The cardiac sonographer workforce impacts upon the inequity of provision of echocardiography within New Zealand

Belinda Lewis (nee Buckley)

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Unitec Institute of Technology 2015
Abstract

**Aim:**

To identify population based regional provision of echocardiography provision within New Zealand (NZ) public hospitals. The relationship between the cardiac sonographer workforce size, demographics and capacity will be explored to better understand the regional provisions.

**Methods:**

In March 2013 surveys were distributed to 18 public hospitals with a sonographer led echocardiography service, return rate was 100%. Questions related to sonographer workforce size and demographics, workflow processes and echo volumes. Information on District Health Board (DHB) population was obtained from government public access websites. Multivariable linear regression was performed using DHB population characteristics and workforce demographics to determine their potential contribution to echocardiogram volume. Workforce capacity was calculated from scan duration, annual scan volumes, workforce size and availability and compared to predictions using international models.

**Results:**

There are 84 cardiac sonographers in NZ, 14 of them trainees. The total full-time equivalent (FTE) of cardiac sonographers is 70.4; echo FTE was 61.9 with 75% of the workforce performing echo as the only component of their role. Thirty-one (44.3%) qualified sonographers and 10 trainees (71.4%) are titled cardiac sonographer or echocardiographer. Sixty-eight (81%) cardiac sonographers have a cardiac physiology background. Thirty-five (50%) qualified cardiac sonographers hold Australasian echo qualifications.
Significant regional differences in echocardiogram volumes per 100,000 population were seen amongst DHBs but not between surgical and regional centres (surgical median 1802, regional median 1658, p=0.18). There were also wide regional differences in the workforce size (FTE) per 100,000 of population served unrelated to centre type (median 1.4, range 0.9-2.7). In multivariable modelling, the population-based scan volumes were predicted by DHB demographics (socioeconomic status, Māori/Pacific ethnicity and age) and workforce demographics (workforce size, centre type, trainee proportion).

There were regional differences in both population-based clinical capacity and scan duration, with no clear relationship to centre type. The NZ workforce capacity is similar to predictions using a UK model, and consistently less than the USA model for all scan types.

**Conclusion:**

This study demonstrates regional differences in the provision of echocardiography services in NZ by population-based echo volumes. The echo volumes are impacted by both DHB demographics and the cardiac sonographer workforce size, demographics and clinical capacity. This study also provides an update on the cardiac sonographer workforce which will be essential for planning the future growth.
Prepublications

*Journal publications*


*Abstracts*

Buckley B, Farnworth MJ, White S, Whalley G. The cardiac sonographer workforce in NZ - Results from the 2013 SCANZ workforce survey. Heart Lung Circ 2014; 23 (1)


Buckley B, Farnworth MJ, Whalley G. Echocardiography service provision in New Zealand: Capacity modelling the cardiac sonographer workforce. Accepted for oral presentation At Cardiac Society of Australia NZ (CSANZ) NZ scientific meeting 2015

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<th>Description</th>
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<tbody>
<tr>
<td>ACS</td>
<td>Acute coronary syndrome</td>
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<tr>
<td>APC</td>
<td>Annual practicing certificate</td>
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<td>ASA</td>
<td>Australian Sonographers Association</td>
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<tr>
<td>ASUM</td>
<td>Australasian Society of Ultrasound in Medicine</td>
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<tr>
<td>BCS</td>
<td>British Cardiac Society</td>
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<tr>
<td>BSE</td>
<td>British Society of Echocardiography</td>
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<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
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<tr>
<td>CPRB</td>
<td>Clinical Physiologist Registration Board</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular disease</td>
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<tr>
<td>DHB</td>
<td>District Health Board</td>
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<tr>
<td>DMU</td>
<td>Diploma in Medical Ultrasound</td>
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<tr>
<td>DSE</td>
<td>Dobutamine stress echocardiography</td>
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<tr>
<td>ESE</td>
<td>Exercise stress echocardiography</td>
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<tr>
<td>FTE</td>
<td>Full time equivalent</td>
</tr>
<tr>
<td>HPCA</td>
<td>Health Practitioners Competency Assurance</td>
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<tr>
<td>IP</td>
<td>Inpatient</td>
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<td>MRTB</td>
<td>Medical Radiation Technology Board</td>
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<td>NZ</td>
<td>New Zealand</td>
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<td>OP</td>
<td>Outpatient</td>
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<tr>
<td>QUT-GDip</td>
<td>Queensland University of Technology Graduate Diploma in Cardiac Ultrasound</td>
</tr>
<tr>
<td>TOE</td>
<td>Transoesophageal echocardiography</td>
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<tr>
<td>TTE</td>
<td>Transthoracic echocardiography</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<td>USA</td>
<td>United States of America</td>
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<td>VA</td>
<td>Veterans Administration</td>
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Background

The NZ public healthcare setting

Health services in NZ are predominantly provided within a publicly funded healthcare system led by the Minister of Health. Allocation of funding to district health boards (DHBs) allows them to provide and co-ordinate the inpatient, outpatient and primary care services for individuals who live within their regional boundaries. There are 20 DHBs in NZ and DHB population and geographical size varies greatly (Figure 1). For example Auckland has three large DHBs within a single city compared to the lower South Island with a single DHB encompassing two major cities and covering a very large geographical area. Regardless of the size of the DHB, the share of the funding each receives depends on the regional population size and demographics (age, gender, ethnicity and deprivation) as well as historical use of health services.¹

Figure 1 NZ District Health Board regional boundaries¹
Each DHB has many healthcare providers – mostly in primary care, and at least one public hospital with inpatient beds. Not all DHBs provide all healthcare services, with more specialised services provided at either only a single hospital within the DHB or at another DHB. Hospitals within DHBs are often described as community/rural, secondary/regional or tertiary depending on the type of services they provide. Community or rural hospitals provide general care with or without inpatient beds whereas secondary or regional hospitals provide 24hrs/day specialist inpatient services. Tertiary hospitals provide all of the secondary services as well as a range of sub-specialities. Regardless of where the healthcare service is provided, the cost of the healthcare is met by the DHB in which the patient resides. In addition to the public healthcare system, there are private service providers who are funded by private health insurance. These providers vary in availability and specialty throughout the country.

In NZ most healthcare is provided within the public system and most healthcare practitioners are regulated either under formal legislation (licensure) or by voluntary self-regulation by professional bodies. The Health Practitioners Competency Assurance (HPCA) Act was established in 2003 by the Minister of Health with the purpose of public protection by licensure of health professions which have demonstrated risk of harm. In order to practice in a licensed profession, practitioners register in a defined scope of practice with their professional regulatory authority. Practitioners are also required to hold an annual practising certificate (APC) which requires demonstration of on-going learning. Examples of licensed health professions are medical, nursing and some allied health professions such as physiotherapy, medical radiation therapy, occupational therapy, laboratory science and social work.

Health professions which do not meet the inclusion criteria in the HPCA act may manage the professional standards of their practitioners by self-regulation. Self-regulated professions often also require practitioners to register and hold an APC, but the professional bodies do not have the ability to censure members. Examples of professions which are self-regulated include many allied health professions.
including clinical physiology (including cardiac sonography), acupuncture, speech language therapy and audiology.

**Cardiovascular disease (CVD) in New Zealand**

Cardiovascular disease (CVD), the diseases of the heart and blood vessels, continues to be the leading cause of death in NZ,\(^5\) and carries a high cost burden to the healthcare sector.\(^6\) It is estimated that more than 280,000 New Zealanders have been diagnosed with CVD\(^7\); 176,000 of these with coronary artery disease (CAD).\(^8\) Coronary artery disease (narrowing or blockage of the coronary arteries) reduces blood flow to the heart muscle and is the leading cause of heart failure.\(^6\) Although improving treatments have significantly reduced the overall risk of death from CAD over the last few decades,\(^5\) the incidence, hospitalisation rate and healthcare cost of heart failure has increased.\(^9\) Both CAD and heart failure have increased prevalence with age, and since the predicted proportion of population aged 65 and over in NZ is expected to double by 2050,\(^10\) future predictions are for an rapid population growth in CAD and heart failure with an increase in the aging population.\(^9,11,12\)

Although the mortality rates for CAD and CVD have declined overall, the rates of decline differ relating to ethnicity and socio-economic status.\(^6,13,14\) Cardiovascular disease mortality for Māori is two and half times that of non-Māori,\(^15\) whilst age at hospitalisation and mortality of heart failure is also markedly different for Māori and non-Māori.\(^6,15\) Additionally, high levels of deprivation have also been strongly associated with increased CAD mortality.\(^13,14\) These differences may be explained by both an increase in the number and severity of risk factors such as diabetes mellitus and obesity for Māori as well as higher levels of deprivation.\(^6,11,14\) In the future, the burgeoning epidemics of obesity and diabetes are expected to be widespread and the overall population incidence of CVD will rise after decades of decline leading to strain on CVD healthcare resources.\(^12\)
Echocardiography

Echocardiography (cardiac ultrasound) is an imaging technique involving the use of high frequency ultrasound to produce an image of cardiac structures and to measure blood flow. Echocardiography is an important tool in the provision of patient care for a wide range of cardiovascular conditions and there are 3 main types of echocardiography procedures:

**Transthoracic echocardiography** (TTE) is the most commonly performed cardiac ultrasound procedure. During a TTE examination the transducer is placed at various locations on the chest wall. The ultrasound penetrates the chest wall to the heart and reflections return to the transducer producing an image.

**Stress echocardiography** involves imaging the heart during or after a period of cardiac work. Stress echocardiography is a valuable technique used in the diagnosis of CAD; during exercise blocked coronary arteries are not able to meet the increased blood-flow demand required, this results in changes in cardiac function. Exercise stress echocardiography (ESE) uses TTE imaging techniques to image the heart before and immediately after a period of vigorous exercise (usually on a treadmill). Pharmacological stress echocardiography uses medication to simulate the effect of exercise on the heart. During the test the medication is increased at regular intervals to increase cardiac workload and TTE imaging is performed throughout. The most common pharmacological stress is a dobutamine stress echocardiogram (DSE).

**A transoesophageal echocardiogram** (TOE) is performed by imaging the heart from inside the oesophagus and stomach. This imaging technique provides superior imaging since the transducer is close to cardiac structures, and is primarily used when detailed imaging is required for diagnosis.

In NZ echocardiography was established nearly 40 years ago, and since then has become widely available throughout both public and private healthcare providers. In 2005 the provision of echocardiography in NZ was investigated by a national audit of all providers of echocardiograms (SCANZ). This study performed a collection of all echocardiogram referrals over a one week period and demonstrated echocardiograms being provided in 23 public hospitals and 14 private providers. In
2010 a follow-up survey of NZ public echocardiogram services found that all 20 DHBs provided TTE echocardiography services, 13 hospitals performed stress echo (ESE and DSE) and 15 hospitals performed TOE.4

Throughout the world echocardiography utilisation is increasing due to its reliability, safety and relatively low cost.17,18 Echocardiography demand is also increasing as a result of an aging population and burgeoning risk factors increasing the prevalence of CVD. Increasing demand has also been seen in public echocardiography services in NZ, with a 17% increase in echo volumes between 2008 and 2012, reported in a 2012 national survey of echo waiting and reporting times.19 Although the annual NZ population-based echocardiography utilisation has not been reported, it is likely that NZ echocardiography utilisation is low when compared to other countries. There were between 42,800 and 47,700 echocardiograms performed per million population in the UK in 2005,20 whereas in Australia there were 45,800 echo procedures billed through Medicare per million population in the 2013/2014 year.21 In the USA 20% of Medicare Fee for Service beneficiaries over 65 receive an echocardiogram annually.22

The cardiac sonographer workforce

Throughout much of Europe and Asia, echocardiograms are performed by a physician. However in NZ, like Australia, the United States of America (USA), the United Kingdom (UK) and Canada, echocardiography is performed by specially trained non-physician healthcare professionals. Although there are some differences in role and title, these professionals are generally referred to as cardiac sonographers.4 Cardiac sonographers undergo a high level of training since the ultrasound examination is highly operator dependent, with the outcome reliant on the clinical knowledge, skill and critical decision making of the sonographer.4

The cardiac sonographer workforce in NZ was investigated for the first time in 2010, as part of a national audit of public echocardiography services (SCANZ)4 and as a follow up to a 2005 audit (SCANZ).16 As well as auditing all echocardiography
referrals over a single week, the 2010 audit also included a detailed questionnaire of the cardiac workforce and equipment. Prior to this survey little was known of the sonographer workforce since the cardiac sonography scope of practice in NZ is shared by two different professional organisations and this has made benchmarking of the workforce difficult. Additionally, since NZ cardiac sonographers do not have compulsory legislative registration compared to other types of sonography there is no single national workforce database. Non-cardiac sonographers in NZ are regulated under the HPCA Act and registered with the Medical Radiation Technology Board (MRTB), whereas cardiac sonographers share strong links with the cardiac physiology profession and are more likely to voluntarily register with the Clinical Physiologist Registration Board (CPRB) in the self-regulatory environment. The 2010 survey found that although 70% of the cardiac sonography workforce were registered (36% with the CPRB, 23% with the MRTB) more than half of those registered with the MRTB did not meet registration requirements by holding the required APC.

The SCANZ2 survey also found that the NZ cardiac sonographer workforce size was small with a total of 84 sonographers nationally, 24% of these were trainees. Interestingly, only 40% of those identified as qualified held Australasian echo qualifications, whilst a further 14% held an international echo qualification. As there are no NZ based cardiac ultrasound qualifications the most common qualifications were the Diploma in Medical Ultrasound (DMU) and the Graduate Diploma in Cardiac Ultrasound (QUT-GDip). The DMU qualification is the most longstanding professional sonography qualification in New Zealand and Australia and is facilitated through the Australasian Society in Ultrasound in Medicine (ASUM). The QUT-GDip is facilitated through the Queensland University of Technology, and NZ candidates are able to enrol as Australian domestic citizens. The DMU and QUT-GDip are both graduate level entry, require the candidate to be in a training position with a suitable supervisor and require minimum scan numbers to demonstrate practical competency. The two qualifications differ in how they are delivered to students, with the DMU being predominantly self-directed distance learning and the QUT-GDip requiring attendance at course modules. Both the DMU and QUT-GDip are the only qualifications which have been recognised for registration with both the
CPRB and MRTB for cardiac sonographers.⁴ Although the low numbers of cardiac sonographers with formal echo qualifications was surprising, the 2010 workforce data were limited in that qualification status was unknown for nearly 20% of the workforce, making the true numbers of those qualified unclear.

The SCANZ2 survey also found that although the NZ workforce was small, the cardiac sonographer workforce size in full-time equivalent (FTE) per million population was considerably higher than in the UK.⁴ However limitations in both the NZ and UK data made the results uncertain and international comparisons difficult. In the NZ study there were large differences between the total workforce size by the number versus FTE of cardiac sonographers and it was unclear whether the differences were due to a large proportion of part-time workers, or whether some the reported FTE as unrelated to the sonography role. The UK study did not state whether vacancies were included, and since the vacancy rate was high this may have affected the FTE reported.

Regional disparity

It has long been recognised that regional variation in healthcare provision exists. Studies in the USA in the 1980s demonstrated that “geography is destiny” meaning that the healthcare received depends largely on the availability of healthcare resources where the user lives.⁵ This is also commonly described as post code lottery.⁶ If the geographic disparity is unrelated to the healthcare needs of the population then a need versus access imbalance occurs which has the potential to disadvantage some population groups.

In the UK the regional differences in the provision of cardiovascular care at a national level were described in a pair of reports by the British Cardiac Society (BCS) in 2004 and 2005.⁷,⁸ The BCS investigated the provision of cardiac services in the four nations of England, Scotland, Northern Ireland and Wales by collecting data on selected cardiac activities including the number of cardiologists, cardiac surgeons and their related procedural volumes per region and country. Both reports compared the age standardised death rates from coronary heart disease per 100,000
population for men and women for each country in the UK, with mortality used as a measure of need. The highest mortality rates were seen in Scotland and Wales with the lowest rate in England. The 2004 study demonstrated that although Scotland and Wales had the greatest coronary artery disease burden, the level of service provision of cardiac investigation and treatment (measured as number of cardiologists, coronary angiograms and non-surgical revascularisation) was lowest in these countries – demonstrating a need versus access imbalance which was described as “national lottery”. These national disparities still existed in a follow up study in 2007, with the additional identification of further national differences relating to cardiac rehabilitation and complex cardiac therapies.

Regional differences in the provision of cardiovascular care as well as need versus access imbalances have also been described in NZ. In 2002, and repeated in 2007, an audit was performed over two weeks in all NZ hospitals admitting patients with a suspected or definite acute coronary syndrome (ACS). These studies reported the differences in management and treatment of patients admitted to hospital with or without intervention facilities and demonstrated that centres without interventional facilities showed increased delay and reduced level of access to angiogram and revascularisation for patients, as well as higher DHB population of Māori. Since Māori have higher mortality rates from CAD, this demonstrated reduced access to coronary artery facilities for a population who have a higher need. In 2012 an audit similar to those in 2002 and 2007 was performed over a two-week period in 435 public and private hospitals in NZ and Australia. This study was called the SNAPSHOT-ACS and aimed to investigate the management and treatment of ACS relating to best practice guidelines. This study also demonstrated regional differences in provision of care, with patients receiving different intervention and therapy rates and practices relating to the size or specialty of the hospital they were admitted to.

Disparity of regional provision of echocardiography that is unrelated to population distribution or need has also been described both internationally and within NZ. In the USA a large retrospective study investigated echocardiography utilisation in the
Veterans Administration (VA) healthcare system and reviewed population-based echo utilisation of each VA centre over two time periods.\textsuperscript{34} This study found that there was a significant variation in echo use regionally despite no significant differences in population demographics, distribution of funding or healthcare policy between centres. In Canada, a report by the Canadian Cardiovascular Society described the variability of access to echocardiography most particularly looking at wait times, and it also described large variability in echocardiography provision across the country.\textsuperscript{35} In the UK, the 2005 study by the BCS reported on the provision of echocardiography, obtained by a postal survey performed by the British Society of Echocardiography.\textsuperscript{27} This study showed significant national differences in the provision of echocardiography demonstrated by the low numbers of echocardiography performed per million population in Scotland and Wales. In addition there was also demonstration of need versus access inequality with much lower stress echocardiography utilisation in Scotland than other nations despite Scotland having the greatest coronary artery disease burden.

Regional differences in echocardiography utilisation have also been described in NZ. For example, the utilisation of echocardiography for management of ACS patients was investigated within NZ in 2002 and 2007,\textsuperscript{30,31} since the assessment of LV function by echocardiography is important for the prognosis and risk assessment of ACS patients. The utilisation of echocardiograms for risk assessment was seen to be lower in non-interventional centres than those centres with interventional facilities; this demonstrated regional disparity in echocardiogram use.\textsuperscript{30} In 2005, the SCANZ survey investigated the wider provision of echocardiography in NZ in much greater depth and found that the population-based echo utilisation varied significantly across DHBs.\textsuperscript{16} This was seen within the same centre type suggesting that caseload was not a factor in the differences seen. In 2013 a national survey of NZ DHB echocardiogram utilisation and waiting lists found large regional differences for both wait times and utilisation.\textsuperscript{19}

A variety of potential causes in the regional disparities have been described from both the international and local studies. The British Cardiac Society attributed the
differences across the four nations as being related to differing healthcare policy and funding affecting national distribution of resources. However, in the VA system in the USA the regional differences described were found to be unlikely to relate to funding differences as there was no financial incentive for echocardiogram utilisation. Suggestions of possible causes for the NZ regional echocardiogram differences identified in 2005 included physical access to resources (rural versus urban), compliance with recommended health guidelines and the study design with the numbers of private patients per DHB being unable to be identified.

One commonality amongst studies was the relationship between sonographers and echo utilisation. In the UK, the 2005 BSC survey found that the national differences in echocardiography provision related to both the number and expertise of staff. This study analysed the number of cardiac sonographers per million population for each nation and found a strong correlation between the number of echoes performed per nation annually and the size of the sonographer workforce (in FTE) per country. 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”. Although the 2005 SCANZ survey suggested a lack of workforce to be a possible cause in the NZ regional differences, the relationship between echo utilisation and the cardiac sonographer workforce has not been investigated within NZ.

An understanding of the capacity of the cardiac sonographer workforce is essential to understanding how it might impact on the regional inequalities described. The capacity of any workforce is a measure of its ability to deliver a service whilst maintaining adequate staffing levels and meeting variable demands. Capacity planning in healthcare is essential to enable forecasting of adequate staffing and training levels to ensure that high quality healthcare is able to be provided. Capacity planning the future cardiac sonographer workforce requires knowledge of the current workforce to ensure that the workforce is able to meet any increasing demands for echocardiogram services. This knowledge needs to include both the size of the workforce and its service delivery, measured from the number of
echocardiograms performed by the workforce. Important factors which should be considered in service delivery include differences in the population served (population size and demographics including age, ethnicity, socioeconomic status and differences in disease burden) as well as differences in how the service is delivered to the population (echo scan duration, hospital size and services, outreach or centralised).
Aim

The aim of this study is to determine whether the regional disparity in public echocardiography services in NZ first described in 2005 still exists and to identify DHB population predictors of echocardiogram volumes. Of particular interest is the relationship between the sonographer workforce size, regional population demographics and echocardiogram utilisation as this relationship has been described internationally but is unexplored within NZ.

In addition a contemporary and more comprehensive oversight of the NZ cardiac sonography workforce will allow benchmarking to similar workforces internationally. This study will also model the capacity of the workforce at a DHB and national level, compare them to international models and provide information which will enable future planning and development.

My overarching research question is: Does the cardiac sonographer workforce impact upon the provision of echocardiography within New Zealand? My hypothesis is that the number of examinations performed per sonographer shows regional variation, and that the population-based echo utilisation for each DHB is linked to the cardiac sonographer workforce size.
Method

This is a workforce survey that combines questionnaires on workforce and annual reported statistics from individual hospitals. I also used publicly available population-based data about DHB areas and their populations served. Ethical considerations regarding confidentiality and voluntary consent were taken into consideration during the design and distribution of this survey, although formal advice from the Ministry of Health national ethics committee was that as a workforce questionnaire, ethics approval was not necessary.

Data Sources

In March 2013 surveys were distributed by e-mail to the team leaders of echocardiography services at 18 public hospitals. Participants were identified through networks and included all providers of echocardiography who employed cardiac sonographers. Two hospitals that were previously surveyed in 20104 (Wanganui and Wairarapa) were excluded from distribution as they no longer employ sonographers and provided a physician-only echo service. The survey questions were answered by a single respondent at each hospital.

Survey questions included information on:

- **Cardiac sonographer workforce demographics** — size (in head count and FTE), training (qualified or trainee), qualifications (type), professional background (physiology, radiographer, etc), clinical/non-clinical responsibilities and proportion of FTE spent on each, vacancies (current and length unfilled), education/study leave provision.

- **Hospital centre demographics** — the 2012 echocardiogram volumes for all echo procedure types were provided and included echo services provided to other hospitals as out-reach, on-call services, reporting physician workforce size (in head count and FTE), reporting practices (sonographer or cardiologist release of results), percent of scans annually not performed by a sonographer (e.g. by physicians and registrars)
• **Workflow processes** – standard durations for each scan type (e.g. TTE, TOE, DSE, etc) for both inpatients (IP) and outpatients (OP), annual proportion of scans for each scan type that are longer or shorter than the standard duration (and reason for this difference), scan duration difference from standard duration for each scan type that are longer or shorter than the usual duration. Scan duration included the time to perform, interpret and formally report the scan.
Table 1: District Health Board survey hospitals

<table>
<thead>
<tr>
<th>District Health Board</th>
<th>Surgical hospital</th>
<th>Primary regional hospital</th>
<th>Outreach service hospitals</th>
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<td>Whangarei</td>
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<td>Southern</td>
<td>Dunedin</td>
<td>Invercargill</td>
<td>na</td>
</tr>
</tbody>
</table>

*Specialist centre, providing national surgical services for congenital heart  disease only. Not classified surgical for the survey.

*Service provided by Christchurch

$Service provided by Christchurch
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. Although two methods of data collection were used, interviewer response bias was minimised by the design of the survey, which used closed questions and required factual answers. The survey responses were entered into a database separated by centre, coded and checked for accuracy.

Information on the sonographer workforce was entered into separate spreadsheets for qualified and trainee staff. Workforce size was entered as both the number of sonographers and FTE (based on a 40 hour working week). FTE was further separated into the portion of the working week spent on different clinical and non-clinical roles.

Information about scan duration and workflow for each echo procedure type (adult transthoracic, paediatric, dobutamine stress, exercise stress and transoesophageal) was separated by centre. Centres were identified as either surgical (tertiary providers of adult cardiac surgery) or regional. Information on outreach centres serviced by a major hospital were included in the major hospital data.

Annual (2012) echocardiogram volumes for each procedure type were entered into an additional spreadsheet separated by centre.

Publicly available data

Information on DHB population size (for the 2013/2014 year) was obtained from the Ministry of Health public access website. The most recently available DHB demographic information (age, ethnicity, deprivation) from the 2006 census was obtained from the Statistics New Zealand public access website and was combined with the DHB population size in a separate spreadsheet. It should be noted that the 2012 census data were delayed due to the Christchurch earthquakes.
**Statistical analyses:**

1. **Population-based DHB and workforce analysis**

For DHBs where more than one hospital centre performed echocardiogram services within the DHB the data were combined to reduce 18 centres to 16 DHBs. Echocardiogram volumes for each DHB were adjusted per 100,000 DHB population.

For each DHB, the echo service portion of the cardiac sonographer workforce FTE was adjusted per 100,000 DHB population.

2. **Multivariate analysis**
   
   2.1 **DHB population modelling**

A multivariable linear regression model was developed to estimate the associations between available population descriptors and DHB scan volume per 100,000 head of population (independent variable).

The number of variables that can be included in the model was limited by the small sample size (16 DHBs) and these variables were selected as being relevant to the major indications for echocardiography:

- age group (represented as the percentage aged<20 years compared to ≥20 years and the percentage aged+20-65 years compared to <20 or >65 years)
- percentage of population served that are Māori/Pacific ethnicity (compared to non-Māori/Pacific)
- percentage in quintile 4 and 5 (most deprived) of the deprivation index compared to quintiles 1-3 (least/less deprived). The deprivation status for the population of each DHB was derived from the 2006 census using the NZDep2006 atlas of deprivation.39

The co-efficients were used in a model to predict the increase or decrease in the total number of echocardiograms performed for each variable.

The median numbers of scans performed were compared using the Wilcoxon rank sum test. R statistical software v3.0.0 was used for all analyses.40
2.2 Sonographer workforce modelling

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 (independent variable).

- Model 1 represented the workforce as the percentage of trainee FTEs
- Model 2 represented the workforce as total FTEs, irrespective of whether qualified or trainee

Both models included centre type (surgical or regional) and median scan time as additional variables.

The co-efficients were used in a model to predict 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.40

3. Capacity analysis

3.1 Scan duration

The scan duration for each echo procedure category (TTE, TTE inpatient, TTE training, TTE portable, DSE, ESE, TOE and TTE paediatric) was tabulated at each centre and grouped into centre type (surgical or regional) to allow for comparison. Duration for TTE inpatient, TTE training and TTE portable durations were calculated from the length of time (in minutes) that the scan was longer or shorter than the TTE duration at each centre. For both surgical and regional groups the mean and median scan durations were calculated.

The UK model scan durations are from a published paper by the Cardiac Workforce Committee of the British Cardiac Society.41 These scan times were validated by comparing to a 2008 survey of clinical practice which found comparable daily scan numbers.42
The USA model scan durations used are based on international accreditation standards\textsuperscript{43} which are recommended as best practice in the USA.\textsuperscript{44}

3.2 Actual capacity

Actual capacity is the clinical time of echo procedures performed by cardiac sonographers, calculated in scan hours per 2012 year by centre and DHB. Scan hours for all echo procedure types are based on scan duration and sonographer performed scan volumes.

For each centre:

- DSE, ESE and TOE scan volumes were converted to scan hours by multiplying the procedure volume by the scan duration (in hours)
- TTE scan volumes were converted into sonographer scan hours by:
  - Calculating the proportion of the scans not performed by a sonographer and adjusting the total TTE volumes.
  - Proportioning the TTE scan volumes to 50% IP and 50% OP volumes
  - Calculating the proportion of scans which are longer and shorter than the standard TTE time for both IP and OP scan volumes.

\textit{Example:}

765 IP scans, 15\% are 15 minutes longer than the standard TTE duration (of 45 minutes). 30\% are 15 minutes shorter than standard TTE duration

Calculation: 15\% of 765=115 scans at 60 minutes, 30\% of 765=230 scans at 30 minutes, 765-115-230=420 scans at 45 minutes

- Scan duration for each TTE procedure is the sum total of all scan durations for both IP and OP
- Actual capacity for each procedure is the scan duration for each procedure (hours) multiplied by the total volume of scans for the procedure type
3.3 International predicted capacity models

National actual capacity for each procedure type and as a total for all procedures combined was compared to predicted capacity (hours) calculated from 2012 procedure scan volumes using scan durations from the USA\textsuperscript{43} and UK\textsuperscript{41} models.

The UK model was split into two different IP and OP weightings: the 30:70 model and the 50:50 model. The 30:70 model proportioned 30\% IP and 70\% OP volumes and was developed to allow comparison to NZ DHBs with lower volumes of IP (most like smaller regional centres). The 50:50 model proportioned 50\% IP and OP volumes and was developed to allow comparison to NZ DHBs with even proportions of IP and OP (most like large regional or tertiary centres).

- All DHB volumes were combined for national totals for each procedure type
- NZ (national) procedure volumes for each procedure were multiplied by the scan duration for each international model to calculate the predicted actual capacity.
  - \textit{Example:} NZ actual capacity TTE: 48000 hours, NZ volume of TTE:65000 scans
  - UK 30:70 model: 19500 IP scans, 45500 OP scans. OP duration 35 minutes. IP duration 53 minutes. 
    Predicted capacity= 19500x53 minutes + 45500x35 minutes (in hours)
  - UK 50:50 model: 32500 IP scans, 32500 OP scans. OP duration 35 minutes. IP duration 53 minutes. 
    Predicted capacity= 32500x53 minutes + 32500x35 minutes (in hours)
  - USA model=65000 scans x 60 minutes (in hours)

3.4 Population based actual capacity

DHB population-based actual capacity was calculated for each DHB by adjusting the DHB actual capacity per 100,000 population of the DHB.

The USA model and 30:70 UK predicted capacity for each DHB was also adjusted per 100,000 population of the DHB.
3.5 Potential capacity

Potential capacity is the potential clinical time available for echo procedures performed by cardiac sonographers and is calculated in scan hours per 2012 year by centre and DHB. The potential scan hours are based on available clinical hours per working week and workforce size and adjusted from a UK workforce planning model.\(^{41}\)

For each centre:

- Calculations were made of the number of available working days per FTE in 2012 based on total working days\(^ {45}\) minus statutory holidays, annual leave provision (4 weeks) and assumption for half of contractual sick leave provision (5 days).
- Calculations were made of the clinical sessions/year/FTE available at 2 sessions/day and 3.75hr/session.
- Calculations were made converting clinical sessions to clinical hours/year/FTE.
- Clinical hours/year/FTE were adjusted with a 10% reduction based on a UK workforce modelling paper\(^ {41}\) which adjusted for one non-clinical session/week.
- Calculations of total available clinical hours/year were made from the clinical hours/year/FTE multiplied by the total FTE.
- The additional leave provisions for each centre were calculated for both trainee and qualified sonographers: study leave (trainees), education leave and any other centre specific additional leave. Available clinical hours/year were adjusted for the additional leave.
- Potential clinical capacity was calculated by reducing the total available clinical hours by 20% for workflow inefficiencies described in the UK workforce planning model.\(^ {41}\)

3.6 Actual versus potential capacity

To compare the actual versus potential clinical capacity of each DHB, the time difference (in clinical hours) between the actual and potential capacity was calculated and expressed as a percentage excess. A positive excess demonstrated
calculations of actual capacity to exceed potential capacity whilst a negative excess demonstrated potential capacity to exceed calculations of actual capacity.
Results

1. Sonographer workforce demographics
   1.1. Workforce size

There are 84 cardiac sonographers in NZ, of which 14 (16.7%) are trainee sonographers. The total workforce FTE is 70.4, 13.5 of the FTE being trainees. The FTE provided nationally to the echocardiography role alone is 61.9. The vacant FTE of 3.2 is 4.5% of the total workforce size

Figure 2 Cardiac workforce size by number and FTE

Cardiac Sonographer Workforce Size

Black bars represent qualified cardiac sonographers, white bars represent trainees
Abbreviation: FTE = full time equivalent
1.2. Sonographer role and responsibilities

Eighteen (25.7%) of 70 qualified cardiac sonographers and 3 (21.4%) of 14 trainee cardiac sonographers perform other clinical duties in addition to performing echocardiography. Other clinical duties are cardiac technical roles (e.g. pacing, holter monitoring, exercise treadmill testing), with one sonographer also performing vascular sonography. Eight (11.4%) qualified cardiac sonographers also perform non-clinical roles involving management and training duties.

Thirty-two sonographers (45.7%) at 6 centres produce provisional sonographer reports which are fully reviewed and finalised by a physician. Four (5.7%) qualified cardiac sonographers (at 3 centres) finalise all sonographer reports without physician review. A further 21 qualified sonographers (30%) at 6 centres finalise more than 60% of reports without physician review.

Thirty cardiac sonographers (35.7%) are required to participate in an out-of-hours on-call roster (at 5 centres).

1.3. Job title and professional background

Thirty-one (44.3%) qualified sonographers and 10 (71.4%) trainees have the title of cardiac sonographer or echocardiographer. Thirteen qualified sonographers have a team leader or charge title. The title of 3 sonographers (4.3%) is unknown.

Fifty-eight (82.9%) qualified cardiac sonographers and 10 (71.4%) trainees have a cardiac physiology background. Radiology is the second most common background for qualified staff at 5.7% of the workforce. The professional background of 4 sonographers (5.7%) is unknown.
1.4. Education and qualifications

Twenty-two (31.4%) qualified cardiac sonographers hold the DMU; 13 (18.6%) hold the QUT-GDip. A further 16 (22.9%) hold an overseas echo qualification. The most common overseas echo qualification is the British Society of Echocardiography (BSE) accreditation examination held by 11 sonographers. Fifteen (21.4%) sonographers hold no echo specific qualifications but have been classed as qualified.

Seven (50%) trainees were undertaking the DMU qualification, and 5 (35.7%) trainees were currently completing the QUT-Gdip. One trainee is aiming to complete the European paediatric accreditation examination. Eight trainees expect qualification in 2013, with a further 4 expecting to complete qualification in 2014.

2. Regional comparisons

2.1 Scan types

Seventeen of the 18 centres (94.4%) perform adult transthoracic scans. Two centres (11.1%) do not perform paediatric scans (including adult congenital). Both ESE and DSE are performed in 13 centres (72.2%). Fifteen centres (83.3%) also perform TOE.

2.2 Population-based District Health Board echocardiogram volumes and workforce size

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 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 of 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 3: Regional echocardiogram service provision by full-time equivalent (FTE) sonographers and echocardiogram scan numbers per 100,000 DHB population

Echocardiography Service per Population

- Full-time Equivalent Sonographers
- Echocardiograms

New Zealand DHBs

*Surgical Centre
2.3 DHB population modelling

Table 2: DHB population characteristics by DHB

<table>
<thead>
<tr>
<th>District Health Board</th>
<th>Total Population, N</th>
<th>Age, years (%)</th>
<th>Ethnicity</th>
<th>Deprivation status</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>&lt;20</td>
<td>20-65</td>
<td>&gt;65</td>
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<td>Counties Manukau</td>
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<td>27</td>
<td>59</td>
<td>14</td>
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* Denotes DHBs who have more than one hospital centre within the catchment
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). Although none of the variables independently reached statistical significance, probably related to the low sample size (each DHB was a sample) some interesting relationships were observed. It is beyond this study, but it is likely that these relationships would endure if we were able to explore the data beyond the DHB level.

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 one percent increase in those aged <20 years).

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). 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.

Low socioeconomic status (Q4/Q5) was associated with an increase in the number of echoes performed, which was statistically significant (p = 0.02).
Table 3: Model of DHB demographics versus the number of echocardiograms performed per 100,000 population per annum

<table>
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<th>Coefficient</th>
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<th>p-value</th>
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<td>0.41</td>
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<td><strong>Age</strong></td>
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<tr>
<td>&lt;20 years</td>
<td>-79</td>
<td>134</td>
<td>0.57</td>
</tr>
<tr>
<td>20-65 years</td>
<td>131</td>
<td>62</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
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<tr>
<td>Māori /Pacific</td>
<td>-35</td>
<td>40</td>
<td>0.39</td>
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<td>Quartile 4/5</td>
<td>75</td>
<td>29</td>
<td>0.02</td>
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Data were entered into the model as binary variables; adjusted $R^2 = 40.5\%$

2.4 Workforce size

The average number of echocardiograms performed per cardiac sonographer FTE was 1323 per annum. 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).

2.5 Workforce size and demographic modelling

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

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 1 – Trainee versus Qualified workforce

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<th>Coefficient</th>
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<th>p-value</th>
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<tbody>
<tr>
<td>Intercept</td>
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<td>0.01</td>
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<tr>
<td>% of workforce trainees</td>
<td>-9.0</td>
<td>636</td>
<td>0.37</td>
</tr>
<tr>
<td>Surgical centre</td>
<td>712</td>
<td>9.6</td>
<td>0.04</td>
</tr>
<tr>
<td>Median scan time (minutes)</td>
<td>-11</td>
<td>15</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Adjusted $R^2 = 25.5\%$

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

Table 5: Model 2 – Total workforce size by FTE

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<thead>
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<th>Coefficient</th>
<th>Standard error</th>
<th>p-value</th>
</tr>
</thead>
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<td>Total FTE</td>
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<td>Surgical Centre</td>
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<tr>
<td>Median scan time</td>
<td>-22</td>
<td>17</td>
<td>0.20</td>
</tr>
</tbody>
</table>

| (minutes)              |             |                |         |

Adjusted $R^2 = 42.8\%$

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.
3. Capacity modelling

3.1 Procedure scan duration

There are scan duration differences between centres for adult TTE scans but no difference between centre types. Of the centres who perform paediatric echocardiogram scans, four out of 16 (25%) report the median scan duration increased compared to adult scans, with duration increased an additional 25% to 33% of standard time. At one regional centre paediatric scans were 33% shorter than adult TTEs. Nine out of 18 (50%) of centres reported increased scan duration for trainee sonographers (from an additional 25% to 100% of standard duration). Five out of 18 (28%) of centres reported increased scan duration for portable scans by 25% to 66%. Nine out of 12 (75%) of centres reported increased duration by 20% to 100% for DSEs. Nine out of 13 (69%) centres increased reported duration from 20% to 33% for ESEs whilst one centre shortened scan duration by 25% for ESEs. Four out of 16 (25%) of centres reported increased duration for TOEs, however two regional centres reduced duration for TOEs compared to standard scans.

NZ median scan durations (all centres) are shorter than the UK model for all procedures except TTE and paed TTE and shorter than the USA model for all procedures except portable scans. Scan duration differences between NZ and the UK model vary widely from -14 minutes (NZ in excess) for paed TTE to +49 minutes (UK in excess) for ESE. Scan durations in NZ for portable scans, ESE, DSE and TOE are considerably shorter than the UK model. Scan duration differences between NZ and the USA model vary from -3 minutes (NZ in excess) for portable scans to +29 minutes (USA in excess) for DSE.
### Table 6: Procedure scan duration – NZ surgical and regional centres, UK and USA models

<table>
<thead>
<tr>
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<th>Scan duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TTE</td>
</tr>
<tr>
<td>NZ surgical centres (n=5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-60 mean 45 median 45</td>
</tr>
<tr>
<td>NZ regional centres (n=13)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-60 mean 47 median 45</td>
</tr>
<tr>
<td>UK model$^{41}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
</tr>
<tr>
<td>USA model$^{43}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

TTE - transthoracic echo, TTE training – transthoracic scan performed by a trainee sonographer, TTE portable – transthoracic scan performed at the patient’s bedside, DSE – dobutamine stress echo, ESE – exercise stress echo, TOE – transoesophageal echo, TTE paed – transthoracic scan performed on a paediatric patient
3.2 NZ echocardiogram actual capacity versus international models

For both adult TTE and all procedures, the UK 30:70 model predicts similar total combined hours compared to NZ. For the NZ, UK and USA models the largest proportion of clinical hours was spent performing adult TTE. There is a 23% difference in total scan hours (17364 scan hours) between the NZ actual and USA model. New Zealand paediatric clinical hours exceed both UK models but are less than the USA model.

Both UK and USA models predict increased clinical hours for performing DSE, ESE and TOE scans compared to the NZ actual clinical hours for these scan types (figure 4a and b)
Fig 4a and 4b NZ actual clinical hours (by procedure) based on 2012 national echocardiogram volumes, compared to clinical hours predicted using UK and USA scan time weighting models\textsuperscript{42,44}

Adult TTE - adult transthoracic echo, paed TTE - paediatric transthoracic echo, DSE - dobutamine stress echo, ESE – exercise stress echo, TOE – transoesophageal echo

UK 30:70 – 30% inpatient, 70% outpatient    UK 50:50 – 50% inpatient, 50% outpatient
3.3 Population based DHB echocardiogram actual capacity versus international models

There are marked differences in NZ actual total echocardiogram clinical scan hours between DHBs (923 to 2623 hours). Nine out of 16 (56%) DHBs produce less actual clinical hours than those predicted from both the UK and USA models. The USA model predicts higher clinical hours than NZ or the UK for all DHBs (fig 5)
Figure 5: NZ annual clinical hours per 100,000 of population for NZ DHB’s compared to clinical hours predicted using UK and USA scan time weighting models\textsuperscript{42, 44}
3.4 Actual versus potential clinical capacity

Six out of 16 DHBs (37%) demonstrate a positive excess time difference in actual capacity – demonstrating the actual capacity calculations (based on scan volume and duration) exceed the calculation of potential capacity (based on workforce size and clinical availability). There is wide variability between DHBs - from 29% positive excess (actual greater than potential) to 72% negative excess (potential greater than actual). There is no difference between surgical and regional DHBs: surgical 7% positive excess to 34% negative excess; regional 29% positive excess to 72% negative excess.

Figure 6: Comparison of actual versus potential clinical capacity by DHB expressed as a % excess time difference (in clinical hours)
Discussion

1. Sonographer workforce demographics

Workforce size

The overall size of the workforce (by sonographer numbers) remains the same as in 2010\textsuperscript{4} despite two hospitals no longer employing sonographers, suggesting that there has been growth in the size of the sonographer workforce in some centres. The total workforce FTE has increased by 10, with the number of sonographers exceeding this, indicating that a number of sonographers have part-time roles. In this study, 43\% of cardiac sonographers work part-time which is similar to the rate of 47\% described in the Australian sonography workforce.\textsuperscript{46}

One of the limitations of the 2010 study was that it was unclear what proportion of the reported FTE was for echocardiography alone, and whether any other clinical roles were being performed by the sonographers. This study details the FTE related only to the provision of echocardiograms by sonographers, finding that the echo FTE is 8.5 FTE less than the total FTE. This suggests that 12\% of the total FTE is not related to providing echocardiograms.

There are 14 trainees, five of them in the five surgical centres. Compared to 2010, the number of trainees has reduced by 30\% (14 compared to 20 in 2010) with the same workforce size,\textsuperscript{4} indicating an improving skill mix measured by the proportion of qualified versus trainee staff. The proportion of qualified versus trainee cardiac sonographers is 80\% which is similar to the equivalent Australian cardiac sonography workforce at 77.5\%\textsuperscript{47} and the NZ non-cardiac sonographer workforce at 81.5\%.\textsuperscript{48} Training positions are essential in the workforce to ensure future growth of the profession. In the Northern region of NZ the proportion of qualified versus trainee non-cardiac sonographers is high at 89.2\% but this lack of trainee positions has led to a sonographer skill shortage (Northern Region Sonographer Project, June 2013).
The vacancy rate of 4.5% is nearly half of that in 2010\textsuperscript{4} and is much lower than that seen in international studies. An audit of the UK non-cardiac sonography workforce in 2009 showed a vacancy rate of 10%,\textsuperscript{49} whilst a 2005 study of the UK cardiac sonographer workforce described vacancies of one or more positions in 44% of English hospitals.\textsuperscript{27}

The NZ cardiac sonography workforce size is smaller than the comparable workforce in Australia. In NZ the estimated population-based cardiac sonographer workforce size in NZ is 1.9 total cardiac sonographers per 100,000 population or 1.6 qualified cardiac sonographers per 100,000 population. In 2009, the Australian cardiac sonographer workforce was 3.11 qualified cardiac sonographers per 100,000 population,\textsuperscript{47} nearly double the equivalent workforce in NZ. The NZ non-cardiac sonographer workforce is also considerably larger than for cardiac sonographers. Using MRTB registration figures in 2013, the NZ population-based numbers\textsuperscript{50} of non-cardiac sonographers is 10.1 per 100,000 population. In 2013 the Northern Region Sonographer Project performed a stock take of all non-cardiac sonographers in NZ, and calculated a rate of 8.68 sonographers per 100,000 population (Northern Region Sonographer Project, 2013). Although the higher proportion of non-cardiac sonographer part-time workers makes direct comparisons more difficult, this workforce size is still much larger than the equivalent cardiac sonography workforce. This difference in cardiac versus non-cardiac sonographers' workforce size is due to differences in the breadth of clinical conditions diagnosed by each type of sonography, with cardiac sonography predominantly limited to cardiac conditions whereas non-cardiac sonography encompasses all other body systems.

\textit{Roles and responsibilities}

Since cardiac sonographers have a strong link with the cardiac physiology profession, with shared professional background and the same professional registration board,\textsuperscript{4} anecdotal reports suggested that most cardiac sonographers were performing other cardiac technical roles in addition to performing echocardiography. This study shows that not to be the case, with only one quarter of the total workforce performing cardiac technical duties in addition to their cardiac
sonography role. There is no clear relationship to centre type with three of the 10 centres where cardiac technical duties are performed by sonographers being surgical centres. Trainees are less likely to perform other clinical roles compared to qualified sonographers. One possible cause for this is the training demands of the professional qualifications, with both DMU and QUT-GDip requiring minimum scan numbers and full-time commitment to the sonography role.

Although 20% of the qualified workforce by job title are in team leader/charge roles only 11% of the qualified workforce have designated non-clinical time to perform their management and training duties. This suggests that many of those who hold senior roles do this whilst performing their clinical duties and without any additional time support. A further three sonographers have designated non-clinical time for training responsibilities (0.2 to 0.4FTE allocated for training each).

A minority (36%) of the total cardiac sonographer workforce also participate on an after-hours on-call roster as part of their clinical duties at five centres. Provision of an after-hours on-call service is strongly related to centre size (size of the sonographer workforce) and centre type. Four out of the five centres who provide an on-call service are surgical centres, with a median of six on-call sonographers per centre, and a minimum of four. All centres with a workforce size of four or more provided an on-call service.

In the 2005 SCANZ audit\textsuperscript{16} sonographer reporting of scans was documented for the first time as a role performed by cardiac sonographers in NZ. Although the traditional responsibility of reporting and releasing reports is a physician role, at that time 39% of reports were reported by a sonographer only and released without review by a cardiologist.\textsuperscript{16} In this study this rate still remains high nationally with 30% of reports released without physician review. The 2005 survey\textsuperscript{16} discussed how digital reporting should improve access rates for reporting to geographically remote centres and therefore increase physician reporting in the future. In 2013 all centres reported scans on digital systems with access to a cardiologist in person or remotely within
one hour; therefore it does not seem likely that the lack of access to specialist physicians is the cause of the continued high rates of sonographer reporting.

Although the number of centres releasing without physician review has decreased over time, the reporting and releasing of reports is still considered a qualified sonographer role rather than physician role in many centres; three hospitals perform 100% sonographer-only reporting (by four sonographers) and a further six centres with sonographer-only reporting rates at between 60 and 99% (by 21 sonographers). Nearly a half of qualified sonographers work in the six centres hospitals where sonographers do not report and release results, suggesting that the centre size (by the number of sonographers at each hospital) is an important factor in whether reports are reviewed by a physician.

The number of centres with 100% sonographer-only reporting is markedly different in this study compared to a national review of echocardiogram services performed by survey in 2012, which found that nine of 19 centres (48%) had 100% of the echoes reported by a physician. The cause of this difference is unclear, but may relate to differences in survey design or changes that occurred between release times of the two surveys.

There is no consensus internationally whether sonographer reporting should or should not be included in the sonographer role or scope of practice. In Australia, a report by the Australian Sonographers Association (ASA) acknowledged that many of its members routinely provided information to physicians which was acted upon for treating the patient, whilst the Australasian Society of Ultrasound in Medicine (ASUM ) advocate that the responsibility for communication of sonographer findings lies with individual hospital policy. However in the USA the law in most states describes sonographer interpretation and reporting as “practicing medicine without a licence”.

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Since the sonographer role has changed from the “traditional radiologic model” many professional organisations are developing a role description and pathway to ensure quality in this model of patient care. In Australia, the ASA acknowledges the need to develop an extended role for senior sonographers with recognised training and education. In the USA, the American Society of Echocardiography (ASE) is developing a career advancement programme for senior sonographers with a role called the “advanced cardiovascular sonographer” and the Society of Diagnostic Medical Sonographers (SDMS) has also developed a proposed role for an “ultrasound practitioner”. It is unlikely that either of these professional roles in the USA will include sonographer reporting as a component since other successful advanced roles have clearly defined this as out of scope for a sonographer role. In NZ, the MRTB are investigating the need for an expanded role within the existing scopes or new advanced scope of practice. The development of an advanced role for cardiac sonographers would be an advantage in NZ, ensuring quality within the current workforce where sonographer reporting is practiced routinely.

**Title and professional background**

In NZ, only half of those who perform the role of a cardiac sonographer are called sonographers. This is similar to international findings where those who perform cardiac ultrasound are less likely to be titled as sonographers compared to other sonography scopes. This survey also reports a significantly higher proportion of trainees called cardiac sonographers or echocardiographers compared to qualified personnel (71.4 % versus 44.3%). The reason for the difference in role versus title is unknown but is likely to relate to individual employer interpretation of the HPCA Act regarding title protection for HPCA registered professions. In 2010 the numbers of cardiac sonographers who were registered with the MRTB (the only HPCA Act registered professional board representing cardiac sonographers) was low so it is likely that many employers will only designate the title of sonographer to any sonographer registered by the MRTB.

Thirteen qualified sonographers at 18 centres have a charge or team leader title. Although centres without a designated charge sonographer are most likely to be
regional this is unrelated to centre size (by size of the sonographer workforce) with some centres of up to 6 sonographers having no designated leadership role.

85% of cardiac sonographers have a cardiac physiology background which is consistent with findings from 2010.⁴ Although the overall proportion of those with a cardiac physiology background has increased from 75% in 2010, this is more likely to reflect the numbers of those whose professional background were unknown in 2010 rather than any real workforce change.

Of those cardiac sonographers who do not have a cardiac physiology background, a higher proportion of these are trainees, with 28.6% of trainees compared to 17.1% of qualified sonographers reporting an alternative professional background. This is consistent with changes internationally where the traditional radiology background of non-cardiac sonographers is changing. In Australia, one third of sonography trainees do not have a radiography-based entry level degree whilst in America nearly two thirds of sonography graduates do not have a radiography background.⁵⁸ This trend likely reflects the recognition that sonography is a relatively new but separate profession and that “the knowledge, skills and attributes demonstrated by sonographers are significantly different to medical radiation professions”.⁵⁸ With the evolution of the separate sonography profession there is also the increasing trend for sonographers to perform a single role with less multi-skilling. This is reflected in the reduced proportion of trainees who perform other clinical roles, as well the increased proportion of trainees who are titled sonographer compared to the qualified workforce.

Education and qualifications

The number of sonographers who hold formal echo specific qualifications has increased since 2010⁴ (40% in 2010, 50% in 2013) and this is consistent with overseas trends where traditional on the job training is being replaced with more formal educational pathways.⁵⁹ Additionally there are larger number of sonographers
holding overseas echo qualifications (14% in 2010; 23% in 2013), suggesting more sonographers are entering the NZ workforce from overseas. The most common overseas echo qualification held is accreditation with the British Society of Echocardiography (BSE).

In 2013 the proportion of those with no echo specific qualification has increased from fewer than 10% in 2010 to 21.4% in 2013. The importance of this is unclear since in the 2010 survey\(^4\) qualification information was unknown in nearly 20% of the workforce, and it was unknown whether this was primarily caused by omission in data collection or by a lack of formal qualifications. The 2013 findings suggest that it is likely that most of the unknown qualifications in 2010 were from those with no formal echo qualification rather than any real change in workforce demographics. Of the 21.4% of sonographers who have been classed as qualified but who do not hold an echo-specific qualification, it would be expected that these were likely experienced sonographers trained on-the-job before qualifications became widely required. However, almost all of the very experienced sonographers (over 15 years’ experience) hold an echo qualification which is reflected in the increase in qualifications from 2010 to 2013. New Zealand’s cardiac sonography workforce is largely experienced with more than half having at least 5 years’ experience and over 20% reporting more than 15 years of experience.

The most common echo qualification held was the DMU, followed by the QUT-GDip. Trainees in 2010 were predominantly undertaking the DMU qualification,\(^4\) however in 2013 substantially more trainees were undertaking the QUT-GDip qualification. The reasons for this may relate to the differences in how the courses are delivered and the level of support required, or may relate to the fact that increased professionalism of sonographers is seen to benefit from a university-based post graduate level of education.\(^46\) Although the number with formal echo qualifications have increased over time, only half of qualified sonographers (compared to 40% in 2010) who hold the DMU and QUT-GDip qualifications currently acceptable for registration with both of the professional bodies who register cardiac sonographers - the MRTB and CPRB.\(^4\) There is no relationship between qualified sonographers
holding DMU versus QUT-GDip and centre size or type. One commonality is that all sonographers at a single centre are more likely to hold the same qualification, which may be a financial decision or the preference may relate to previous experience supporting the training for that qualification.

2. Regional comparisons

Scan types

Since 2010, there is one additional centre which no longer performs paediatric scans. The reason for this is unknown but may relate to changes in the skills/ability of the sonographer workforce, or changes in reporting lines or clinical practice at the hospital. One specialist paediatric centre does not perform adult transthoracic scans. The number of centres that perform stress echocardiography (both ESE and DSE) and TOE are unchanged since 2010 at 13 and 15 centres respectively. Of the three centres that do not perform TOEs, two are small regional centres without on-site cardiologists, whilst one is a surgical centre with on-site cardiologists. Of the centres which do not perform stress echoes, two are small regional centres without on-site cardiologists; two are regional centres with cardiologists, whilst one is a specialist paediatric centre. This suggests that it is differences in clinical practice rather than lack of access to cardiologists which determine whether stress and TOE procedures are performed.

Population-based DHB volumes and workforce size

This study demonstrates marked regional disparities in echocardiogram volumes throughout New Zealand DHBs, with a two to three fold difference between highest and lowest centres, unrelated to centre type. Although for this study echocardiogram volumes were reported per annum, whereas the 2005 audit reported volumes over a single week, the same disparity first identified in 2005 still exists. This study also demonstrates wide regional differences in the population-based FTE between centres, with a three-fold difference in workforce size between centres.
The 2012 national echo utilisation measured by an annual echocardiogram volume of 78,900, or 17,810 per million population\textsuperscript{60} is low when compared to other countries; the NZ volumes are 39\% of those reported in Australia\textsuperscript{21} and 37-41\% of those reported in the UK.\textsuperscript{20} Although comparison to international healthcare systems can be difficult, the UK and Australian systems are similar enough to NZ to make comparisons valid. Additionally, both countries have similar incidence of cardiovascular disease,\textsuperscript{61,62} suggesting that it is not differences in the health status of the populations which are affecting the utilisation. Since the population-based sonographer workforce by FTE in NZ is also low compared to other countries it is likely that the small workforce is likely to be contributing the low overall number of echocardiograms performed in NZ.

Interestingly, although at a national level there is a relationship between the population-based echo volumes and the workforce size, no relationship between the two is seen within individual DHBs. Possible reasons for this were explored by multivariable analysis modelling.

**DHB population modelling**

Multivariable regression analysis of DHB demographics showed that deprivation and ethnicity 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 Pacifica suggests the potential for a need versus access imbalance described by the inverse care law,\textsuperscript{13} since Māori and Pacific are known to have higher prevalence of cardiac risk factors\textsuperscript{14} 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, 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 compounding by 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 echocardiogram volumes that are not included in this study. One consideration is that surgical centres service populations from outside their geographic catchment area and the volumes of these echocardiograms are unknown. Additionally, since 10 of the 16 DHBs perform echocardiograms at more than one centre and nine of these provide echocardiogram services as an outreach through mobile travelling clinics there are likely differences in how echocardiogram services are provided between centres. A further consideration is differing wait list volumes as the number of echocardiograms performed does not equate to demand. Wait list volumes are known to 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.

**Workforce size and demographic modelling**

This study demonstrates regional differences in the average number of echocardiograms performed per sonographer FTE, with a more than three-fold difference between centres. When the relationship between the workforce and
echocardiogram volumes was explored by multivariable analysis, the results suggest 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. In NZ, cardiac sonographers are usually trained in an employed (rather than supernumerary) capacity, with on-the-job training combined with academic study. This model of training impacts on productivity since the trainee needs to be fully supervised, effectively reducing the workforce size. There are more trainees in regional than surgical centres (64% versus 36%) and this may reflect the ability for the larger centres to recruit qualified and experienced staff.

The results from this research also show that the overall size of the cardiac workforce at a DHB affects the echocardiogram volume. Large centres may have increased efficiencies and infrastructure differences which may account for this, since support staff are important in releasing time which can be used more effectively for performing clinical work.

Both workforce models consistently show that the type of centre impacts on the echo volume produced. Population-based FTE volumes demonstrated that surgical centres performed on average more scans per FTE than regional centres, and this was supported in the multivariate modelling as being independent to all other factors. This increased echo volume capacity of surgical centres may relate to the experience of the sonographers working in surgical centres, with 63% of the workforce in surgical centres having more than 15 years of experience compared to 33% in regional centres.

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. This was explored more fully by investigating the capacity of each DHB.
3. Capacity modelling

Procedure scan duration and capacity

This study demonstrates marked regional differences in scan duration of echo procedures. All NZ echocardiographic procedures showed wide differences in reported average scan duration between centres with a scan duration in some centres double the duration of others, with no relationship to centre type. The largest difference in scan duration between centre types was for trainee TTE, with scan duration longer for surgical centres. The cause of this is unknown but may relate to differences in case complexity at surgical centres.

Nationally the duration of TTE is longer than the UK model, but shorter than the USA model. The TTE duration of the USA model reflects the minimum of 45 minutes for image acquisition and an additional 15 minutes reporting time, with a single scan duration for all TTE scan types. This is comparable with USA workforce surveys which show an average daily scan number of nine. The UK model TTE duration is based on national averages of 35 minutes (including reporting) which is comparable to a survey of practice in the UK which found that on average 13 scans were performed per day.

United Kingdom scan durations are lengthened for TTE inpatients, and to allow comparison of adult TTE scans to NZ capacity two UK models were developed since the proportion of IP and OP scans is unknown in NZ. The 30:70 model reflects capacity with fewer inpatients to outpatients whilst the 50:50 model reflects capacity with an even split of inpatients to outpatients. The capacity predicted by the UK 30:70 model aligns closely with the NZ capacity for both adult TTE and total all scan types, whereas the UK 50:50 model predicts capacity between the NZ actual and USA model. The reason for the additional duration in the UK for inpatient and portable scans (performed at the patient bedside) is unknown but is likely related to increased transport times, increased case complexity or both. In comparison, there is no additional time allocated for inpatient scans in NZ, and although the duration for portable scans is 15 minutes longer than a standard scan it is much less than the UK model.
Another key difference between the NZ and international models is the duration for DSE procedures. Dobutamine stress echo durations in NZ are reported to be 29 minutes shorter than the USA accreditation standards\textsuperscript{43} and 44 minutes shorter than the average in the UK.\textsuperscript{41} The cause of this is unknown but is most likely related to differences in clinical practice regarding scan booking processes. Patients who require a DSE procedure also require a TTE scan as part of their clinical assessment and it may be that in the UK and USA a TTE performed at the same time as the DSE is measured as a single DSE procedure, whilst in NZ the TTE is often done preceding the DSE and is recorded separately. The differences in the duration of the DSE is reflected in capacity, with the capacity in NZ for DSE nearly half that of the UK and two thirds of the USA models. Although these times for procedural echoes are interesting, overall it appears that it is the duration of TTE scans rather than other procedure types that is driving the capacity differences, since the capacity differences in the TTE procedure is the same as that seen in the total capacity time for all procedures combined. This is not unexpected since adult TTEs are the most common type of scan performed in NZ.\textsuperscript{16}

\textit{Population-based DHB actual capacity}

This study also demonstrates marked regional differences in the population-based capacity of cardiac sonographers. One explanation for this variation is DHB differences in procedure scan duration since scan duration is strongly associated with capacity. Another explanation is the DHB differences in procedure scan volumes (utilisation).

The complex relationship between capacity and utilisation is apparent in the regional capacity differences in the proportion of sonography trainees. Workforce demographic multivariate modelling demonstrated that training affects echo utilisation and this is supported by the duration data, which shows 50\% of centres increasing training scan duration compared to standard TTE scans. Although the calculation of actual capacity takes into account the differences in scan time for trainees, it does not reflect the reduced clinical capacity of the trainer. Since training of cardiac sonographers requires one-on-one supervision\textsuperscript{63} training centres will have
reduced actual clinical capacity, not only from the increased trainee scan time but also from the direct supervision required. This will also be reflected in reduced scan volumes (utilisation) at that centre.

Regional differences in capacity may also relate to individual centre adherence to health and safety best practice guidelines.\textsuperscript{67} Since cardiac sonographer musculoskeletal injury risk increases with scan duration and scan volume,\textsuperscript{68} capacity may be deliberately limited by processes to reduce the risk of injury to sonographers. It is also likely that there are other unidentified differences in echocardiography service provision which will also affect clinical capacity. These areas are out of the scope of the current thesis however.

\textit{Actual versus potential capacity}

There are also marked regional differences in the potential versus actual capacity between DHBs which are not related to centre type. Aside from the causes for differences in actual capacity already described, another possible explanation for this variation may relate to the assumptions made in the calculation of the potential capacity of each DHB. Potential capacity is dependent on clinical availability, with a UK workforce planning model used for the number of clinical sessions available per sonographer FTE per week,\textsuperscript{41} however it may be that clinical availability differs between DHBs. Potential capacity is also dependent on leave provision, with calculations assuming an average four weeks annual leave per year per sonographer FTE. Since annual leave provision often relates to length of service, DHBs with more senior sonographers and greater leave provision may have the calculation of potential clinical time overestimated.

\textit{Planning for service provision}

In NZ, capacity modelling for the cardiac sonographer workforce is difficult due to a lack of a centralised workforce database. In addition the utilisation of echocardiograms as a measurement of the workforce activity is also difficult to obtain
since echocardiograms are not separately identified within funding coding as they are in Australian and the USA.

Needs modelling for a service requires a measurement of the population need for echocardiography services, at a DHB and national level. Measuring the disease specific population need for echocardiograms is difficult since echocardiography is widely used for the diagnosis and prognosis of many different types of heart disease and conditions. In the UK the national need for echocardiography has been calculated as the number of studies per million population per year required based on eight main indications, and this has been modelled as an estimated need for 28-40 cardiac sonographers per million population. In NZ there are 16 cardiac sonographers per million population, this is 43% to 60% less than the estimated need based on UK modelling. Although the same disease population data is not readily available in NZ, disease prevalence is unlikely to be markedly different indicating that there is likely a significant need versus capacity mismatch for the cardiac sonographer workforce in NZ.

Demand modelling for a service requires information about both the current utilisation and the unmet need, which is related to waitlist volumes. Demand also reflects differences in referral practices including the appropriateness of the referral. In the future, demand in echocardiography services is likely to increase due to an aging population and changing population needs, and accommodating an increase in demand without a change in the size of the cardiac sonographer workforce would only be possible if echocardiography services were provided differently than current practice. This could involve new training models with training provided externally and trainees as supernumerary rather than employed, an increase in clinical hours by extension to a 7 day working week and also additional support roles established to increase efficiency of time able to be spent on performing clinical work.
To accurately plan for echocardiogram provision in the future the cardiac sonography workforce capacity, as well as population need and demand modelling is required for at a national and regional level.

Limitations

This study has a relatively small sample size because each DHB is a single “participant”, but nevertheless it forms a complete national sample of public echocardiography services. Since only public hospitals with echocardiograms performed by cardiac sonographers were included, sonographers in private hospitals and echocardiography performed by physicians were excluded from this survey. However, this is unlikely to have major impact since most comprehensive diagnostic echocardiography in New Zealand is performed by sonographers.

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 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.
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.

Data from some centres included a range of clinical times to perform procedures, where a range was given the median number scan duration was used. Since TTE inpatient and outpatient volumes were not identified separately, a 50:50 IP/OP split was assumed for calculating the proportion of scans over and under the standard time for inpatient and outpatients. This assumption would have made a minimal difference to the calculation of actual clinical hours in a few centres only.

Finally, this study identifies the cardiac sonographer workforce capacity only and does not measure the capacity of echocardiogram services which would include all the resources available to provide the service, including the physical resources such as equipment and rooms.
Conclusion

This study demonstrates that regional disparity in public echocardiography services, first identified in NZ in 2005 still exists today. The reasons for the differences in population-based echo volumes were investigated relating to both DHB demographics and cardiac sonographer workforce distribution and demographics. This study found that the regional differences in echo volumes could be explained by the DHB demographics of age, ethnicity and socioeconomic status whilst the DHB echo volumes could also be explained by the cardiac sonographer workforce size and distribution of trainees. Additionally centre type (surgical or regional) and scan length were also contributing factors.

Adding to this knowledge, this study has also identified several additional regional differences relating to the cardiac sonographer workforce which have not been previously described in NZ. These include regional population-based differences in the cardiac workforce size by FTE, regional differences in the volume of echoes per cardiac sonographer FTE, regional differences in procedure scan duration as well as in capacity of the workforce.

This survey provides an important update to the demographics of the cardiac sonography workforce last studied in 2010. The additional information gives a greater depth of understanding of the workforce and enables investigation of how the workforce affects echo service provision nationally and regionally. Of particular importance is the identification and measurement of the echo component of the cardiac sonographers’ role as this information was not known previously. Measurement of the size of the workforce is important in modelling the capacity of the workforce as well as benchmarking against international workforces. This study shows for the first time that NZ, like similar workforces overseas, is establishing cardiac sonography as an independent profession. This is seen by changing trainee demographics - an increase in non-physiology backgrounds, increased use of the
title sonographer, as well as the high percentage of trainees who perform sonography as the only clinical component of their role.

This study for the first time allows the NZ echocardiogram service to be compared to similar services internationally and identifies that NZ echocardiogram utilisation is low compared to both Australia and the UK, and that the NZ cardiac sonographer workforce is small compared to Australia. Additionally the cardiac sonographer workforce capacity is low compared to the USA and the UK. Although this study has not considered indication-specific population need nor referral appropriateness, comparison to a UK need based model suggests that there is a need versus capacity mismatch in the cardiac sonographer workforce in NZ.

Although there is acknowledgement and commitment to minimise and potentially close inequality gaps in all areas of cardiac healthcare in NZ, there has been no formal workforce modelling performed due to the small size and low profile of the cardiac sonography profession. This study demonstrates that the cardiac workforce has a pivotal role in the provision of echocardiography and that planning the cardiac sonography workforce is important to ensure the workforce meets the patient demands of both the present and future.

Future directions

Although many regional differences in echo services were identified, some differences at an individual centre level were more difficult to explain. It would be beneficial to interview individual centres to identify differences in service provision including infrastructure and support to better understand a wider range of factors which might impact on clinical capacity.

To accurately understand the need and demand for echocardiogram provision at a national and regional level, future work should include need modelling based on all clinical indications for echocardiograms as well as the development of national
appropriateness guidelines. Any future planning of echocardiogram services would also need on-going data collection of the workforce size and demographics as well as echo utilisation.

The future focus should be on planning for a required level of echocardiogram service provision and how this might be best supplied economically rather than planning for the “right” number required of a profession. This may involve innovative solutions in how the service is provided in the future.
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Appendix A

Workforce Survey
SCANZ Workforce

Survey of Clinical Echocardiography Around New Zealand

Background information and instructions

On behalf of the SCANZ group I invite you to complete this survey which is an update to information collected in 2005 and 2010. This information is being used to better understand cardiac sonography providers and personnel at a regional and national level. Previously the SCANZ audit from 2005 identified regional differences in echo volumes (http://journal.nzma.org.nz/journal/121-1269/2924/). The 2010 SCANZ update collected some information on echo DHB personnel but remains unpublished. This survey aims to collect more detailed and up to date information which will be used to gain better understanding of the similarities and differences of the echo workforce regionally.

Please assist us by taking a few minutes to complete this survey, your return will be accepted as an agreement of your voluntary consent.

Return by post or e-mail to: B.Buckley@adhb.govt.nz, or Belinda Buckley, Cardiac Ultrasound Department, Level 3, Auckland City Hospital, Private Bag 92 024 Auckland

Any information you provide will be treated as confidential and individual DHB's will not be identified in publication.

With thanks

B. Buckley

General information:

Please fill in the information in the spaces provided

Please Circle the appropriate answer

Date: ...........................................................................................................................................

Name of hospital: ..................................................................................................................................
1. Do you perform echoes at more than one hospital?

   YES    NO

2. What is/are the name(s) of the other hospital(s) you provide services to? How does this service differ from that provided at your main site?

   ........................................................................................................................................................

   ........................................................................................................................................................

3. What department is the echo service provided within?

   Cardiac Physiology   Cardiology   Radiology   Medical

   Other (please specify) ..................................................................................................................
**Information on Cardiac Sonography workforce**

**Instructions/explanations of definitions:**

**Job title**
Specify the title employed under or on job description

**FTE**
Full-time equivalents – assumes that 1.0 FTE equals a 40hr working week

**FTE in non-clinical role**
Non patient work – work which does not involve providing patient care. Examples are special roles such as training or management. This does not include clerical work if this is performed as part of patient care (eg: organising patient appointments)

**Highest professional qualification**
Include the most recent or echo specific qualification if holding more than one

**Trainees**
Staff who are training in performing echoes. May include those who are qualified in other clinical roles but who are training to perform echoes and undertaking an echo specific qualification

**Please complete the table below for TRAINEES: Staff training in echoes**

<table>
<thead>
<tr>
<th>Job title</th>
<th>Length of time in position</th>
<th>Professional background</th>
<th>Total FTE</th>
<th>FTE in echo</th>
<th>FTE in other clinical role</th>
<th>Type work in other clinical role</th>
<th>FTE in other non-clinical role</th>
<th>Type of work in non-clinical role</th>
<th>Highest professional qual</th>
<th>Echo qual currently doing</th>
<th>Expected year training completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXAMPLE: cardiac sonographer</td>
<td></td>
<td>Radiology</td>
<td>1.0</td>
<td>1.0</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>N/A</td>
<td>DMU General</td>
<td>QUT</td>
<td>2014</td>
</tr>
<tr>
<td>EXAMPLE: Clinical cardiac physiologist</td>
<td></td>
<td>Physiology</td>
<td>0.8</td>
<td>0.4</td>
<td>0.4</td>
<td>p/m checks, defib implants</td>
<td>0</td>
<td>N/A</td>
<td>DMU Pt 2</td>
<td></td>
<td>2013</td>
</tr>
</tbody>
</table>
Please complete the table below for QUALIFIED STAFF: Staff working in echoes who are NOT training

<table>
<thead>
<tr>
<th>Job title</th>
<th>Length of time in position</th>
<th>Professional background</th>
<th>Total FTE</th>
<th>FTE in echo</th>
<th>FTE in other clinical role</th>
<th>Type work in other clinical role</th>
<th>FTE in other non-clinical role</th>
<th>Type of work in non-clinical role</th>
<th>Highest professional qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXAMPLE: Cardiac sonographer</td>
<td></td>
<td>Radiology</td>
<td>1.0</td>
<td>1.0</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>N/A</td>
<td>BSE, DMU</td>
</tr>
<tr>
<td>EXAMPLE: Clinical specialist</td>
<td></td>
<td>Physiology</td>
<td>1.0</td>
<td>0.6</td>
<td>N/A</td>
<td>N/A</td>
<td>0.4</td>
<td>Training specialist</td>
<td>DMU</td>
</tr>
<tr>
<td>EXAMPLE: Team leader</td>
<td></td>
<td>Physiology</td>
<td>1.0</td>
<td>0.6</td>
<td>0.2</td>
<td>p/m checks, defib implants, holter analysis</td>
<td>0.2</td>
<td>management</td>
<td>QUT</td>
</tr>
</tbody>
</table>
Information on non-clinical sessions:

Please fill in the information in the spaces provided

4. How many sessions (one session equals 4hrs) of non-clinical time are trainees provided for study per week?

..................................................................................................................................................................................

5. How many study/examination leave days are provided for trainees annually?

..................................................................................................................................................................................

6. How many study/continuous education days are provided for qualified staff annually?

..................................................................................................................................................................................

Information on vacancies:

Please complete the answers below if you have any current vacancies

Please fill in the information in the spaces provided

7. What is the FTE of current vacancies?

..................................................................................................................................................................................

Please Circle the closest appropriate answer

8. What proportion of the vacancy is for trainees?

None 20% 40% 60% 80% 100% (all) Other- please specify
9. How long has the **trainee** vacancy been vacant?

Less than 1 month  1-3 months  3-6 months  6-12 months  
Greater than a year

Not applicable (no trainee vacancy)

10. How long has the **qualified** vacancy been vacant?

Less than 1 month  1-3 months  3-6 months  6-12 months  
Greater than a year

Not applicable (no qualified vacancy)

11. If your vacancy has been unfilled for 6 months or more – what do you consider to be the **main** reason for this unfilled vacancy? (circle only one)

No qualified sonographers have applied  Position not attractive due to pay

Position not attractive due to location  Right candidate not yet found

Other (please state) …………………………………………………………………………………………………………….

............................................................................................................................................................................
............................................................................................................................................................................
**Information on clinicians:**

*Please Circle the most appropriate answer*

12. How many cardiologists report echoes and/or perform echo procedures in your hospital? If you have physicians rather than cardiologists who perform this function please complete but note in comments section

<table>
<thead>
<tr>
<th>None</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments

.................................................................................................................................................................

13. How many cardiologists who report echoes and/or perform echo procedures in your hospital have echo specific qualifications?

<table>
<thead>
<tr>
<th>None</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

unknown

14. What is the total combined proportion of Cardiologist FTE spent working in echoes for in your hospital?

.................................................................................................................................................................

*Please Circle all appropriate answers*
15. When required, how soon is the Cardiologist support available?

|Immediately| Within 1 hr| Within 1 day| Within 1 week|

Other (please state) ..................................................................................................................

16. When Cardiologist support is required, how is this provided?

|In person| By telephone| Via computer| All of these|

Other (please state) ..................................................................................................................

---

Information on workflow processes:

**Adult transthoracic scans (not including adult congenital)**

*Please Circle* the nearest round number

17. What is the standard booking time for an adult inpatient transthoracic echocardiogram?

| 15 mins | 30 mins | 45 mins | 60 min |

Other (please state) ..................................................................................................................

18. What is the standard booking time for an adult outpatient transthoracic echocardiogram?

| 15 mins | 30 mins | 45 mins | 60 min |

Other (please state) .....................................................................................................................
19. Do you perform outpatient scans at a different site than inpatient scans?

YES  NO

20. If the booking times for adult inpatient and outpatients scans differ what is the main reason for this (circle only one)?

Scans performed at different sites  Wait list pressures  Complexity of patients
Booking processes

Other (please state) ..........................................................................................................................................

21. What are the reasons for booking scans shorter than the standard booking time (circle as many as relevant)?

Recent full scan  Effusion check  Targeted scan  Screening scan

Other (please state) ..........................................................................................................................................

22. How much time do you reduce your standard booking time for these reasons?

10 mins  15 mins  20 mins  30 min

Other (please state) ..........................................................................................................................................
23. Given the reasons stated above - approximately what percentage of inpatient transthoracic scans would be shorter than your standard booking time?

Less than 10% 10-20% 20-30% 30-40% Greater than 40%

24. Given the reasons stated above - approximately what percentage of outpatient transthoracic scans would be shorter than your standard booking time?

Less than 10% 10-20% 20-30% 30-40% Greater than 40%

25. What are the reasons for booking scans longer than the standard booking time (circle as many as relevant)?

Trainee performing scan  Complicated diagnosis  Contrast study

Intraoperative  Procedural  Portable bedside scan

Other (please state) .................................................................

26. How much time do you increase your standard booking time for these reasons?

10 mins 15 mins 20 mins 30 min

Other (please state) .................................................................

27. Given the reasons stated above - approximately what percentage of inpatient transthoracic scans would be longer than your standard booking time?

Less than 10% 10-20% 20-30% 30-40% Greater than 40%
28. Given the reasons stated above - approximately what percentage of outpatient transthoracic scans would be longer than your standard booking time?

<table>
<thead>
<tr>
<th>Percentage</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-20%</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>20-30%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30-40%</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Greater than 40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Paediatric transthoracic scans (including adult congenital)**

Please circle the nearest round number

29. What is the standard booking time for a paediatric inpatient transthoracic echocardiogram?

- 15 mins
- 30 mins
- 45 mins
- 60 min

Other (please state) .............................................................

30. What is the standard booking time for a paediatric outpatient transthoracic echocardiogram?

- 15 mins
- 30 mins
- 45 mins
- 60 min

Other (please state) .............................................................

31. If the booking times for paediatric inpatient and outpatients scans differ what is the main reason for this (circle only one)?

- Scans performed at different sites
- Wait list pressures
- Complexity of patients
- Booking processes

Other (please state) .............................................................
32. Do you perform outpatient scans at a different site than inpatient scans?

**YES**  
**NO**

Please **Circle** the most appropriate answer

33. What are the reasons for booking scans shorter than the standard booking time (circle as many as relevant)?

- Recent full scan
- ACHD patient
- Targeted scan

**Other (please state)** ……………………………………………………………………………………………………………

34. How much time do you **reduce** your standard booking time for these reasons?

- 10 mins
- 15 mins
- 20 mins
- 30 min

**Other (please state)** …………………………………………………………………………………………………

35. Given the reasons stated above - approximately what percentage of **inpatient** paediatric transthoracic scans would be shorter than your standard booking time?

- Less than 10%
- 10-20%
- 20-30%
- 30-40%
- Greater than 40%

36. Given the reasons stated above - approximately what percentage of **outpatient** paediatric transthoracic scans would be shorter than your standard booking time?

- Less than 10%
- 10-20%
- 20-30%
- 30-40%
- Greater than 40%
37. What are the reasons for booking scans longer than the standard booking time (circle as many as relevant)?

Trainee performing scan    Complicated diagnosis    ACHD patient

Intraoperative    Procedural    Portable bedside scan

Other (please state) ........................................................................................................................................

38. How much time do you increase your standard booking time for these reasons?

10 mins    15 mins    20 mins    30 min

Other (please state) ........................................................................................................................................

39. Given the reasons stated above - approximately what percentage of inpatient paediatric transthoracic scans would be longer than your standard booking time?

Less than 10%    10-20%    20-30%    30-40%    Greater than 40%

40. Given the reasons stated above - approximately what percentage of outpatient paediatric transthoracic scans would be longer than your standard booking time?

Less than 10%    10-20%    20-30%    30-40%    Greater than 40%

Reporting transthoracic scans

Please Circle the most appropriate answer

41. Does the standard booking time include reporting time?

YES    NO
42. If the standard booking time **does not** include reporting time – how much additional time does reporting take?

5 minutes  
10 minutes  
15 minutes  
20 minutes  
greater than 20 minutes

43. Do you use a digital reporting system?

YES  NO

44. Do cardiac sonographers write/issue preliminary reports?

YES  NO

45. If yes – is the preliminary report identified as preliminary or technical (not reported by a clinician?)

YES  NO

46. What percentage of echo reports are released as final without being reported by a clinician?

None  <5%  5-10%  10-20%  20-40%  40-60%  60-80%

80-99%  All

---

**Transoesophageal scans**

*Please Circle* the nearest round number
47. What is the standard booking time for an **adult** transoesophageal echocardiogram?

- 30 mins
- 45 mins
- 60 mins
- 90 mins

**Other (please state) .................................................................**

48. What is the standard booking time for a **paediatric** transoesophageal echocardiogram?

- 30 mins
- 45 mins
- 60 mins
- 90 mins

**Other (please state) .................................................................**

49. If the booking times for **adult** and **paediatric** transoesophageal scans differ what is the **main** reason for this?

- Scans performed at different sites
- Performed by different clinicians
- Time for sedation
- **Other (please state) .................................................................**

Please **Circle** the most appropriate answer

50. Do sonographers assist Cardiologists/Physicians with transoesophageal scans?

- **YES**
- **NO**

51. Do sonographers perform transoesophageal scans?

- **YES**
- **NO**
Stress tests

52. What is the standard booking time for an exercise stress echocardiogram?

45 mins 60 mins 1hr 15 mins 1hr 30 mins

Other (please state) ..............................................................................................................................................

53. What is the standard booking time for a pharmacological stress echocardiogram?

45 mins 60 mins 1hr 15 mins 1hr 30 mins

Other (please state) ..............................................................................................................................................

Additional Information:

For the 2012 calendar year 1st January up to and including 31st December please provide the number of each scan types performed:

<table>
<thead>
<tr>
<th>Scan numbers</th>
<th>Adult transthoracic scans</th>
<th>Paediatric transthoracic scans (including ACHD)</th>
<th>Exercise stress echo</th>
<th>Dobutamine stress echo</th>
<th>Transoesophageal echo</th>
</tr>
</thead>
</table>

Please Circle the nearest round number
54. What % of scans annually are not performed by a sonographer?

5%  10%  15%  20% or more

55. Does your hospital perform foetal echoes?

YES  NO  DON'T KNOW

56. Who performs foetal echoes in your hospital?

Cardiac sonographer/Technologist  Cardiologist  Other clinician

Other health professional (please state).................................................................................................................................

Don't know

Please Circle the most appropriate answer

57. How many cardiac sonographers participate on the out of hour’s on-call roster?

1  2  3  4  5  6  7  8  9

None – we don’t have one

Many thanks for your time and co-operation
Appendix B

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The cardiac sonography workforce in New Zealand

Abstract

Introduction: The aim of this paper is to investigate the cardiac sonography workforce characteristics and registration requirements in New Zealand (NZ), with a comparison to similar workforces internationally.

Methods: The Survey of Clinical Echocardiography in New Zealand 2 (SCANZ2) audit was performed in December 2010. All of NZ’s public-funded District Health Board (DHB) centers providing echocardiography services responded to questions relating to staff, equipment, procedure types and patient statistics. The Medical Radiation Technologists Board (MRTB), Clinical Physiological Registration Board (CPRB) and Australian Sonographers Association Registry (ASAR) websites were reviewed in March 2012 for registered sonographers with a cardiac scope of practice. The cardiac sonography workforces in Australia, the UK, the USA and Canada were investigated for comparison.

Results: There are 84 cardiac sonographers (80.3 full-time equivalent) working in DHBs. 71% from a cardiac technical background; 40% have post-graduate qualifications; a further 17% are undertaking post-graduate qualifications; and 59 cardiac sonographers have registration with professional bodies in NZ and/or Australia. Cardiac sonographers in NZ do not undergo compulsory registration, but other sonographers in NZ have compulsory registration with the MRTB. Sonographers are predominantly not licensed internationally.

Discussion: Disparity exists between registration of cardiac and non-cardiac sonographers in NZ. Many cardiac sonographers have voluntary registration but few are registered with the MRTB. Reasons for this include professional alignment, educational qualifications and representation. International trends show increased pressure from governments and professional bodies to regulate sonographers.

Conclusions: This study provides a snapshot of the cardiac sonography workforce in NZ for the first time.

Keywords: background, cardiac sonographer, registration, workforce.

Background

Cardiac sonographers are healthcare professionals with a high level of skill and responsibility. Since the depth and breadth of the examination performed is reliant on the diagnostic decisions the sonographer makes during the scan. In Australia, the United Kingdom (UK), Canada and the United States of America (USA), cardiac sonography is recognised as a specialty of sonography. In New Zealand there is a well-defined sonography scope of practice but no recognition of separate sonography specialties.

Echocardiography first began to be practiced within New Zealand over 35 years ago and is now widely available throughout the country in both the public and private sector. In NZ, the provision of echocardiography services was first documented in 2005 through the Survey of Clinical Echocardiography in New Zealand (SCANZ) audit but there has been no investigation of the profession of cardiac ultrasound or of the cardiac sonographers who perform this role. The repeat of this national audit in 2010, SCANZ2, offered an opportunity to investigate the profession of cardiac ultrasound and the cardiac sonographer workforce.

The aim of this paper is to investigate the cardiac sonography profession and workforce in NZ specifically related to workforce size, professional and educational background and the role performed. In addition, registration status will be investigated with a comparison to similar workforces internationally.

Methods

Data sources

The SCANZ2 national audit was distributed in December 2010 to all public health or District Health Board (DHB) centres providing echocardiography services in NZ. Of all echocardiograms performed in NZ, 79% are provided through the DHB system and all acute echocardiograms are performed within this system. The SCANZ2 audit was a follow-up to the 2005 SCANZ audit and was primarily designed to assess the number of examinations performed.
Table 1: Professional background of cardiac sonographers.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cardiac sonographer number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac technician</td>
<td>60 (1.1%)</td>
</tr>
<tr>
<td>Other Cardiology</td>
<td>3 (0.6%)</td>
</tr>
<tr>
<td>Radiology</td>
<td>6 (1.1%)</td>
</tr>
<tr>
<td>Nurse</td>
<td>1 (0.2%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>14 (16.7%)</td>
</tr>
</tbody>
</table>

Table 2: Professional qualifications of cardiac sonographers.

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Cardiac sonographer number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMU (Cardiac)</td>
<td>22 (26.1%)</td>
</tr>
<tr>
<td>DMU (Cardiac) student</td>
<td>12 (4.3%)</td>
</tr>
<tr>
<td>QUT-PGD</td>
<td>12 (4.3%)</td>
</tr>
<tr>
<td>QUT-PGD student</td>
<td>2 (2.4%)</td>
</tr>
<tr>
<td>No echo qualification</td>
<td>8 (9.5%)</td>
</tr>
<tr>
<td>Overseas echo</td>
<td>12 (4.3%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>15 (19.0%)</td>
</tr>
</tbody>
</table>

Abbreviations: DMU = Diploma in Medical Ultrasound (cardiac), QUT-PGD = Queensland University of Technology Postgraduate Diploma Cardiac Ultrasound

Results

Workforce size
There were 84 cardiac sonographers working in DHBs nationally. 20 (24%) were identified as students resulting in a total full time equivalent (FTE) workforce of 60.3. At the time of the audit, vacancies were reported at 9.5% of the total workforce (9 sonographers, 5.7 FTE) and not included in the total workforce number (Figure 1).

Professional background of cardiac sonographers
Slity out of the 84 cardiac sonographers originated from a cardiac technical background, a further three had other (non-specified) cardiology related backgrounds; six cardiac sonographers had a background related to radiology professions and one cardiac sonographer was a trained nurse. The professional background of 14 cardiac sonographers was not specified (Table 1).

Professional qualifications of cardiac sonographers
Thirty-four cardiac sonographers (40.4%) have postgraduate qualifications currently accepted for MRTB registration within NZ Diploma of Medical Ultrasound (DMU) Cardiac and Queensland University of Technology PG Diploma (QUT-PGD). There are an additional 14 (16.8%) who are undertaking DMU or QUT-PGD qualifications. Twelve cardiac sonographers (14.4%) have other international cardiac ultrasound qualifications. Qualification information was not provided for 16 (19%) (Table 2).

Registration status
There are 59 (70%) cardiac sonographers registered with professional representative bodies in NZ and Australia. The highest proportion is registered with the CPRB (30, 36%), followed by the MRTB (19, 23%), although many of these do not meet MRTB requirements. For example only nine sonographers...
(11%) meet current MRTB registration and annual practicing certificate (APC) requirements. There are two trainees registered with the MRTB (one with and one without an APC). Eighteen (21%) maintain registration with the ASAR, and some of these (eight, 9.5%) also hold registration with a professional body within NZ (Table 3).

The role cardiac sonographers perform in NZ

All DHBs perform adult thoracic echocardiography (TTE), with 17 (85%) DHBs performing both adult and paediatric TTE scans. No DHBs performed only paediatric scans. Thirteen centres (65%) perform stress echo procedures (exercise stress and dobutamine stress). Fifteen (75%) of centres perform transoesophageal echocardiography (TOE) (Table 4).

Comparison of sonographer and medical radiation technologist (MRT) workforce in NZ and internationally

In NZ, non-cardiac sonographers and MRTs are able to register through the MRTB; however, cardiac sonographers do not have compulsory registration. In Australia, sonographers do not have compulsory legislative registration but do have compulsory accreditation with the Australian Sonographers Accreditation Registry (ASAR) when providing Medicare services. In comparison, medical radiation technologists (the equivalent of NZ’s MRTs) begin compulsory registration under the National Registration and Accreditation Scheme (NRASS) from 1st July 2012. In the UK, sonographers do not need accreditation or compulsory registration to practice and voluntary accreditation is facilitated through The British Society of Echocardiography (BSE) and The Society of Radiographers (SOR). MRTs in the UK are called diagnostic or therapeutic radiographers and have compulsory registration in order to practice. In the USA, sonographers in most states are not required by law to be accredited or credentialed and do not need compulsory registration to practice except in New Mexico and Oregon. In the USA MRTs are called radiologic technologists and national licensing is not compulsory except in two states but most states are fully or partially licensed. In Canada, sonographers and MRTs are not licensed at a national level although regulations vary by province. The Canadian Association of Registered Ultrasound Professionals (CARDUP) runs voluntary certification for sonographers, a national registry and national competency profiles for each sonography specialty.

Discussion

Size of the cardiac sonographer workforce

The SCANZ2 audit is the first time in New Zealand that the number of cardiac sonographers working in public healthcare has been identified. New Zealand is a small country geographically, with a population of just over four million people, and as a result, the cardiac sonographer workforce is also small. NZ’s compares favourably to the UK when comparing the cardiac sonographer FTE per million of population. Based on the NZ population the FTE equivalent per million population is approximately 14. This is much higher than that seen in the UK which varies from 5 to 6 in Scotland and Wales, to 12 in Northern Ireland. The UK data do not describe whether sonographer FTE included vacancies, whereas the SCANZ2 sonographer FTE did not include existing vacant FTE. As the number of vacancies in the UK was much higher than those from the NZ SCANZ2 data, this may explain some of the difference. Although recruitment and retention of a small workforce can be an issue, the SCANZ2 data shows that the vacant FTE is relatively low at less than 10% of the sonographer FTE available.

There is a mismatch between the considerably fewer FTE provided to the scanning role compared to the total number of cardiac sonographers. It is unclear from the data whether this is due to the number of cardiac sonographers who work part-time or whether some proportion of the FTE is performed in other roles.

The number of sonographers undergoing training was approximately one quarter of the total sonographer FTE. Three of those defined as students (by qualification status) in the audit have significant echo experience (greater than five years) and are likely experienced sonographers who are up-skilling to an echo relevant qualification. This is consistent with international trends where formal professional qualifications are increasingly an expectation of healthcare professionals.
Table 5: Comparison of sonographer and medical radiation technologist (MRT) workforce in NZ and internationally.

<table>
<thead>
<tr>
<th></th>
<th>NZ</th>
<th>Australia</th>
<th>UK</th>
<th>USA</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sonographer</td>
<td>MRT</td>
<td>Sonographer</td>
<td>MRT</td>
<td>Sonographer</td>
</tr>
<tr>
<td>Licensed</td>
<td>Excluding cardiac</td>
<td>✓</td>
<td></td>
<td></td>
<td>New Mexico and Oregon</td>
</tr>
<tr>
<td>Authorized certified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of sonography specialties</td>
<td>1 (and one tertiary)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Job titles</td>
<td>Sonographer</td>
<td>Medical radiation technologist</td>
<td>Sonographer</td>
<td>Medical radiation technologist</td>
<td>Cardiac technologist</td>
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<td></td>
<td>Echo technologist</td>
<td>Cardiac technologist</td>
<td>Cardiac technologist</td>
<td>Cardiac technologist</td>
<td>Cardiac technologist</td>
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</table>

Cardiac sonographer qualifications
The largest proportion of qualifications held is DMU Cardiac (Diploma of Medical Ultrasound) as was expected since DMU is the longest standing qualification available to NZ sonographers. The Graduate Diploma in Cardiac Ultrasound (QUT-PGD) is run by the Queensland University of Technology and enrolls NZ citizens as domestic students. Entry level for both DMU and QUT-PGD is a bachelor level degree. There is no cardiac ultrasound professional qualification provided by NZ based education providers. Currently only DMU and QUT-PGD are qualifications acceptable for registration as a cardiac sonographer with the MRT. Countries of origin of an overseas echo specific education were predominantly the UK, with some USA and South African qualifications.

Qualification information was not obtained for 19% of cardiac sonographers working in DHIs in NZ. The reasons for this are unknown but may relate to the absence of formal qualifications, or true omissions in data collection. Since each DHl had a single respondent for all cardiac sonographers working at that centre, it is possible that qualification information may have been omitted if not readily known.

Although most DHIs perform a mixture of adult and paediatric scans there is no paediatric post-graduate level qualification either nationally or internationally. The European Association of Echocardiography (EAE) runs a certification examination in congenital heart disease and there is a paediatric echocardiography credential available through the American Registry of Diagnostic Medical Sonography (ARDMS) in the USA but neither is recognised by NZ registration bodies.

Cardiac sonographer background
The high proportions of cardiac sonographers who come from a cardiac technological background demonstrate the close ties with the cardiac technology profession within NZ. Cardiac technologists continue to be a significant source for training into the sonographer role as the cardiac technologist has valuable and transferrable knowledge and skills that are essential for a cardiac sonographer, including an in-depth knowledge of cardiac anatomy/haemodynamics and the ability to integrate clinical, haemodynamic and physiologic data. In some centres, those performing cardiac ultrasound are employed as cardiac technologists and perform a variety of other non-invasive and invasive cardiac technological procedures. Initially most of those performing cardiac ultrasound were cardiac technologists but in more recent years the separate profession of cardiac sonography has become established and in many larger centres cardiac sonographers are employed to perform only this role.

The role and background of cardiac sonographers in NZ is similar to Australia, the UK and the USA but largely different to Canada. In Australia, the overlap of the cardiac technological
and ultrasound roles seen in NZ also exists with some centres employing cardiac technologists to perform echo as well as other technical duties and some centres employ only cardiac sonographers. In the UK, most cardiac sonographers are employed as cardiac physiologists and perform either invasive and non-invasive testing. In the USA, although cardiac sonographers are under the umbrella title of Cardiovascular Technologist, the cardiac sonographer role is generally a separate one and overall it is less common to perform other cardiac technical duties. In Canada, cardiac sonographers are employed and trained specifically for the role as a speciality of medical sonography.

Cardiac sonographer registration

Licensure in the form of compulsory registration of some healthcare professions is enforced in NZ. Licensure makes it illegal for unlicensed persons to perform acts within a lawfully defined scope of practice. The Health Practitioners’ Competency Assurance (HPCA) Act 2003 is controlled by the Ministry of Health (MOH) and the principal purpose is to protect the health and safety of the public by ensuring health practitioners are competent to practice. 

Examples of registered health professions include medical, nursing and some allied health professions such as chiropractic, medical laboratory science, physiotherapy and medical radiation technology. An additional assurance of public safety is the listing of specific activities that must be restricted to registered health practitioners. It is a requirement of registration to have a current annual practicing certificate (APC) to practice.

Cardiac sonographers in NZ are not required to register to practice as cardiac sonography is not a listed restricted practice, nor was it regulated under prior legislation (pre the HPCA). Presumably on the basis that there is no proven risk of harm in diagnostic ultrasound. In comparison, non-cardiac sonographers are required to undergo compulsory registration with the MRTB to practice under the HPCA Act since they are members of the medical radiation technology profession and to the HPCA Act, MRI’s were regulated under the Medical Auxiliaries Act 1966 and the Radiation Protection Act of 1965. The exclusion of registration into non-invasive forms of medical imaging was probably based on professionals’ boundaries rather than risk per se.

Although registration is not compulsory for cardiac sonographers, 70% have voluntarily registered with a professional body in NZ or Australia. In NZ, cardiac sonographers can obtain voluntary registration with either or both of the professional bodies (MRTB or CPRB), which list the scope of practice covering cardiac ultrasound. The CPRB ensures competency for clinical physiologists, scientists, technologists and technicians in the cardiology, respiratory and sleep sciences and lists the echocardiography role under non-invasive procedures performed by the profession of cardiac technologists. The MRTB is responsible for administration of the HPCA Act 2003 in respect of the profession of medical radiation technology and has eight listed scopes of practice including sonographer and trainer sonographer. Within healthcare this sharing of scopes of practice by more than one profession is common practice. Less than half of the cardiac sonographers who are registered with the MRTB meet the legislative requirements of the HPCA Act by holding a current APC. The cause of this is unknown but may relate to the differences in interpretation of the Act relating to cardiac sonographers by employers. NZ citizens performing cardiac sonography may also register with the ASAR and most registered with ASAR have registration with a NZ registration body also.

The shared sonography scope and overall national alignment of cardiac sonographers with the profession of cardiac technology rather than medical radiation technology has created confusion and discord with the ownership and use of the title sonographer. The HPCA Act states that an unqualified person must not claim to be a Health Practitioner by name, words or title. By definition in the Act a Health Practitioner is “a person registered with a particular health profession”. The MRTB regulates the profession of medical radiation technology and the regulated health practitioners they regulate under the Act are medical radiation technologists and regulated health practitioners who are physicians of radiation professionals (MRIPs) with different scopes of practice. The MRTB must only those with current MRIC registration are able to use titles or suggest they are able to practice in the scope of practice gazetted for the profession of medical radiation technology. However, the HPCA Act does not list specific skills or activities to be restricted to a profession except those listed as restricted activities and does not list titles restricted to professions.

In other countries the legislation around restriction of title use is much clearer. The professional regulatory laws in British Columbia, a province of Canada, are very specific in that they list current reserved titles and state that it expressly prohibits a registrant other than from that regulatory authority from using the title or abbreviation of the title to describe the person’s work. In the UK the Health Professions Council (HPC) register 15 professions and the titles of diagnostic radiographer, radiographer and therapeutic radiographer are protected. In Australia, the National Alliance of Self-Regulating Health Professionals (NASRHP) is aiming to implement reserved protected title legislation to remove confusion around health practitioners versus unregulated workers.

Although professional licensing is voluntary at present for cardiac sonographers in NZ, and most sonographers internationally, there are some advantages to this form of professional control. The main advantage proposed is patient safety. This is the principal purpose of the NZ HPCA Act and also all other professional organisations internationally that regulate, certificate or accredit their health professional workforce. In the situation of cardiac sonography within NZ there has not be adequate evidence to demonstrate that the use of ultrasound is dangerous or that public health could be compromised by unlicensed use.

Another advantage to licensing is its proposed ability to enhance the image of the profession and leads to professionalism. A profession is created when an occupation develops academic training, requirements for formal qualifications and regulatory bodies with power to admit and discipline members. Waggoner et al. state that to be regarded as a professional the required minimal level of formal education should be a bachelor’s degree
and professional-led certification exams. Although sonography is described as a profession in Australia, the UK, Canada and the USA, it does not meet this definition of professional status due to either the lack of disciplinary power by the professional bodies that regulate it or from non-bachelor levels of formal education. The ASAR and BSE admit members who demonstrate a minimum level of education/experience but they do not have the power to review and ensure the professional conduct of registrants. In contrast, the NZ MRTRB does have this power; the minimum entrance level is a bachelor’s degree and therefore MRTs and non-cardiac sonographers in NZ can be said to be called health care professionals. Licensing can also improve the education/training and continuous learning of practitioners by the requirement of continuing professional development (CPD). CPD is an important way of ensuring that registered practitioners maintain up to date knowledge and skills to continue practising at a high level throughout their careers. This is especially relevant in healthcare which has rapidly evolving technology and practices.

A final advantage in professional licensing is its ability to provide information that can be used for future workforce planning. Experience in Australia has shown that professions regulated within a legislative framework have improved ability to identify and resolve workforce issues. Voluntary registered professions can only collect member data leaving the rest of the profession inaccessible which impacts on workforce planning. The lack of compulsory legislative registration for cardiac sonographers in NZ makes information on the workforce difficult to collect and the profession has suffered in cohesive national planning relating to education, adequate representation and professional legislative advocacy.

There are some disadvantages with professional licensing which also need to be considered. Registration of professions in NZ under the HPCA Act gives professional regulatory authorities the authority to set scopes of practice and prescribe qualifications for the profession. When including a new profession or making changes to scope of practice there needs to be consideration of the impact on the existing workforce. Changes may compromise the supply of healthcare professionals or have economic effects and needs to be weighed against potential harm to the public.

Although there is an advantage in the improved education to healthcare professionals, there must be consideration of the availability and access of the required education to the profession as a whole. In NZ there is no NZ based cardiac sonography qualification and no post-graduate qualification available in the paediatric echocardiography specialty worldwide. There is significant cost with regard to overseas course costs and travel, which may affect accessibility to NZ students. There are also members of the existing workforce who will not meet existing registration entry criteria with the MRTRB. Eight cardiac sonographers nationally (nearly 10% of the workforce) have physiology technology qualifications as their highest professional qualification and a further 12 (14%) have an overseas qualification not currently acceptable for registration with the MRTRB or CPREG. It is unknown what proportion of these have the requisite entry level educational requirements for entering DMU or QUT. All of these cardiac sonographers are very experienced (all have more than 5 years experience and many have more than 15 years experience) and their age may make re-qualification prohibitive. To minimise the impact on the workforce, it is essential that legislation be introduced at the time of compulsory licensing which provides a long time for minimum qualifications to be met.

Licensing also comes with a cost to either the sonographer or employer. The formal cost of legislative regulation includes the one of application to the regulatory body for admittance and an annual APC with CPD requirements. This is usually achieved by attendance at conferences and or other educational forums and also in self-directed way. These mandatory costs add a significant cost burden to the public health sector. The other major cost involved with licensing comes from the cost of obtaining required qualifications. Other less obvious costs of compulsory licensing include time away from patient care complying with certification, employer HR system changes and potential legal costs.

Compulsory registration for cardiac sonographers in NZ may also limit the flexibility in the workforce, which would impact on service provision and patient care. Most cardiac sonographers in public health come from a cardiac physiology background but it is unknown how many are still routinely performing other non-sonography tasks in their roles. It is suspected that in smaller centres more cardiac sonographers perform more than sonography routinely. Compulsory registration may limit the flexibility in smaller centres to provide essential services by requirement of minimum numbers for maintenance of a licence.

International experiences in registration

Internationally, most health professions are seeking inclusion in formal regulation and sonography is no exception. In Australia, the USA, Canada and the UK there have been on-going government or professional organisation led mandates to control cardiac sonography. All have argued for public safety as the primary motive in restricting practice to accredited, credentialed or licensed practitioners. In NZ the 2009 MOH review of the HPCA Act revealed the concern that there was an increasing number of professions applying for inclusion into the Act and also a proliferation of registration bodies. The review proposed that any changes to regulation within the HPCA Act should reflect the same over-riding principles as the UK, Ontario and particularly Australia. In Australia only one quarter of health professions are currently regulated but a further 26 professions have made submissions for inclusion. The National Alliance of Self-Regulating Health (NASRHP) argues that current methods of self-regulation do not do enough to protect public safety and proposes that a single framework is used to regulate all health practitioners with titled practitioners to meet standards set by the professions self-regulation authority. In the UK the Society of Radiographers (SOr) submitted to the Health Practice Council (HPC) to include regulation of sonographers which was accepted by the HPC but rejected by the Secretary of State for Health. In Ontario the Ontario Society of Diagnostic Medical Sonographers (OSDMS) has been pursuing the self-regulation of sonography in Ontario since 1983 without any resolution.

More recently there has been a collaborative approach to the challenges of professional licensing internationally. In the USA, as a response to the introduction of licensing in Oregon
and New Mexico, proposed licensing in West Virginia and North Carolina and the federal CARE bill (which may result in compulsory licensing of medical imaging procedures at a national level) there has been collaboration with other health professions to ensure that concerns of sonographers are heard and addressed. In Australia, NASRHP is a forum made up of eight self-regulating allied health professional associations and is involved in modelling the regulation all health practitioners. In Nova Scotia, the Nova Scotia Society of Diagnostic Medical Sonographers joined the Medical Radiation Technologists and Magnetic Resonance Technologists to work cooperatively and collectively to request that the current act governing MRIIs be reopened and that a new regulatory college be formed to license these three professions under one umbrella.

In New Zealand both the MRTB and CPRB are attempting to include the cardiac sonographers’ scope of practice into the HPCA Act. The MRTB have recently put out for consultation changes to scope of practice, which may make the compulsory registration of cardiac sonographers with the MRTB a reality. Cardiac sonographers could be regulated under the HPCA Act by the MRTB as they already regulate non-cardiac sonographers, and have a sonography scope of practice. However, cardiac sonographers are not aligned with the medical radiation profession and have no representation on the MRTB in the USA bills to license sonographers have been introduced in various states over the years - most without professional body representation or cardiac sonographer input and most have tried to link sonography in with Radiology professions for control by radiological professional bodies. The American Society of Echocardiography (ASE) does not believe that licensure for sonographers should be combined with licensure for other medical specialties. The CPRB continue to submit applications to the MOH for inclusion in the HPCA Act. Indications from the MOH are that if this is accepted then it is likely to be included within an existing regulatory board. The latest inclusion to the HPCA Act was by the Anaesthetics Technicians who became regulated within an existing health regulatory authority – the Medical Laboratory Science Board accepted responsibility for regulating the two distinct health professions.

A final route for consideration of registration of cardiac sonographers in NZ could be the inclusion of NZ cardiac sonographers into Australian regulation. The Thai-Thai Mutual Recognition Act is a bill that allows an individual who is registered in an Australian jurisdiction for an occupation the same entitlement in NZ. If Australian compulsory licensing of sonographers was established then since the ASAR currently recognises and accredits NZ cardiac sonographers these sonographers could potentially meet NZ requirements for registration.

**Limitations**

The SCANZ2 audit used to examine the cardiac workforce has limitations since the audit was designed primarily to assess the number of examinations performed regionally. This audit captures a snapshot in time (December 2010) and the workforce may differ from the current workforce. In addition as the SCANZ2 audited only DH1 providers the number of cardiac sonographers identified will be lower than that provided in the role throughout the country. Finally the audit data identified a difference in the number of sonographers nationally compared to the full time equivalent they provide to the role but it is not possible from the data available to determine the cause of this. Although 15% of sites reported performing foetal echocardiograms it is unknown whether this is performed by clinicians or sonographers, and does not include foetal echocardiography performed by non-cardiac sonographers.

Registration numbers were not reviewed at the same time as the SCANZ2 survey. The number of registered sonographers relates to numbers registered in March 2012 rather than December 2010 so direct comparison of registration of the same workforce as the SCANZ2 audit cannot be performed, although it is unlikely that significant changes have occurred.

**Conclusion**

The SCANZ2 audit is the first time that the cardiac sonography workforce in NZ has been identified at a national level. The size of the cardiac sonography workforce in NZ is small and this makes it a challenge for establishing independence from other professions. Although there are clear ties of background with the cardiac technological profession and shared scope of practice with sonographers from radiological professions the cardiac sonographer role is unique enough to not fit adequately with either professional group.

Internationally the separate profession of cardiac sonography has been established despite the variety of roles performed and role titles used. Within NZ cardiac sonography is not represented separately, and the difference in both employment title and role has lead to confusion for cardiac sonographers and those who employ them. Furthermore the split of sonography into those who are regulated and those who are not has lead to difficulties employing overseas sonographers who get conflicting messages over requirements to practice in NZ.

As cardiac sonography is a recognised separate profession in NZ there is no established national community and this lack of advocacy by cardiac sonographers has disadvantaged the profession. The ultimate goal for cardiac sonography as a profession in NZ should be to establish a national community to set minimum education and competency requirements. Registration would be an advantage if the professional registration body was inclusive of cardiac sonography representation and collaborative on decision making at all levels. It is important for the cardiac sonography community to drive future changes as Wagener, et al. states “if we continue to be passive about filling in the gaps of our standards and requirements and instead rely on others to define our position, we ultimately undermine our goal to be recognised as professionals and have no-one but ourselves to blame”.

**Disclosure**

Belinda Buckley is the Cardiac Representative on the CPRB.

**References**


Appendix 1

SCANZ2 contributing regional centres
Whangarei Hospital (Northland DHB)
North Shore/Waitakere Hospitals (Waitakere DHB)
Auckland City Hospital (Auckland DHB)
Starship Hospital (Auckland DHB)
Middlemore Hospital ( Counties Manukau DHB)
Waikato Hospital (Waikato DHB)
Taaranga Hospital (Bay of Plenty DHB)
Rotorua Hospital ( Lakes DHB)
Hawkes Bay Hospital (Hawkes Bay DHB)
Gisborne Hospital (Tairawhiti DHB)
Taranaki Base Hospital (Taranaki DHB)
Wanganui Hospital (Wanganui DHB)
Wairarapa Hospital (Wairarapa DHB)
Palmerston North (Mid central DHB)
Hutt Hospital (Hutt Valley DHB)
Wellington Hospital (Capital and Coast DHB)
Nelson Hospital (Nelson Marlborough DHB)
Christchurch Hospital (Canterbury DHB)
Dunedin Hospital ( Southern DHB)
Invercargill Hospital ( Southern DHB)

Appendix 2

SCANZ2 additional contributing centres
Whakatane Hospital (serviced by Taaranga Hospital)
Ashburton Hospital (serviced by Christchurch Hospital)
Timaru Hospital (serviced by Christchurch Hospital)
Warraa Hospital, Blenheim (serviced by Nelson Hospital)
Kaitaia Hospital (serviced by Northland DHB)
Bay of Islands Hospital (serviced by Northland DHB)
Dargaville Hospital (serviced by Northland DHB)
Rawene (serviced by Northland DHB)
Appendix C

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Regional differences in echocardiography provision in New Zealand – results from the 2013 SCANZ workforce survey

Regional differences in echocardiography provision in New Zealand—results from the 2013 SCANZ Workforce Survey
Belinda A Buckley, Katrina Poppe, Mark J Famworth, Gillian Whalley

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.\textsuperscript{1} Echocardiography is a common diagnostic imaging test that plays a crucial role in the provision of patient care for cardiovascular conditions, 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\textsuperscript{2} 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.\textsuperscript{3,4} And lastly, large variability in echocardiography provision throughout Canada has also been described.\textsuperscript{5}

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).\textsuperscript{6} 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”.\textsuperscript{7} 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.\textsuperscript{8,9}
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, 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”.2 In NZ the size of the cardiac sonographer workforce was investigated for the first time in 2010 and reported a “scarcity of personnel” as a possible factor in the regional differences seen in the 2005 SCANZ audit.4 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 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.11

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 20–65 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 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 coefficient predicted the increase or decrease in the total number of echocardiograms performed for each variable. R statistical software (v3.6.0) was used for all analyses.12
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 1700 echocardiograms per 100,000 population per annum were performed, with no significant differences seen between tertiary surgical and regional centres (surgical median 1802, range 1352–2077; 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

Echocardiography Service per 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 echocardiograms 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 echocardiograms 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

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* 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

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<td>0.29</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Data were entered into the model as binary variables; adjusted R² = 0.356.

Workforce size and demographics

There were 84 cardiac sonographers in NZ, 14 (17%) of which were trained 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...
Seventy-seven percent 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 139, range 1039–2193; regional median 1218, range 631–1938).

Table 3. Model 1 – trainee versus qualified workforce

<table>
<thead>
<tr>
<th>Interv/</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1385</td>
<td>636</td>
<td>0.01</td>
</tr>
<tr>
<td>% of workforce trainee</td>
<td>-0.0</td>
<td>636</td>
<td>0.37</td>
</tr>
<tr>
<td>Surgical centre</td>
<td>7.7</td>
<td>6.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Median scan time (minutes)</td>
<td>-11.1</td>
<td>15</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Adjusted $R^2$ = 35.5%

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

<table>
<thead>
<tr>
<th>Interv/</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2134</td>
<td>677</td>
<td>0.0001</td>
</tr>
<tr>
<td>Total FTE</td>
<td>50</td>
<td>77</td>
<td>0.52</td>
</tr>
<tr>
<td>Surgical centre</td>
<td>561</td>
<td>413</td>
<td>0.20</td>
</tr>
<tr>
<td>Median scan time (minutes)</td>
<td>22</td>
<td>17</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Adjusted $R^2$ = 73.8%

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 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. Since Māori and Pacific are known to have higher prevalence of cardiac disease, much higher prevalence of cardiac risk factors 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 proportionately higher deprivation is known to exist in Māori and Pacific populations, 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 the 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. 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 echos performed. This is not surprising as training of sonographers is time intensive and requires one on one direct supervision. 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. 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 echocardiograms per DHB with each minute increase in median scan time reducing the volume of echocardiograms 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 1.5 cardiac sonographer FTE per 100,000 population compared to 3.1 in Australia. 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 publicly 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 a 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 and the regional disparity in echocardiography volume has been noted previously, there have been no previous studies relating cardiac sonographers’ workforce distribution to regional echo service provision.
Competing interests: Nil.

Author information: Belinda A Buckley, Cardiac Sonographer, Cardiac Investigation Unit, Counties Manukau Health, Otauhu, Auckland; Katrina Poppe, Research Fellow, Department of Medicine, University of Auckland; Mark J Farnworth, Senior Lecturer, Natural Sciences, Unitec Institute of Technology, Auckland; Gillian Whalley, Professor/Associate Dean, Social and Health Sciences Research, Unitec Institute of Technology, Auckland

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Correspondence: Mrs Belinda Buckley, Cardiac Investigation Unit, Counties Manukau Health, Private Bag 2211, Otauhu, Auckland 1640, New Zealand. belinda.buckley@middlemore.co.nz

References


Full name of author: Belinda Lewis

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