability for larger centres to recruit qualified and experienced staff from other centres or overseas.

Both workforce models consistently show that the type of centre impacts on the echo volume produced. Surgical centres perform more scans per sonographer FTE, independent of all other factors. This increased echo volume capacity of surgical centres may relate to the experience of the sonographers working in surgical centres.

The overall size of the cardiac workforce at a DHB may also affect the echocardiogram volume; increased efficiencies at large centres and infrastructure differences such as clerical support for bookings or patient transport services may be helpful.

Scan time is also demonstrated as an important predictor of volume of echoes per DHB with each minute increase in median scan time reducing the volume of echoes able to be performed.

From these data, it appears that the sonographer workforce in New Zealand is small, and is likely to be contributing the low overall number of echocardiograms performed. In New Zealand, the population average per year is 1.6 cardiac sonographer FTE per 100,000 population compared to 3.1 in Australia.<sup>18</sup> What these data also show is that there remains important disparity both in terms of population based FTE and number of echocardiograms at the different DHBs in New Zealand.

**Limitations**—This study forms a complete national sample of echocardiography services provided by publically funded DHBs but is not representative of all echocardiography provision nationally since private providers were excluded. Furthermore only public hospitals with echocardiograms performed by cardiac sonographers were included—two public hospitals were excluded from survey distribution for this reason. However, this is unlikely to have major impact since most comprehensive diagnostic echocardiography in New Zealand is performed by sonographers. The study also excludes point-of-care and limited scope echocardiography performed by other physicians.

The multivariable analysis in this study is limited by the small sample size with only 18 participating public hospitals—although a complete national sample was collected. The sample was further reduced to 16 for DHB analysis (as two DHBs were represented by two hospitals each) and the small sample size limited the number of variables which could be included in the models. Since the variables included were predictive in other studies it is unlikely that important predictors were excluded from the analysis but this study does not investigate all possible variables. Furthermore the use of composite measures for ethnicity and deprivation in the reported DHB population characteristics may result in compounding as these variables were not modelled independently. For DHBs with more than one hospital the combined workforce and volumes may not accurately reflect the complexity and differences of each hospital within the DHB.

Although this survey was performed over a 3-month period it reflects an accurate point in time representation of the cardiac sonographer workforce and echocardiography service within each DHB. The DHB age and quintile demographic information used was from the 2006 census but was the most recent available. However information on DHB total population was from the most recent (2013/2014) estimates to enable a closer time match with survey information.

**Conclusion**—This study demonstrates that regional disparity in public echocardiography in New Zealand exists today – potentially disadvantaging populations with the greatest need. This is demonstrated by the unequal geographic distribution of echo services. The reasons for this are multifactorial, but are likely contributed to by DHB demographic differences in age, ethnicity, and socioeconomic deprivation status as well as the size and demographics of the cardiac sonographer workforce.

Although there is acknowledgement and commitment to minimise and potentially close inequality gaps in all areas of cardiac healthcare<sup>13</sup> and the regional disparity in echocardiography volume has been noted previously,<sup>6</sup> there have been no previous studies relating cardiac sonographers' workforce distribution to regional echo service provision.

**Competing interests:** Nil.

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