Echocardiography service provision in New Zealand: The implications of capacity modelling for the cardiac sonographer workforce

Belinda Buckley, Mark J Farnworth, Gillian Whalley

ABSTRACT

AIM: Regional disparity in both utilisation and the cardiac sonographer workforce has previously been identified. We sought to model the capacity of the cardiac sonographer workforce at a national and District Health Board level to better understand these regional differences.

METHOD: In 2013, surveys were distributed to 18 hospitals who employ cardiac sonographers (return rate 100%). Questions related to cardiac sonographer demographics, echo utilisation and workflow. Actual clinical capacity was calculated from scan duration and annual scan volumes. New Zealand national actual capacity was compared to predicted capacity from three international models. Potential clinical capacity was calculated from the workforce size in fulltime equivalent (FTE) and clinical availability.

RESULTS: In New Zealand, scan duration and population-based clinical capacity varies between centres. The New Zealand capacity is similar to the UK 30:70 model, and consistently less than the US model for all scan types. There are marked regional differences in potential versus actual capacity, with 10/16 DHBs demonstrating excess potential capacity.

CONCLUSION: There is regional disparity in the capacity of the cardiac sonographer workforce, which appears to be strongly related to scan duration. Workforce capacity modelling should be used with need and demand modelling to plan adequate levels of service provision.

Echocardiography is the most common non-invasive imaging technique used for the diagnosis and prognosis of cardiovascular diseases. In New Zealand, like Australia, the UK and the US, echocardiography is mostly performed by cardiac sonographers, who are highly skilled and specialised healthcare professionals.[1]

Internationally, echocardiography services are under pressure due to a steady increase in echocardiography utilisation[2-4] and a shortage of cardiac sonographers.[4-6] This lack of additional workforce capacity has led to increasing waitlists,[7] reduced access and regional inequalities in the provision of echocardiograms.[5] Furthermore, a significant growth in echocardiography is predicted due to an increase in the prevalence of cardiovascular disease as a result of an aging population, burgeoning risk factors, and reduced mortality with improving treatments.[8]

There is similar pressure on echocardiography services within New Zealand, with a 17% increase in echo volumes from 2008 to 2012[9] and large differences between District Health Boards (DHBs) for both wait times and regional echo utilisation.[9,10] Overseas research has shown that the number of echocardiograms performed is correlated with the availability of fulltime equivalent (FTE) cardiac sonographers.[11] Our group has also previously identified regional disparity in the size and population-based distribution of the cardiac sonographer workforce in New Zealand.[10] The impact of this regional workforce disparity is of concern, and a better understanding of

the capacity of the cardiac sonographer workforce is essential to forecast adequate staffing and training levels to ensure high quality healthcare is provided.[12]

The aim of this paper is to model the capacity of the cardiac sonographer workforce at a national and DHB level using two models; the actual clinical capacity (total clinical hours performed) based on echo utilisation and scan duration, and potential capacity (available clinical hours) based on workforce size and clinical availability. Additionally, the New Zealand capacity will be compared to international models.

Methods

Data sources

In March 2013, surveys were distributed by e-mail to charge sonographers at 18 public hospitals. Survey participants were identified through networks and included all providers of echocardiography using a sonographer-led service. Survey questions were answered by a single respondent and related to the cardiac sonographer workforce characteristics, echocardiogram volumes for all scan types, the proportion of scan volumes not performed by sonographers and estimated usual scan durations for all scan types.

Data analysis

Surveys were returned between March and July 2013. Return rate was 100%, 15 centres responded by e-mail or post and 3 centres by telephone interview using a single interviewer. The survey responses were entered and separated by centre type (either surgical as tertiary providers of cardiac surgery, or regional). Information on DHB population was obtained from the Statistics New Zealand and Ministry of Health public access websites.[13,14] Utilisation for each scan type was the annual (2012) echocardiogram volumes (actual number of echocardiograms performed per centre) adjusted for the estimated proportion of scans performed solely by sonographers at each centre. Scan duration was the estimated usual scan duration for each scan type, including sonographer reporting time. Mean and median scan durations for each scan type were calculated at each centre and adjusted by the estimated proportion of scans which were longer and shorter than the usual duration.

The *actual* clinical capacity is the total clinical scan hours performed as echocardiograms by cardiac sonographers (in hours per year). Total scan hours for each procedure were calculated as scan duration for each procedure (converted from minutes to hours) multiplied by the procedural scan volume in 2012. Total scan hours were summations of both the usual scan volume and scan duration, as well as estimated volume and adjusted scan durations for the proportions of scans longer or shorter than the usual scan duration. Total scan hours were calculated for the following procedures: adult and paediatric transthoracic (TTE) scans (including trainee performed and portable bedside scans); exercise stress echo (ESE); dobutamine stress echo (DSE); and transoesophageal echoes (TOE).

Predicted clinical scan hours were calculated from 2012 procedure scan volumes (national and DHB) using procedure-specific time weightings from two international models; the UK workforce planning model[15] (with different inpatient and outpatient scan time weights to make two different models) and the US accreditation guidelines.[16] The DHB population-based actual capacity was calculated as the actual clinical hours per 100,000 population and compared to the clinical hours predicted using UK and US scan time weighting models.[15,16]

The *potential* clinical capacity is the clinical hours available for performing echocardiograms (in hours per year) and was calculated for each centre from the following 2012 information: the number of clinical sessions per working week based on the UK workforce planning model;[15] clinical workforce size (measured as the clinical FTE for performing echocardiograms only) of both trainees and qualified sonographers based on a 40-hour working week; calculations of available working days in 2012;[17] and leave provision information provided for both qualified and trainee sonographers. The total time was adjusted 20% for workflow inefficiencies described in the UK workforce planning model.[15]

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.

Table 1: Procedure scan duration: New Zealand surgical and regional centres, UK and US models.

		Scan duration (minutes)							
		TTE	**TTE IP**	**TTE training**	**TTE portable**	**DSE**	**ESE**	**TOE**	**TTE paed**
New Zealand surgical centres (n=5)	Range	30–60	30–60	45–75	45–75	45–90	45–90	45–60	30–75
	Mean	45	45	60	60	64	58	56	49
	Median	45	45	45	45	52	45	60	45
New Zealand regional centres (n=13)	Range	30–60	30–60	50–90	50–90	45–60	40–90	30–60	30–60
	Mean	47	47	46	66	58	54	48	48
	Median	45	45	60	45	60	45	52	45
UK model[15]		35	53	53	88	105	105	70	35
US model[16]		60	60	60	60	90	60	60	60

DSE: dobutamine stress echo; ESE: exercise stress echo; TOE: transoesophageal echo; TTE: transthoracic echo; TTE paed: transthoracic scan performed on a paediatric patient; TTE portable: transthoracic scan performed at the patient's bedside; TTE training: transthoracic scan performed by a trainee sonographer

A positive excess demonstrated calculations of actual capacity to exceed potential capacity (more echocardiograms produced than clinical time available), a negative excess demonstrated potential capacity to exceed calculations of actual capacity (more clinical time available than the echocardiograms produced).

Results

Procedure scan duration: New Zealand surgical and regional centres, UK and US models

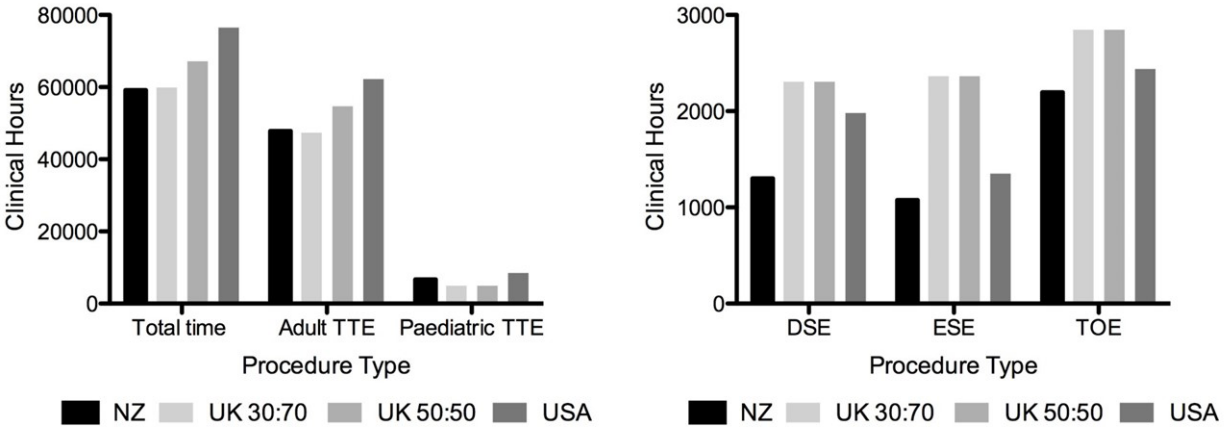
There are scan duration differences between centres for adult TTE scans, but no difference between centre types. Of the centres that perform paediatric echocardiograms, 4/16 (25%) increase the scan duration compared to adult scans, with duration increased an additional 25% to 33% of usual duration. At one regional centre, paediatric scans were 33% shorter than adult TTEs. Of the centres that have trainee sonographers, 9/18 (50%) of centres increased scan duration (from an additional 25% to 100% of usual duration). Other differences were noted: 5/18 (28%) of centres increased scan duration for portable scans by 25% to 66%; 9/12 (75%) of centres increased duration by 20% to 100% for DSEs; 9/13 (69%) centres increased duration from 20% to 33% for ESEs, whilst one centre shortened scan duration by 25% for ESEs. Finally, 4/16 (25%) of centres increased duration for TOEs, however two regional centres reduced duration for TOEs compared to standard scans.

New Zealand median scan durations (all centres) are shorter than the UK model for all procedures except TTE and paed TTE and shorter than the US model for all procedures except portable scans. Scan duration differences between New Zealand and the UK model vary widely from -14 minutes (New Zealand in excess) for paed TTE to +49 minutes (UK in excess) for ESE. Scan durations in New Zealand for portable scans, ESE, DSE and TOE are significantly shorter than the UK model. Scan duration differences between New Zealand and the US model vary from -3 minutes (New Zealand in excess) for portable scans to +29 minutes (US in excess) for DSE.

New Zealand echocardiogram actual capacity versus international models

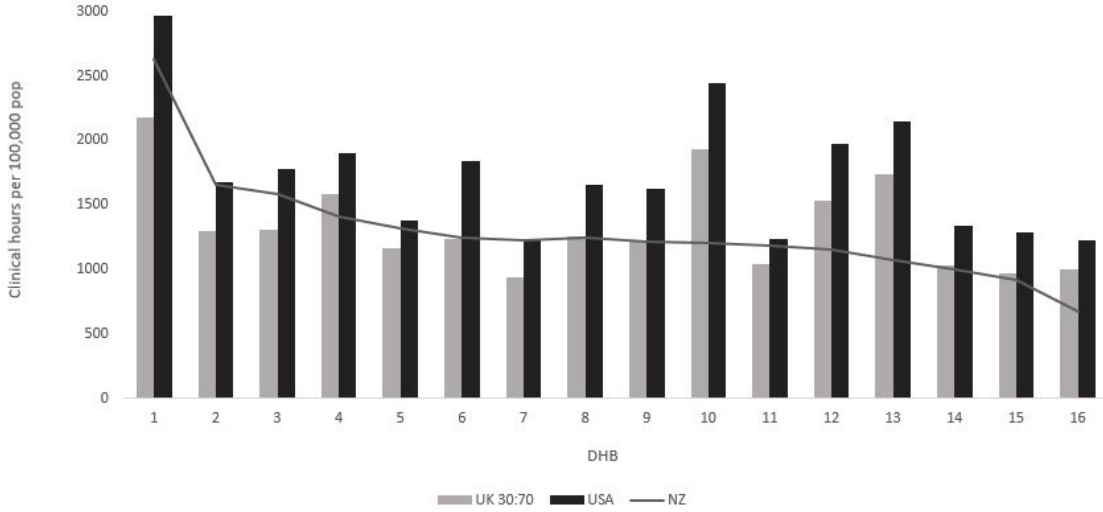
For both adult TTE and all procedures, the UK 30:70 model predicts similar total combined hours compared to New Zealand. For the New Zealand, UK and US models, the largest proportion of clinical hours were spent performing adult TTE. There is a 23% difference in total scan hours (17,364 scan hours) between the New Zealand actual and US model. New Zealand paediatric clinical hours exceed both UK models,

Figure 1a and 1b: New Zealand actual clinical hours (by procedure) based on 2012 national echocardiogram volumes, compared to clinical hours predicted using UK and USA scan time weighting models.[15,16]



DSE: dobutamine stress echo; ESE: exercise stress echo; TOE: transoesophageal echo; Adult TTE: adult transthoracic echo; paed TTE: paediatric transthoracic echo; UK 30:70: 30% inpatient, 70% outpatient; UK 50:50: 50% inpatient, 50% outpatient.

Figure 2: New Zealand annual clinical hours per 100,000 population for New Zealand DHB's compared to clinical hours predicted using UK and USA scan time weighting models[15,16]



NZ: New Zealand; UK 30:70: 30% inpatient, 70% outpatient; USA: United States of America

but are less than the US model. Both UK and US models report increased clinical hours for performing DSE, ESE and TOE scans compared to the New Zealand actual clinical hours for these scan types.

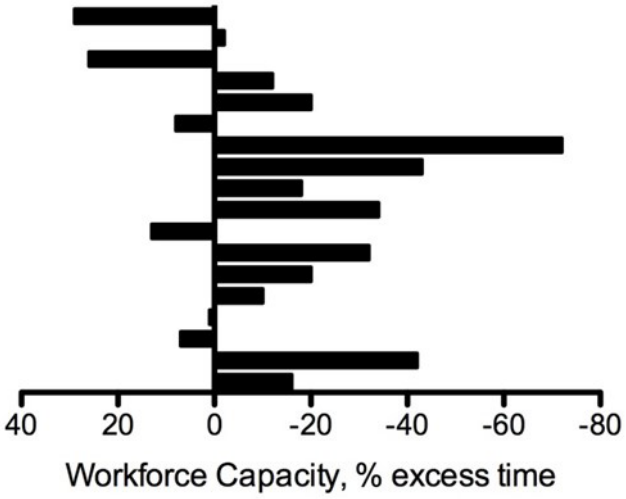
Population-based DHB echocardiogram actual capacity versus international models

There are marked differences in New Zealand actual total echocardiogram clinical scan hours between DHBs (923 to 2623 hours). 9/16 (56%) of DHBs produce less actual clinical hours than those predicted from both the UK and US models. The US model predicts higher clinical hours than New Zealand or the UK for all DHBs.

Actual versus potential clinical capacity

6/16 DHBs (37%) demonstrate a positive excess time difference in actual capacity—these DHBs produce more scans (calculated from scan volume and duration) than is predicted (calculated from workforce size and clinical availability). There is wide variability between DHBs—from 29% positive excess (more scans—actual greater than potential) to 72% negative excess (less scans—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 3: Comparison of actual versus potential clinical capacity by DHB expressed as a % excess time difference (in clinical hours).



Discussion

This study demonstrates marked regional differences in the population-based capacity of cardiac sonographers. One possible explanation for this variation may be the differences in procedure scan duration for each DHB, since scan duration has been associated with echo utilisation previously.[10] All echocardiographic procedure types showed wide differences in scan duration between centres with a scan duration in some centres double the duration of others and no relationship to centre type.

The international models also show marked differences in capacity, with the US capacity[16] and scan duration significantly higher than the UK,[15] although they showed similar trends. The US model uses scan durations that are recommended best practice[18] and are based on national accreditation standards.[16] The 60-minute TTE duration 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 US workforce surveys, which show an average daily scan number of nine.[19,20] The UK model scan durations[15] are based on national averages of 35 minutes for a standard TTE (including reporting), which is comparable to a survey of practice in the UK which found that on average 13 scans were performed per day.[3] However, UK scan durations are markedly different for TTE inpatients and outpatients, and since New Zealand utilisation proportions are unknown, we developed two UK models to allow comparison to New Zealand capacity. The 30:70 model reflects capacity with fewer inpatients to outpatients—anecdotally a similar workload distribution of New Zealand smaller regional centres. The 50:50 model reflects capacity with an even split of inpatients to outpatients—most likely similar to New Zealand larger centres. The capacity predicted by the UK 30:70 model aligns closely with the New Zealand capacity for both adult TTE and total all scan types, whereas the UK 50:50 model predicts capacity between the New Zealand actual and US model. Overall, it appears that it is the duration of TTE scans rather than other scan types that is driving the capacity differences, which is not unexpected since adult TTEs are the most common type of scan performed in New Zealand.[10]

Another likely factor in the regional capacity differences is the proportion of sonography trainees, with our groups previous study demonstrating that training affects echo utilisation.[10] This is supported by the 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 is time intensive and requires one-on-one supervision[10] it is expected that training centres will have reduced actual clinical capacity, not only

from the increased trainee scan time, but also from the direct supervision required.

Other possible causes for the regional differences in clinical capacity relate to differences in service provision and centre size.[10] Clinical capacity may be reduced in centres with little or no clerical support if sonographers spend clinical time performing these duties, whereas in centres which operate as outreach, or on more than one site, clinical capacity may be reduced by travel time. Additionally regional differences may relate to individual centre adherence to health and safety best practice guidelines.[21] Since musculoskeletal injury risk increases with scan duration and volume,[22] capacity may be limited by processes to reduce the risk of injury to sonographers. It is likely that there are other unidentified differences in echocardiography service provision which will also affect clinical capacity; future work should aim to identify all differences at an individual centre level.

There are also marked regional differences in the potential versus actual capacity between DHBs which are not related to centre type. Aside from 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 model used for the number of clinical sessions available per sonographer FTE per week,[15] 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.

In New Zealand, capacity modelling for the cardiac sonographer workforce is difficult due to a lack of accessible information. There is no national collection of cardiac sonographer workforce information since cardiac sonographers have no formal requirement for licensing.[1] 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.[6] In the future, demand in echocardiography services is likely to increase[23] 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[23] and also additional support roles established to increase efficiency of time able to be spent on performing clinical work.[23]

Although this study models the capacity of the cardiac sonographer workforce it does not measure the need for echocardiography services. 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.[1] In the UK, the national need for echocardiography was calculated as the number of studies per million population per year required from eight main indications, and this has been modelled as an estimated need for 28–40 cardiac sonographers per million population.[15] In New Zealand, there are 16 cardiac sonographers per million population[10]—43% to 60% less than the estimated UK need. Although the same disease population data is not readily available in New Zealand, 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 New Zealand. This study also does not measure or model the demand for echocardiograms. Demand reflects both utilisation and waitlist volumes[24] as well as differences in referral practices including the appropriateness of the referral.[25] 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. The focus should be on planning for a required level of service provision and

how this might be best supplied economically rather than planning for the 'right' number required of a profession.[26]

Limitations

This study has collected a complete national sample of sonographer performed echocardiography within public healthcare, however since private institutions have been excluded, it does not represent all echocardiography provision in New Zealand. Additionally, the study represents a snapshot of New Zealand echocardiography services over a 3-month period, and as such is an accurate representation of this single point in time only. 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 explored the contribution of workforce size to the regional differences in echocardiography provision within New Zealand and adds to previously described persistent differences. Modelling the capacity of echocardiography services based on the cardiac sonographer workforce shows marked population based differences between DHBs in terms of actual clinical hours and predicted clinical hours available (based on sonographer FTE) and different and lower service provision when compared to international models.

Although this study is unable to calculate the 'right number' of echo volumes or cardiac sonographers required for each region, comparison to a UK need-based model suggests that there is a need versus capacity mismatch in the cardiac sonographer workforce in New Zealand. The reasons for this are likely multi-factorial but appear closely related to scan duration. This study has not considered indication-specific population need, referral appropriateness or capacity unrelated to the workforce. Future planning of echocardiogram services will require ongoing data collection of the workforce and utilisation to allow for trending over time and to predict future service requirements.

Competing interests:
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Author information:
Belinda A Buckley, Cardiac sonographer, Cardiac Investigation Unit, Counties Manukau Health, Otahuhu, Auckland; Mark J Farnworth, Associate Professor, School of Biological Sciences, Plymouth University, Plymouth, UK; Gillian Whalley, Professor/Associate Dean, Social and Health Sciences Research, Unitec Institute of Technology, Auckland

Corresponding author:
Belinda Buckley, Cardiac Investigation Unit, Middlemore Hospital, Private Bag 93311, Otahuhu, Auckland 1640
Belinda.Buckley@middlemore.co.nz

URL:
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