*Original Article*

JRSM Cardiovascular Disease
Volume 7: 1–7

DOI: 10.1177/2048004018779736
journals.sagepub.com/home/cvd
SAGE

# Is it time to change? Portable echocardiography demonstrates high prevalence of abnormalities in self-presenting members of a rural community in Kyrgyzstan

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**Abstract**

**Objectives:** Cardiovascular disease accounts for 42% of male and 51% of female mortality within Europe. Kyrgyzstan, population of almost 6 million, has amongst the highest rates within Europe, second only to Uzbekistan for female cardiovascular disease mortality (588 per 100,000). We attempted to identify established cardiovascular disease prevalence within a rural community in Kyrgyzstan using portable echocardiography.

**Design:** Free open access echocardiography (VIVID-I, GE, USA) was offered to all adults in Batken district. Routine echocardiographic views were obtained and analysis performed using EchoPac Clinical Workstation (GE, USA). Mild valvular regurgitation, mild LV hypertrophy, patent foramen ovales and mild atrial enlargement were considered mild abnormalities; compensated ischaemic or valvular heart disease – moderate abnormalities, and decompensated congenital, ischaemic or valvular disease – severe abnormalities.

**Results:** One hundred and twenty five adults (48 male, 77 female), mean age $53 \pm 16$ years, underwent echocardiography. Only 16% of participants had no significant abnormality, 46% had mild disease, 25% moderate, compensated disease and 13% had severe disease. Nine percent had congenital heart disease including one tetralogy of Fallot and one Ebstein's anomaly. Average LV function was normal, however, 19 participants had EF $< 50\%$. Forty percent of participants had a new diagnosis warranting formal follow-up, 12% a new diagnosis of heart failure.

**Conclusion:** Using portable echocardiography, we identify a higher than reported prevalence of cardiovascular disease in rural Kyrgyzstan. Absence of portable tools and specialists for early diagnosis might lead to presentation in an advanced stage of disease when little can be done to improve mortality. Embracing remote access diagnostics is essential for disease identification within rural communities.

**Keywords**

Cardiology, cardiology, diagnostic testing, echocardiography, epidemiology, etiology, population cardiology

Date received: 22 August 2017; revised: 19 April 2018; accepted: 23 April 2018

## Introduction

Cardiovascular disease (CVD) remains the principal cause of mortality within European and Central Asian states and across the world, and marked inequalities still remain in the impact of CVD between countries.[1,2] Within the recent Epidemiological Update from the European Society for Cardiology, Kyrgyzstan in Central Asia, was identified as a country with substantial inequalities and significant premature mortality compared with many Western European states. Despite the national programme, "Manas-taalimi" aimed at prevention of cardio vascular diseases,[3] with integration of cardiology service systems and education of personnel and investment in

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diagnostics, the CVD mortality rates in 55–64 year old males and females matched that of 75–79 year olds from France. We must also consider that in largely rural countries, access to healthcare is not readily available, and therefore accurate diagnosis at the time of death may be hindered; this could either falsely increase the cardiovascular mortality as patients are wrongly labelled as dying of CVD, or underestimate the true prevalence due to lack of correct timely diagnosis in patients with CVD.

Previous cohort studies utilising echocardiography have been used around the world to identify the undiagnosed burden of CVD, and perhaps give us an indication of its true prevalence but these have largely been performed in developed nations. For over 20 years, the idea of remote telemedicine has been considered in cardiology, with echocardiography performed in rural areas and sent to experts for interpretation.[4–6] As mentioned above, this has largely been confined to rural areas of developed nations. The limited resources of both equipment and expertise within developing nations with large rural populations do not just limit the ability to investigate disease, but also may influence the ease of access to appropriate treatments.

In this study, local residents of a rural area of Kyrgyzstan were invited to have a full echocardiographic study performed by a visiting consultant cardiologist from London, UK. Any individuals living within the Batken district of Kyrgyzstan were eligible to attend an open-access clinic to have the echocardiogram performed.

## Methods

Local residents within the Batken district of Kyrgyzstan were invited to undergo free echocardiography between 9 August 2015 and 26 August 2015. The studies were performed by one operator using portable echocardiographic equipment with an S3 probe (VIVID-I, GE, USA). This open-access, free service was advertised to local residents via local television and newspaper media. Whilst children were included in scanning, only adults (>16 years of age) were included in this cohort study. This service was supplied because this region did not have local access to echocardiography, and for some patients this information could help guide their clinical management. These echocardiographic studies were not done for research purposes and ethical approval and consent were not obtained, as this is a descriptive observational study based on a clinical cohort.

This local area is supplied by a Batken District Hospital, which serves a population of 428,800. This has access to basic medical provisions, but not specialist cardiac care, for which you would have to travel to the capital Bishkek. Whilst two-thirds of the population of Kyrgyzstan is rural, this rises to three quarters in Batken district.

### Echocardiographic assessment

Standard echocardiographic views were taken and analysed as per EACVI guidelines.[7] These were stored principally as loops comprising two cardiac cycles. Doppler imaging was performed at a sweep speed of 75 cm/s with scale maximised to optimise the Doppler trace. Atrial areas, not volumes, were measured in the apical four-chamber view. One patient, due to a known recent history of a transient ischaemic attack (TIA), underwent a bubble contrast study alongside the full echocardiographic study, with 10 ml saline, 2 ml blood and <1 ml air agitated together and injected at rest and during a Valsalva manoeuvre to identify or exclude a patent foramen ovale (PFO).

### Grading of abnormalities

To allow for the statistical and graphical representation of a number of different abnormalities, they were grouped according to severity as determined by the authors. Mild valvular regurgitation, mild left ventricular hypertrophy, PFOs and mild atrial enlargement were considered mild abnormalities. Compensated ischaemic and moderate valvular heart disease were considered moderate abnormalities, and decompensated congenital or valvular disease, with evidence of ventricular dilatation and/or impairment, and severe, symptomatic LV systolic impairment were considered severe abnormalities.

Left ventricular ejection fraction (LVEF) was considered impaired at <50%.

### Clinical assessment

A clinical history and examination was taken alongside the echocardiographic study. This was principally intended to identify patients with cardiac symptoms. This was performed by the visiting consultant cardiologist from the UK, who commonly assesses heart failure patients. BNP was not used, but chest radiograph and 12L ECG were arranged if clinically indicated.

### Statistical analysis

For normally distributed variables, mean ± standard deviation is given. For non-normally distributed variables, median (interquartile range) is shown. As this is a descriptive study, advanced statistical analysis was not performed. A P value <0.05 was considered significant throughout.

## Results

### Population

One hundred and twenty five adults underwent echocardiography (48 male, 77 female). The mean age was $53 \pm 16$ years and ranged from 16 to 88. All screened adults were from the local, rural area.

### Echocardiographic findings by severity

Using the previously defined degrees of abnormalities, 16% (21 participants) had a normal echocardiogram. Forty six percent (57 participants) had a mild abnormality of their echocardiogram. Twenty five percent (31 participants) had a moderate abnormality. Thirteen percent (16 participants) had a severe abnormality (Figure 1). The breakdown of the abnormalities is shown in Table 1.

Of those with a mild abnormality, over half (58%) were mild valvular abnormalities, with 33% having increased left ventricular wall thickness (LVH) as the predominant abnormality.

Four patients had findings typical of rheumatic heart disease, three of which had severe mitral valve disease, two with concomitant associated severe aortic valve disease.

### Congenital heart disease

One participant, due to their previous history, underwent a bubble echo study, which confirmed a PFO. A further participant was found to have an atrial septal defect (ASD) without right heart abnormalities, whilst four participants had ASDs with significant right heart abnormalities (largely RV dilatation). Two participants had abnormal aortic roots involving their aortic valves (ages 19 and 59). One participant had a ventricular septal defect (VSD), one Tetralogy of Fallot, and one participant Ebstein's anomaly. None of these abnormalities had been surgically corrected.

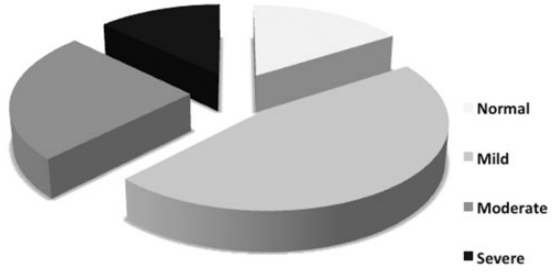


**Figure 1.** The proportion of individuals attending for open-access echocardiography with normal findings, or mild, moderate or severe abnormalities. For definitions of severity of abnormalities please see text.

### Left ventricular function

Whilst the average LVEF was within normal limits (63%, IQR 57–68%), 15% of participants had an abnormal LVEF, as defined by <50% (Figure 2).

### New diagnoses

Forty percent of all attendees were given a new diagnosis that would typically warrant regular follow-up. Twelve percent of participants were given a new diagnosis of heart failure based on echocardiographic findings and symptom description.

## Discussion

Cardiovascular disease is prevalent in Kyrgyzstan with significant morbidity and mortality. The average age at time of CVD death is up to 15–20 years earlier than some Western European states. However, the true prevalence of CVD might have been underestimated, as many adults may not be correctly identified as having CVD prior to or after their death. Risk factor screening and management is not managed as rigorously as in other nations which may lead to a greater proportion of patients presenting with more advanced disease.

In this cohort study, from a largely non-selected group from rural Kyrgyzstan, we have shown a high prevalence of echocardiographic evidence of CVD, with significant valvular, congenital or left ventricular systolic abnormalities found in over one-third of individuals scanned.

### Higher than expected prevalence of significant cardiovascular disease

As stated, we found an unexpectedly high prevalence of abnormalities within this rural cohort. Interestingly, there were 10 participants (8%) with significant congenital heart disease, including previously unknown cases of Tetralogy of Fallot, Ebstein's anomaly and five adults with ASDs, all if uncorrected likely to culminate in heart failure. There were two cases of abnormal aortic valves, one individual aged 19 with massive root dilatation, and a 59-year old with appearances of a hypoplastic aortic leaflet, both leading to severe aortic regurgitation which will ultimately lead to severe left ventricular systolic impairment if uncorrected. Within our predefined moderate and severe categories, there were multiple individuals with significant rheumatic heart disease, regional wall motion abnormalities indicative of ischaemic heart disease and primary valvular disease. All of these conditions would warrant regular cardiac follow-up and many would warrant urgent intervention. Fifteen percent of individuals had

**Table 1.** Breakdown of cardiac abnormalities identified by grade of severity. Where more than one lesion was identified, the most important was listed. Mild aortic valve disease was considered before mild mitral valve disease, which was in turn considered before right heart valve lesions and mild LVH.

| Category of lesions | Type of lesion | Number | % of total |
|---|---|---|---|
| Normal | | 21 | 16.8 |
| Mild | | 57 | |
| | Mild left ventricular hypertrophy | 18 | 14.4 |
| | Mild mitral valve disease | 19 | 15.2 |
| | Mild aortic valve disease/root dilatation | 12 | 9.6 |
| | Patent foramen ovale | 1 | 0.8 |
| | Left atrial dilatation (nil else) | 3 | 2.4 |
| | Mild tricuspid regurgitation (nil else) | 2 | 1.6 |
| | Other | 2 | 1.6 |
| Moderate | | 31 | |
| | Moderate–severe LV dysfunction with RWMAs | 7 | 5.6 |
| | Moderate–severe LV dysfunction without RWMAs | 3 | 2.4 |
| | Moderate–severe compensated MR | 7 | 5.6 |
| | Rheumatic heart disease with mild-moderate mitral or aortic valve involvement | 1 | 0.8 |
| | Evidence of ischaemic heart disease but EF>45% | 2 | 1.6 |
| | Moderate–severe compensated AR | 4 | 3.2 |
| | Severe left ventricular hypertrophy | 2 | 1.6 |
| | Moderate compensated tricuspid regurgitation | 2 | 1.6 |
| | Perimembranous ventricular septal defect | 1 | 0.8 |
| | Unexplained right ventricular dilatation without significant TR/pulmonary hypertension | 1 | 0.8 |
| | Isolated pulmonary hypertension | 1 | 0.8 |
| Severe | | 16 | |
| | Unrestricted secundum atrial septal defect | 5 | 4 |
| | Severe primary MR with ventricular remodelling | 2 | 1.6 |
| | Severe secondary MR with LV impairment | 2 | 1.6 |
| | Severe LV and RV dysfunction with heart failure symptoms | 1 | 0.8 |
| | Severe AR with LV dilatation | 1 | 0.8 |
| | Rheumatic heart disease with severe mitral or aortic valve involvement | 3 | 2.4 |
| | Tetralogy of Fallot | 1 | 0.8 |
| | Ebstein's Anomaly | 1 | 0.8 |

MR: mitral regurgitation; AR: aortic regurgitation; LV: left ventricle; RV: right ventricle; TR: tricuspid regurgitation; EF: ejection fraction; RWMAs: regional wall motion abnormalities.

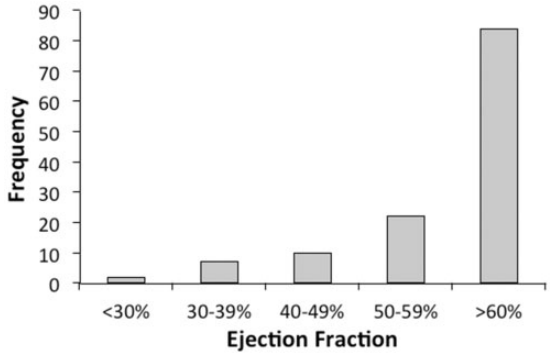


**Figure 2.** Frequency of left ventricular ejection fraction within the 125 individuals, as divided into severe (<30%), moderate (30–39%), mild (40–49%), borderline (50–59%) and normal (≥60%).

impairment of LV systolic function, and 12% already had symptoms and findings consistent with heart failure.

Milder abnormalities were very frequent, found in almost one-half of all individuals. Whilst these mild abnormalities would not typically cause symptoms they may identify individuals at risk, such as future diastolic dysfunction and heart failure with preserved ejection fraction in individuals with left ventricular hypertrophy and left atrial dilatation, or the progression of mild valvular disease to more significant and symptomatic forms. Less than one in six adults had a completely normal scan, despite more than one in five attendees being under the age of 40 years.

### Echocardiographic cohorts

A number of studies have looked at the prevalence of CVD within a population using echocardiography. The ECHOES study from the UK identified the prevalence of left ventricular systolic dysfunction (LVSD) as 1.8%, from a cohort of almost 4000 participants over 45 years of age, although they defined LVSD as an EF < 40%. A further 3.5% of participants had borderline LVSD (EF between 40 and 50%).[8] This combined prevalence of over 5% is well below the identified 15% of attendees with LVEF < 50% seen within our current study. In another UK study based on echocardiography of over 1600 randomly invited adults (ages 25–74), severe LVSD (EF <30%) was identified in 2.9%.[9] Within a US study of almost 12,000 adults identifying moderate–severe valvular heart disease, the prevalence was 2.5% and increased with age to 13.3% in those above 75 years of age,[10] an age group not well represented within our current cohort. The prevalence of congenital heart disease has previously been estimated at between 2 and 4 per 1000 live births.[11] All of these studies show significantly lower prevalence of disease than those seen within this current study.

However, if we look at a population closer in risk to the one studied here, a remote, rural location in Northwestern India, a large burden of undiagnosed cardiac disease was discovered.[12] In the ASE-REWARD study, international physicians and sonographers travelled to India to perform echocardiography over 2 days, scanning over 1000 patients, with remote image transmission for analysis by international experts, located within America. They found almost two-thirds of studies were normal, a higher proportion than in our current study, but interestingly the degree of major abnormalities (defined as ≥ moderate valvular regurgitation, any valvular stenosis, most congenital defects, LV dysfunction and significant LV wall thickening) was high at 16.7%, not dissimilar to the current study with severe abnormalities found in 13%. However, many of our cohort defined as having a moderate abnormality would be classified as severe within the ASE-REWARD study. They also performed screening to limit the echo study to the most suitable. It appears likely that rural Kyrgyzstan may have CVD prevalence higher than rural regions within similarly developed nations.

### Remote cardiac investigation

Development of portable echo machines with high image quality has changed the diagnostic approach in cardiology and has been a robust basis for the development of mobile echocardiography. There has already been high interest in such approach, given the relatively affordable price of diagnostic equipment and low maintenance costs. The studies have ranged from out-of-hours imaging outside the echo department by on-call staff[13] within the hospital, to outreach sonographer services travelling to remote rural regions of developed nations and transmitting the images to central, expert centres.[3,4] Whilst this is not a new concept, with some centres attempting this over 20 years ago, until recently the ability to transmit images internationally, especially from developing nations, was not readily available. Now, internet access can be found around the world, with bandwidth size able to upload and transmit large files characteristic for echocardiographic studies. Image file size remains the primary determinant of transmission time and can take up to 4 hours per study[11] but this is also under considerable development with some companies offering cloud based imaging solutions.[14]

Echocardiography is a skill requiring many years to perfect acquisition and interpretation. However, acquisition without in-depth interpretation can be learnt much quicker, allowing the training of local sonographers in regions such as Batken, with remote interpretation left to expert echocardiographers. These experts could be working in specialist centres within the same country. Equally, collaborations between centres in developed and developing nations could be established to help set up and support rural echocardiographic programmes in the future as demonstrated by the ASE-REWARD study. This could then establish a central database, which is currently absent in many Central Asian countries.

Inevitably, there will be mismatch between healthcare deliveries after remote diagnosis across different countries. In the ASE-REWARD study upon discovering a cardiac abnormality, participants were advised to seek specialist medical help within India, yet on future follow-up only half of identified individuals had further medical interventions. For example, within this study, there were a number of patients with significant valvular disease. In the UK, similar patients would be offered surgery; however, this is unlikely to be possible in a local healthcare service. Nevertheless, optimal medical therapy, particularly in patients with hypertension and heart failure is likely to improve short and long-term outcomes.[15–18] In addition, awareness of the scope of the problem will help planning and rational use of healthcare resources.

### Implications

Established and treated CVD within Kyrgyzstan may only be the tip of the iceberg of true CVD. If mortality statistics are correct, the extent of unknown CVD is likely to be contributing to the significant early mortality seen when compared to other, more developed,

states. Other countries with similar mortality statistics may also have a large, undiagnosed population with significant congenital, valvular or ischaemic heart disease. With early diagnosis and intervention, life expectancy can be significantly improved. Despite limited health resources, echocardiography remains relatively cheap, and even if surgical or percutaneous options for treatment are not readily available, the cost per person for optimal medical therapy for LVSD is low, and is highly cost-effective compared with premature mortality.[19] Potentially small investments in early diagnosis could yield significant improvements in length and quality of life. However, it could also be argued that similar investments in risk factor identification and management could have even larger benefits in reducing both the burden and impact of CVD, with alternative strategies such as smoking cessation or routine blood pressure checks. We must also remember that heart failure is a clinical diagnosis, and the echocardiogram must not be looked at in isolation. Training for local implementers of any service must also be trained in identifying signs and symptoms of heart failure, to best inform patient care.

### *Limitations*

Individuals who underwent echocardiographic assessment were not randomly chosen from the local population, as knowledge of the study was made through local media and word of mouth, with individuals deciding whether to attend for the echocardiographic study or not. It is therefore possible that there would be a higher than average attendance from individuals with abnormal symptoms, which would have the effect of increasing the prevalence of many of these abnormalities, especially the more severe ones. However, it is unlikely to have substantially affected the prevalence of mild abnormalities, which by our definition were markers of increased future risk rather than current symptomatic disease. The high prevalence of mild disease should therefore be more resistant to selection bias.

Almost all of the sessions were performed between Monday and Friday, potentially reducing the proportion of people in full-time employment attending for echocardiography. This group would be expected to have a high prevalence of normal cardiac anatomy and function given that they are able to perform full-time work, and may again bias the cohort's characteristics away from normal, healthy individuals.

Exclusion of PFOs using bubble echocardiography was not routinely offered, and was only performed on individuals who described a previous TIA, or had a dilated right heart without obvious cause.

The cardiologist determined presence of heart failure, based on symptoms, which can be misleading. Natriuretic peptide use would have increased both the specificity and sensitivity of this analysis but was not available.

## Conclusions

Use or mobile echocardiography in a self-selected cohort of 125 adults living within a rural area of Kyrgyzstan demonstrated a higher than published prevalence of established CVD. There was a 38% prevalence of significant echocardiographic abnormalities, with an 8% prevalence of congenital heart disease alone. Many of these abnormalities were previously undiagnosed. This may go some of the way to explaining the significant premature cardiovascular mortality in Kyrgyzstan compared with other European nations. The future of cardiac investigation in rural areas of developing nations may benefit use of portable diagnostic tools and collaboration with worldwide specialist centres to set up remote echocardiographic services, utilising the full potential of recent technological advances. This would then support the training of local, or national, cardiac services, so that ultimately reliance on international experts would not be necessary in the long term.

### Acknowledgements

The authors are grateful for infrastructural support from department of Echocardiography at Harefield hospital.

### Ethical Approval

These echocardiographic studies were not done for research purposes and ethical approval and consent were not obtained, as this is a descriptive observational study based on a clinical cohort.

### Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: There are no relationships with industry and no conflicts of interest. This is not currently under consideration by any other journal, and these data have never been published before. The three contributing authors have all approved the submission of this article. The authors declare that there is no conflict of interest/competing interests.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## Guarantor

Dr Baltabaeva guarantees the work.

## Contributorship

Authors TA and AB promoted the opportunity for local residents to have echocardiography performed on them locally in Kyrgyzstan, and these two authors also acquired the echocardiographic images. AJB and AB interrogated the anonymised images and performed statistical analysis on them. All three authors were involved in manuscript revisions.

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