

An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study

Thomas A Gaziano, Shafika Abrahams-Gessel, Catalina A Denman, Carlos Mendoza Montano, Masuma Khanam, Thandi Puoane, Naomi S Levitt



Summary

Background Cardiovascular disease contributes substantially to the non-communicable disease (NCD) burden in low-income and middle-income countries, which also often have substantial health personnel shortages. In this observational study we investigated whether community health workers could do community-based screenings to predict cardiovascular disease risk as effectively as could physicians or nurses, with a simple, non-invasive risk prediction indicator in low-income and middle-income countries.

Methods This observation study was done in Bangladesh, Guatemala, Mexico, and South Africa. Each site recruited at least ten to 15 community health workers based on usual site-specific norms for required levels of education and language competency. Community health workers had to reside in the community where the screenings were done and had to be fluent in that community's predominant language. These workers were trained to calculate an absolute cardiovascular disease risk score with a previously validated simple, non-invasive screening indicator. Community health workers who successfully finished the training screened community residents aged 35–74 years without a previous diagnosis of hypertension, diabetes, or heart disease. Health professionals independently generated a second risk score with the same instrument and the two sets of scores were compared for agreement. The primary endpoint of this study was the level of direct agreement between risk scores assigned by the community health workers and the health professionals.

Findings Of 68 community health worker trainees recruited between June 4, 2012, and Feb 8, 2013, 42 were deemed qualified to do fieldwork (15 in Bangladesh, eight in Guatemala, nine in Mexico, and ten in South Africa). Across all sites, 4383 community members were approached for participation and 4049 completed screening. The mean level of agreement between the two sets of risk scores was 96·8% (weighted $\kappa=0\cdot948$, 95% CI 0·936–0·961) and community health workers showed that 263 (6%) of 4049 people had a 5-year cardiovascular disease risk of greater than 20%.

Interpretation Health workers without formal professional training can be adequately trained to effectively screen for, and identify, people at high risk of cardiovascular disease. Using community health workers for this screening would free up trained health professionals in low-resource settings to do tasks that need high levels of formal, professional training.

Funding US National Heart, Lung, and Blood Institute and National Institutes of Health, UnitedHealth Chronic Disease Initiative.

Copyright © Gaziano et al. Open Access article published under the terms of CC BY-NC-ND 4.0.

Introduction

The burden of non-communicable diseases (NCDs) in low-income and middle-income countries is very high and compounds the effect of the already high burden of infectious diseases.^{1,2} Cardiovascular disease is a major contributor to the increasing burden of NCDs in these low-income and middle-income countries.² WHO has noted the crucial importance of investing in the prevention of NCDs and of community screening, both for the ability to reach large segments of the population in a cost-effective manner and for building community-based models of care for disease management, which is key to ensuring success in the reduction and management of NCDs.^{3,4}

Population-based approaches are an important aspect of public health strategies and particularly suited to the needs of low-resource settings, which face resource shortages (both human and fiscal) and need community support and contribution to ensure improved health outcomes.⁵

However, effective screening and appropriate management of patients who are at high risk of NCDs in low-resource settings is difficult owing to restricted human and financial resources.⁶ Health worker shortages are noted to be “the greatest impediment to health in sub-Saharan Africa”,⁶ where the proportion of trained health workers (doctors and nurses) in the region who intend to migrate ranges from 26% to 68%.^{6,7}

Lancet Glob Health 2015; 3: e556–63

See [Comment](#) page e508

Published Online

July 15, 2015

[http://dx.doi.org/10.1016/S2214-109X\(15\)00143-6](http://dx.doi.org/10.1016/S2214-109X(15)00143-6)

See [Online/Articles](#)

[http://dx.doi.org/10.1016/S2214-109X\(15\)00142-4](http://dx.doi.org/10.1016/S2214-109X(15)00142-4)

Division of Cardiovascular Medicine, Brigham and Women's Hospital, Boston, MA, USA (T A Gaziano MD); Center for Health Decision Science, Harvard School of Public Health, Boston, MA, USA (S Abrahams-Gessel SM); Centro de Estudios en Salud y Sociedad, El Colegio de Sonora, Sonora, Mexico

(C A Denman PhD); Institute of Nutrition of Central America and Panama, Guatemala City, Guatemala

(C Mendoza Montano PhD);

International Center for Diarrhoeal Disease Research, Dhaka, Bangladesh

(M Khanam MD); School of Public Health, University of the Western Cape, Cape Town, South Africa (T Puoane DrPH);

and Department of Medicine, University of Cape Town, Cape Town, South Africa

(N S Levitt MD)

Correspondence to:

Assistant Professor

Thomas A Gaziano, Division of

Cardiovascular Medicine,

Brigham and Women's Hospital,

Boston, MA 02115, USA

tgaziano@partners.org

This challenge also extends beyond sub-Saharan Africa to other low-income and middle-income country settings. In Asia Pacific, health personnel estimates range from 29·1 physicians, 14·4 nurses, and three laboratory health workers per 100 000 population in Bangladesh to 237 physicians, 816 nurses, and 97 laboratory health workers per 100 000 population in New Zealand.⁸ Task shifting from physicians to nurses in management of NCDs is effective in several countries, including high-income countries.⁹ A review of the evidence about nurse-led interventions shows that nurses are effective at the management of diabetes in primary care, outpatient, and community settings and in the reduction of admissions to hospital, days spent in hospital, several readmissions, patient care, and cost savings, even after the cost of the intervention is factored in.¹⁰ Still, the overall shortage of human resources in low-income and middle-income countries restricts the ability of nurses to manage NCDs and suggests the need for task sharing of some of the prevention work with community health workers.¹¹

Task shifting to community health workers in NCD management has largely focused on improvement of adherence or lifestyle choices, or of screening for cancer.¹² However, whether community health workers could be effective at both screening for, and monitoring of, people with cardiovascular disease is unclear. Studies are needed to assess the role of community health workers in both screening and monitoring of cardiovascular disease separately because they need different skills and functions that overlap with nurses and physicians. Also, community health workers are often not well trained and many do not have the instruments needed to manage NCDs.^{5,13} Furthermore, within the existing health-care system infrastructures in low-income and middle-income countries, the shortage of funding for NCD care, the limited evidence for the best models of care, and scarcity of resources to do laboratory-based assessments for NCD risk factors, such as lipid levels, provide additional challenges to effective screening for high-risk people at the population level.¹⁴

A non-invasive risk indicator was previously developed and validated using National Health and Nutrition Examination Surveys (NHANES) data in the USA and in several South African cohorts to assess the absolute risk of experiencing a cardiovascular-disease-related event 5 years after assessment.^{15,16} The indicator needs sex, age, height, weight, body-mass index (BMI), current smoking status, average systolic blood pressure, and diabetes status, when available, to be collected. We assessed whether community health workers could be effectively trained to do community-based screenings for cardiovascular disease using this non-invasive, risk prediction indicator in low-income and middle-income countries. We aimed to compare the accuracy of the community health workers' risk prediction scoring against those of health professionals.

Methods

Settings, community health worker selection, and participants

This study was done in four countries: Bangladesh, Guatemala, Mexico, and South Africa, which are part of the global network of US National Heart, Lung and Blood Institute and UnitedHealth Group centres of excellence for chronic disease, which total ten country sites representing 18 countries across the world. The four countries in this study recruited community health workers from a combination of rural (Matlab, Bangladesh and Santiago Atitlan, Guatemala), urban (Hermosillo, Mexico), and peri-urban (Khayelitsha, South Africa) sites. Each site recruited at least ten to 15 community health workers on the basis of usual site-specific norms for required levels of education and language competency.

Community health workers are typically people who are employed by government departments of health to assist in delivery of health-care services to offset personnel shortages. Their training is often informal and need based, and their skills are not obtained through degree granting or traditional health professional programmes, such as medical or nursing schools. The minimum number of years in education required at the individual sites were grade 8 for Bangladesh, 3 years of high school for Guatemala, and completion of grade 12 for South Africa. No formal education requirement was needed for community health workers in Mexico, but trainees had all at least completed middle school. Each community health worker had to reside in the community where the screenings were done and had to be fluent in that community's predominant language.

The study population for screening was drawn from the catchment area served by the local community health centres at each of the participating sites. Community health workers were assigned to a specific location within each site and had to visit each household in their assigned location until they recruited 100 eligible people for screening. Community residents aged 35–74 years were deemed eligible for screening and referral. People reporting a previous history of treatment for hypertension, diabetes, or known cardiovascular disease (stroke, myocardial infarction, or angina) were ineligible for screening because they were presumed to have been referred to, or treated in, their local primary health centres at some point before screening. Residents with a measured systolic blood pressure greater than 180 mm Hg were deemed clinically urgent cases. Community health workers did not assess these residents' cardiovascular disease risk, but provided them with an urgent referral for immediate assessment by a health professional (nurse or physician) at the closest health centre. Community health workers screened all remaining eligible participants and assigned them an individual cardiovascular disease risk score, as described below.

The study protocols were reviewed and approved by the individual site ethics and institutional review boards and

the US National, Heart, Lung and Blood Institute equivalent. Both the community health workers and individual participants signed two copies of the written consent form, and kept one copy each.

Training

Training of the community health workers was done over 1–2 weeks and included both practical and didactic components. Training teams were composed of health professionals (eg, nurses, physicians, and nutritionists) who were fluent in both the official and predominantly spoken languages at each site. Practical training covered measurement of the mid-upper arm circumference to establish the correct cuff size for measuring systolic blood pressure and the correct measurement of the mean systolic blood pressure over three readings that were taken 5 min apart with an automated Omron blood pressure machine. Further practical topics covered the measurement of height with an adjustable height stick, and weight with a digital scale, calculation of BMI with a calculator, completion of risk factor questionnaires through an in-person interview, maintenance of confidentiality through the recruitment and screening process, and assistance in the explanation and completion of informed consent forms. Additionally, practical assessments were completed including obtaining of anthropometric measurements on an individual basis by the study coordinator and trainers as part of the post-training assessment.

Didactic training covered cardiovascular disease definitions, symptoms, and assessment of risk factor history; obtaining of a cardiovascular disease risk score with the indicator; and completion of study forms, including consent forms. Didactic elements were assessed with a post-training knowledge test before selection of community health workers to deploy for fieldwork. Only community health workers who passed both the knowledge test (with a minimum score of 60% on content knowledge for cardiovascular disease and 100% on using the risk indicator correctly) and did well enough on the anthropometric measurement skills (100% score needed to pass) were deployed to do randomly supervised assessments during a 1–2 week run-in period; the study coordinator randomly selected a community health worker to accompany them for a day's recruitment and directly observed the health worker recruit for the study, screen the participant, and do other processes outlined in the study protocol. All community health workers were observed in this way before the end of the run-in period to identify any performance issues before their participation in fieldwork. The final selection of community health workers was made from those who did well enough during the run-in period, which resulted in some exclusion of community health workers who had passed the post-training tests. Fieldwork for each community health worker consisted of opportunistic screening of at least 100 community members for

4–6 weeks at community screenings or in members' homes.

Calculation of risk scores

The absolute risk score, developed and published in 2008 and similar to the Framingham risk score, uses self-reported data (sex, age, and current smoking status), measured anthropometric data (height, weight, and mean systolic blood pressure), and calculated data (BMI).¹⁵ The absolute risk score is further defined as the probability of experiencing a cardiovascular disease, or cardiovascular-disease-related event within 5 years after the risk assessment. The survival function underlying the risks assigned to individual cells on the risk scoring chart (figure 1) are described in detail by Gaziano and colleagues,¹⁶ including the development of the risk score and its validation in the NHANES population in the USA and South Africa.¹⁷ The risk chart is the same one used in the 2008 publication¹⁷ and the β coefficients underlying the risk factors used in the model and chart are listed in table 1. Each square in the chart corresponds to the risk range associated with the risk factor responses or measurements for each individual within non-diabetics: age, sex, smoking status, BMI, and systolic blood pressure. In this study, the risk score for eligible participants was determined separately by both the community health workers and health professionals. For this study, the preprinted risk scoring chart divided the risk itself into five categories: low (<10%), some risk (10–20%), moderate (21–30%), increased (31–40%), and high (>40%).

After collecting and calculating the data necessary to determine a risk score, the community health worker used the risk scoring chart to locate the individual cell where all of these variables intersect. They noted the colour of the selected cell and then wrote down both the cell colour and the corresponding risk range for the cell using the legend on the bottom of the chart. People whose risk score was 21–40% were provided with a non-urgent referral letter for a full assessment of risk and appropriate clinical management by a physician or nurse at the closest health clinic within 2 weeks of the date of screening. People whose risk score was greater than 40% were provided with an urgent, same-day referral letter.

A designated health professional at each site was responsible for generating a second risk score with the raw data collected by the community health worker and with the same risk scoring chart to select a cell colour and corresponding risk range within 2 weeks of screening by the community health worker. The health professional was provided with a copy of the raw data collected by the community health worker but was not provided with the community health worker's calculated BMI or risk score assignment. The health professional independently calculated the BMI for use in selecting a risk score. Study coordinators independently recorded both scores onto a

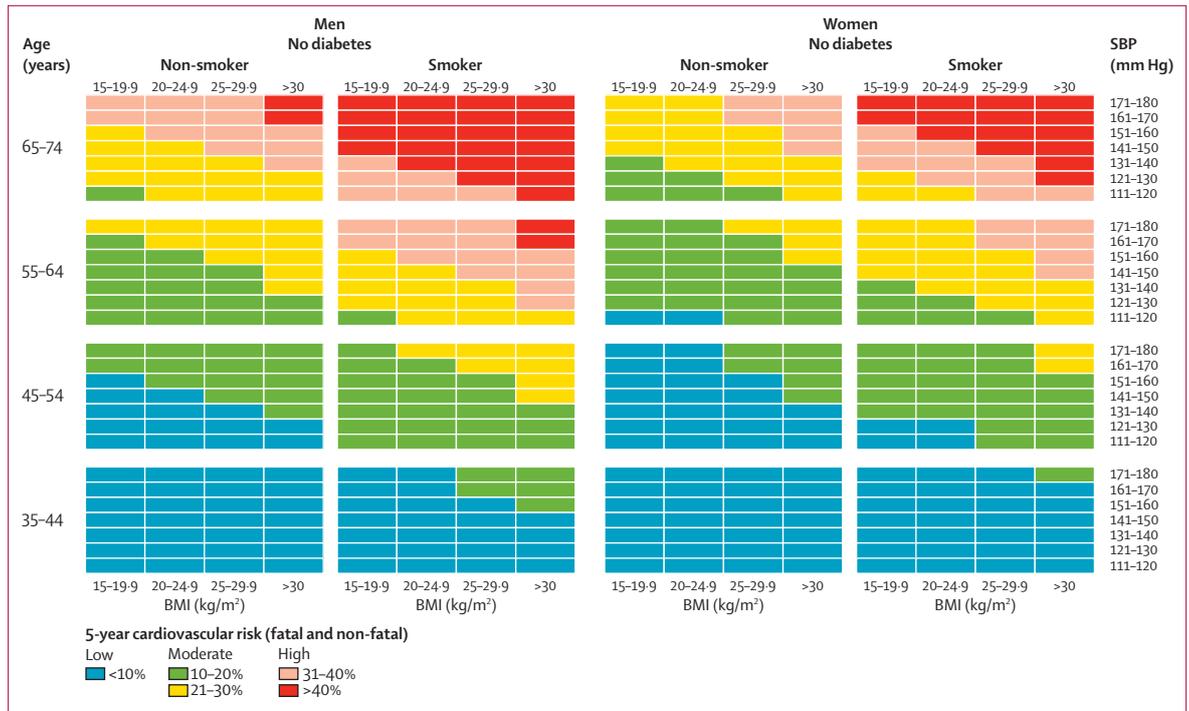


Figure 1: Risk scoring chart

How to use the chart: (1) choose the section with the patient’s sex, diabetes, and smoking status; (2) find the cell that matches the patient’s risk factor profile using age, BMI, and blood pressure; (3) refer to physician those with excessive blood pressure (>180 mm Hg).

	Men	Women
ln(age)	3.5837	3.783
ln(systolic blood pressure)	1.5249	1.499
ln(body-mass index)	0.6552	0.835
Diabetes	0.65	0.66
Smoking	0.59	0.58
Survival at time (t)	0.8914	0.927
Intercept	23.8178	24.8831

t=5 years

Table 1: β coefficients for risk factor variables used to calculate cardiovascular disease risk scores

scoring sheet. All data related to the study, excluding identifiers, were single-entered and double-entered into an access database and sent to the coordinating study centre for cleaning and analyses.

Outcomes

The primary endpoint of this study was the level of direct agreement between risk scores assigned by the community health workers and those assigned by the health professionals. We calculated κ statistics with 95% CI to measure the concordance between the two sets of scores.^{18,19} Checks on the frequency of mismatches between cell colour and noted risk level for community health worker risk scores were also done and had no effect on the primary endpoint results. In

cases where disagreement occurred between the two sets of scores that would warrant a change regarding a treatment referral recommendation, the study identity numbers were provided to the primary investigators to decide the best course of action for the affected participants.

Statistical analysis

Analyses were done using the statistical software packages SAS 9.3 and Stata 12.5.1 with a significance level of 5%. We generated descriptive statistics for the distribution of risk factors for populations in the study by producing mean and SD values for continuous variables (age, height, weight, BMI, systolic blood pressure, and diastolic blood pressure). Percentages are reported for dichotomised (0,1) variables of self-reported data (sex, current smoking status, history of diabetes, history of hypertension, and history of heart disease). Outliers, because they were deemed clinically infeasible and after independent verification from site coordinators values were true transcription errors for which no recorded correction was available, were omitted. In all cases, the values that were omitted were greater than two SDs from the mean for continuous variables (age, height, weight, BMI, systolic blood pressure, and diastolic blood pressure).

Role of the funding source

The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

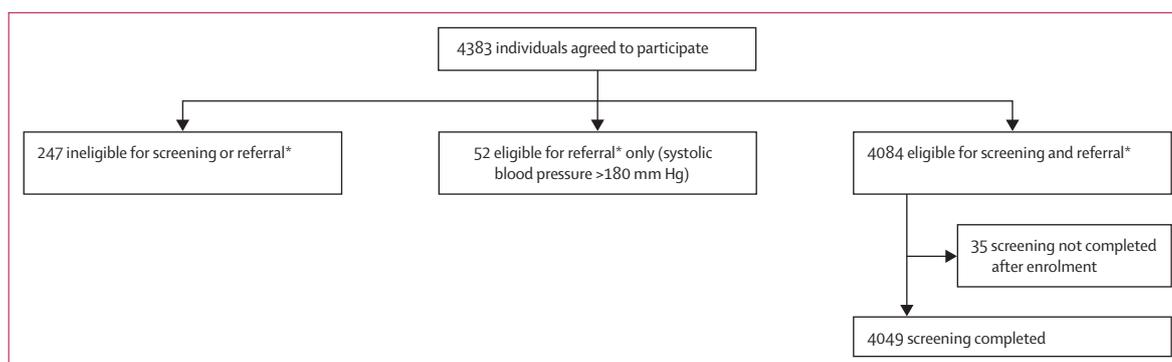


Figure 2: Enrolment algorithm

*Please note that the referral aim of the study is covered elsewhere.

The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Training was done from June 4, 2012, to Oct 15, 2012, depending on the study site. Recruitment for the study was done between June 27, 2012, and Feb 8, 2013, depending on the study site. Of 68 community health worker trainees recruited, 42 were deemed qualified to do fieldwork (15 in Bangladesh, eight in Guatemala, nine in Mexico, and ten in South Africa). There were 54 female (84%) and 10 male (16%) trainees. The mean age of trainees in Bangladesh, Mexico, and South Africa was 37 years. Guatemala did not collect age information about their trainees. Across all sites, 4383 community members (3287 of whom were female [75%]) were approached for participation and 4049 (3047 of whom were female [75%]) completed screening (figure 2). The mean age for women was 44.9 years and 47.4 years for men (table 2). The proportions of smoking and mean BMI in men and women varied widely across the sites. The highest proportion of current male smokers was in Bangladesh (113 [47%]) and the highest proportion of female smokers was reported in Mexico (125 [15%]). The mean BMI for women was 28.69 kg/m² (SD 6.7), ranging from 23.21 kg/m² (SD 4.5) in Bangladesh to 32.15 kg/m² (SD 7.7) in South Africa. Overall, the mean BMI in women was higher than in men at all sites, but women had a lower mean systolic blood pressure.

11 participants did not have both a community health worker and a health professional risk score, leaving 4038 for the primary outcome analysis. The mean level of agreement between the community health worker and health professional scores was 96.8% (weighted $\kappa=0.948$; 95% CI 0.936–0.961). Agreement levels at the sites were 97.4% ($\kappa=0.94$; 95% CI 0.89–1.00) in Bangladesh, 94.2% ($\kappa=0.86$; 0.81–0.92) in Guatemala, 96.5% ($\kappa=0.91$; 0.86–0.96) in Mexico, and 97.0% ($\kappa=0.94$; 0.89–0.98) in South Africa. 263 people (6%) were deemed to be at high risk (>20%) across the entire

	Trial wide (n=4046)	Bangladesh (n=843)	Guatemala (n=956)	Mexico (n=1030)	South Africa (n=1217)
Age (years)					
Female	44.86 (8.83)	47.41 (9.31)	44.6 (9.75)	43.75 (7.7)	44.36 (8.27)
Male	47.44 (9.62)	51 (9.16)	47.19 (10.6)	47.25 (8.87)	45.25 (9.14)
Height (m)					
Female	1.53 (0.09)	1.48 (0.07)	1.45 (0.06)	1.58 (0.07)	1.57 (0.07)
Male	1.63 (0.1)	1.59 (0.07)	1.55 (0.08)	1.71 (0.08)	1.66 (0.09)
Weight (kg)					
Female	67.27 (18.77)	50.59 (10.5)	59.1 (11.23)	74.16 (14.99)	79.59 (19.8)
Male	67.5 (17.18)	53.9 (9.11)	62.58 (9.78)	83.72 (16.92)	69.41 (15.79)
BMI (kg/m²)					
Female	28.69 (6.71)	23.21 (4.46)	28.04 (4.97)	29.7 (5.57)	32.15 (7.73)
Male	25.17 (5.30)	21.32 (3.54)	26.24 (3.96)	28.45 (4.84)	25.17 (5.59)
Mean SBP (mm Hg)					
Female	121.65 (16.29)	113.69 (14.89)	118.96 (15.71)	121.54 (14.19)	129.66 (16.05)
Male	125.55 (16.08)	117.09 (15.34)	121.93 (16.16)	127.13 (13.42)	132.35 (14.83)
Mean DBP (mm Hg)					
Female	74.94 (10.84)	72.19 (9.88)	72.57 (10.57)	74.63 (9.63)	79.23 (11.44)
Male	76.1 (11.11)	72.23 (10.06)	72.89 (9.93)	76.85 (9.04)	80.05 (12.13)
Present smokers (%)					
Female	7.41 (0.26)	0.83 (0.09)	0 (0)	15.38 (0.36)	11.05 (0.31)
Male	31.36 (0.46)	47.28 (0.5)	1.57 (0.12)	23.5 (0.42)	41.67 (0.49)

Data are mean (SD). CVD=cardiovascular disease. BMI=body-mass index. SBP=systolic blood pressure. DBP=diastolic blood pressure. *These data do not include three people from Guatemala for whom gender could not be verified on the original intake forms.

Table 2: Population distribution of key risk factor variables required for cardiovascular disease risk score calculation (non-missing values only)*

study and same-day, clinically urgent referrals were provided for 52 (19.3%) of them. South Africa accounted for 36 (69.2%) of 52 urgent and 93 (44.1%) of 211 non-urgent referrals; Bangladesh for 13 (25.0%) of 52 urgent and 48 (22.7%) of 211 non-urgent referrals; Mexico for 3 (5.8%) of 52 urgent and 35 (16.6%) of 211 non-urgent referrals; and Guatemala had no urgent referrals and 35 (16.6%) of 211 non-urgent referrals. The results of the internal validity check showed that agreement between the community health worker risk

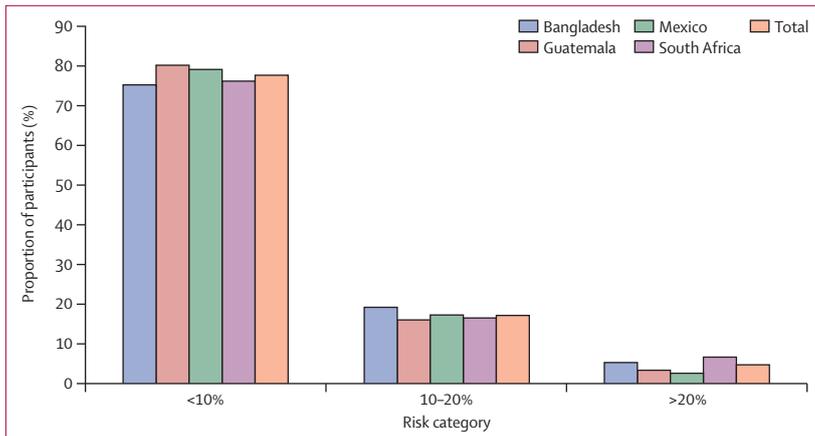


Figure 3: Distribution of community health worker risk scores categories by country

scores based on the range of the risk and the cell colour noted showed only 0.1% discordance (4 of 4038).

Of the 4038 people for whom a cardiovascular disease risk score was generated, 905 (22.4%) had a risk of greater than 10% and 3133 (77.6%) had a risk of less than 10% (figure 3). Participants with a risk of greater than 10% were divided into those with moderate risk (10–20%), 17.4% (704 of 4038), and those with high risk (>20%), 5.0% (201 of 4038). South Africa had the highest proportion of people at high risk. Guatemala had the highest proportion of people in the lowest risk category (<10%), with eight of ten people in this lower risk category.

Among individuals with a cardiovascular disease risk score, only 38 (1%) of the community health workers' risk assessments across the entire study were cases in which referral recommendations would have been changed with a physician's review, with Bangladesh, Mexico, Guatemala, and South Africa each contributing seven, eight, 18, and five of these cases, respectively. Of the 38 cases, 22 were reclassified as needing referral when the community health worker initially assessed no need for referral and 16 (42%) cases in which the community health worker made the recommendation for referral when the health professional's score would not have recommended referral.

Discussion

This study shows that community health workers can be effectively trained to screen for cardiovascular disease risk and generate scores that are in a high level of agreement with those generated by health professionals with formal training (physicians and nurses) across four low-income and middle-income countries. The risk factor data collected confirms that, even after excluding individuals with a previous diagnosis of diabetes, hypertension, or known heart disease, nearly 20% of the remaining low-income and middle-income country community members have a 5-year cardiovascular

disease risk greater than or equal to 10%. This result is a substantial number of people for whom community-based screening can offset development of cardiovascular disease. The level of agreement between community health worker and health professional scores seemed to be independent of individual country risk profiles.

Several reasons can be advanced for the high level of agreement. First, the selection process of community health workers was similar to those for many demographic health studies. Indeed, several surveys such as NHANES²⁰ in the USA and the Demographic Health Surveys²¹ in South Africa have successfully trained non-health professionals to obtain the anthropometric measures and blood pressures used for the risk score. Common to these surveys are intensive training in the appropriate local language. Second, in addition to the official language of instruction needed at each site, site coordinators and trainers were also fluent in the local languages used by most of the community health workers. This ability enabled more intensive instruction and greater room to address any misunderstandings or misconceptions that arose during training than if they had not spoken the languages. Third, community health workers who did not score high enough on proficiency in calculating the score were excluded. This result is consistent with the finding that supervision and audit of performance are key features of successful outcomes in health workers in low-income and middle-income countries.²² Finally, the additional supervision during the run-in period as a further assessment of the community health workers' abilities might have increased their proficiency. The risk chart itself is also simple to use. The chart allows for easy delineation by the six key risk factors and the colour-coding assists to distinguish risk levels.

The ability of well trained community health workers to do as well as formally trained health professionals, with simplified screening instruments, has been shown in high-income, middle-income, and low-income country settings (panel). In Bangladesh, community health workers with little training showed the capacity to screen independently for newborn illnesses with high validity compared with a doctor when using the same screening algorithm.²³ Similarly, community health workers effectively provided point-of-service screening to assess coronary heart disease risk by generating a 10-year Framingham risk score with computerised software, in underserved populations in 34 counties in Colorado, USA.²⁴ The effectiveness of community health workers to prescreen people at high risk for cancer and other conditions as a first step to subsequently increasing screening that requires high-level resources (eg, Papanicolaou smears obtained by physicians) or high-level training (eg, psychosocial risk assessment of pregnant women by nurses or physicians) has been shown in vulnerable populations in the USA.^{25–27}

Some of the challenges in the trial included the low levels of numeracy and literacy. Nonetheless, the number

Panel: Research in context**Systematic review**

We first searched Pubmed's Title and Abstract field using the most common terms to describe health workers without formal, traditional, or professional training or certification in the traditional health professions such as medicine or nursing. The specific search terms used were: "Community health workers", "lay health workers", "volunteer health workers", "community health promoters", "village health workers", "village health volunteers", "lady health workers", "community health aides", "health assistant workers", "home-based caregivers", "home community-based carers", "community health agents", "health surveillance assistants", and "traditional birth attendants". This search yielded more than 31 000 results. Results were filtered to include only articles published between Jan 1, 2004, and Dec 31, 2014, published in English, having full-text available to the Harvard University Library System, covering human participants only, and including the additional search term of "cardiovascular". This search resulted in a subset of 379 publications. Further refinements were made to include, in order, the search terms "heart" (n=307), "prevention" (n=57), and "screening" (n=17). A review of the final subset of articles showed that no studies consisting of primary screening for cardiovascular disease risk or screening in community settings were included. This final subset included studies related to hypertension education or control, knowledge of cardiovascular disease risk factors, educational efforts to promote knowledge about cardiovascular disease, or secondary prevention efforts for people with existing heart disease.

We did two additional searches using the same terms and steps with Google Scholar and the MetaLib[®] library database at Harvard University, which has access to many proprietary databases. No additional articles of relevance were obtained.

Finally, we searched of the publicly available data sources used regularly by us to obtain additional materials related to worldwide efforts in cardiovascular disease prevention, including WHO databases, departments of health (national and state) in the countries where the study was done, and organisations charged with gathering statistical data for public health in these countries, etc.

Interpretation

Overall, all search efforts confirmed that there is very little published evidence about primary screening efforts for cardiovascular disease in community settings in low-income and middle-income countries. Furthermore, the evidence for using validated, effective non-invasive indicators to assess risk, as well as task sharing with community health workers for primary screening in cardiovascular disease in these settings, is non-existent.

Our risk instrument is as effective as traditional, more resource-intensive screening indicators for assessment of absolute cardiovascular disease risk (eg, the Framingham risk score), having been validated in the USA and South Africa. However, before our study, no evidence existed to show the effectiveness of the use of a non-invasive, simple screening instrument for absolute cardiovascular disease risk by lay health workers in low-income and middle-income countries. We have shown in this study that community health workers can be trained to use this risk-screening instrument to ascertain absolute cardiovascular disease risk as well as trained health professionals, and provide evidence that population-based screening in community settings can be effectively accomplished in low-resource settings.

of community health workers who were unable to calculate the score was low and this was assessed efficiently during the training assessment. This challenge can probably be overcome through the development of an automated version of the risk indicator, which has a smaller dependence on a high level of numeracy. Another limitation is the potential generalisability of this intervention. However, there were three different regions represented: Latin America, south Asia, and sub-Saharan Africa, which suggests reasonable consistency in applicability in several regions and in different languages. Furthermore, the two countries in Latin America with different risk profiles, Mexico and Guatemala, had similar results. In each of the countries, there might also be underdetection of diabetes, which could lead to underestimation of the risk. This underestimation would not lead to a difference in the agreement in risk assessment but might lead to an overall underestimation of risk in the population.

The strengths of this study include showing the effective use of population-based screening with a simple

non-invasive risk indicator in different countries. Effective training of community health workers through a combination of didactics and practical training, in conjunction with an easy-to-use non-invasive risk assessment, probably contributed to the high level of agreement between the two sets of risk scores. This result also creates a potential pathway to train community health workers in other tasks related to cardiovascular disease and NCD screening and detection, while also introducing an opportunity to legitimise the standing of community health workers in these health-care systems.

A great opportunity exists for detection of people with latent disease, which, if it leads to improved management, could potentially create cost savings, although a further cost-effectiveness analysis needs to be done to confirm this. Furthermore, in addition to increased allocation of financial resources, time saved in screening by community health workers can free up time for nurses and doctors to focus on the management of the detected cardiovascular disease risks or for other NCDs. Another study has shown that, if community health workers

could help with adherence in addition to screening for NCDs, substantial cost savings could be achieved and time for other tasks by other health professionals would be gained.²⁸ Challenges for the integration of community health workers into the standard health-care team still exist and yet integration is crucial to overall success.²⁹ More studies confirming proficiency of community health workers to help with some necessary tasks will go a long way to improve the efficiency of screening for and management of those at high risk of NCDs such as cardiovascular disease.

Contributors

TAG and NSL conceived the idea and design for the study. TAG and SA-G analysed the data and drafted the report. CAD, CMM, TP, NSL, and MK participated in revisions for the report. TAG is the guarantor of the report. All authors approved the final version of the manuscript.

Declaration of interests

We declare no competing interests.

Acknowledgments

This study has been funded in part with federal funds from the US National Heart, Lung and Blood Institute, and National Institutes of Health, Department of Health and Human Services (HHSN268200900030C). The Center for Health Promotion in Northern Mexico also received funding from the UnitedHealth Chronic Disease Initiative. We thank Tracey Koehlmoos and Abdul Wazed (Bangladesh), Alvaro Rivera (Guatemala), Diana Munguía Carrasco (Mexico), Elsa Cornejo (Mexico), and Jabu Zulu (South Africa) for their assistance in training and supervising the fieldwork. We also thank Sartaj Alam (Harvard) for his assistance in revising the manuscript.

References

- WHO. Working together for health: the world report 2006. Geneva: World Health Organization 2006.
- Leeder S, Raymond S, Greenberg H, Liu H, Esson K. A race against time: the challenge of cardiovascular disease in developing countries. New York: Trustees of Columbia University, 2004.
- WHO. Preventing chronic diseases: a vital investment. Geneva: World Health Organization, 2005.
- WHO. 2008-2013 Action plan for the prevention and control of non-communicable diseases. Geneva: World Health Organization, 2008.
- WHO. Preparing a health care workforce for the 21st century: the challenge of chronic conditions. Geneva: Chronic Diseases and Health Promotion Department, World Health Organization, 2005.
- Anyangwe SCE, Mtonga C. Inequities in the global health workforce: the greatest impediment to health in sub-Saharan Africa. *Int J Environ Res Public Health* 2007; **4**: 93–100.
- Habte D, Dussault G, Dovolo D. The state of the health workforce in Sub-Saharan Africa: evidence of crisis and analysis of contributing factors. *World Hosp Health Serv* 2004; **40**: 23–26.
- Asia Pacific Action Alliance on Human Resources for Health, Health Human Resources Development Center, Ministry of Health, PR China. Annual review of HRH situation in Asia-Pacific region 2006–2007. http://www.who.int/workforcealliance/knowledge/resources/aaah_review/en/ (Dec 14, 2014).
- Riegel B, Carlson B, Kopp Z, LePetri B, Glaser D, Unger A. Effect of a standardized nurse case-management telephone intervention on resource use in patients with chronic heart failure. *Arch Intern Med* 2002; **162**: 705–12.
- Renders CM, Valk GD, Griffin SJ, Wagner EH, Eijk Van JT, Assendelft WJ. Interventions to improve the management of diabetes in primary care, outpatient, and community settings. *Diabetes Care* 2001; **24**: 1821–33.
- Beaglehole R, Epping-Jordan J, Patel V, et al. Improving the prevention and management of chronic disease in low-income and middle-income countries: a priority for primary health care. *Lancet* 2008; **372**: 940–49.
- Lewin S, Dick J, Pond P, et al. Lay health workers in primary and community health care. *Cochrane Database Syst Rev* 2005; **1**: CD004015.
- Fulton BD, Scheffler RM, Sparkes SP, Auh EY, Vujicic M, Soucat A. Health workforce skill mix and task shifting in low income countries: a review of recent evidence. *Hum Resour Health* 2011; **9**: 1.
- Lindholm LH, Mendis S. Prevention of cardiovascular disease in developing countries. *Lancet* 2007; **370**: 720–22.
- Gaziano TA, Young CR, Fitzmaurice G, Atwood S, Gaziano JM. Laboratory-based versus non-laboratory-based method for assessment of cardiovascular disease risk: the NHANES I follow-up study cohort. *Lancet* 2008; **371**: 923–31.
- Gaziano TA, Pandya A, Steyn K, et al. Comparative assessment of absolute cardiovascular disease risk characterization from non-laboratory-based risk assessment in South African populations. *BMC Med* 2013; **11**: 170.
- Pandya A, Weinstein MC, Gaziano TA. A comparative assessment of non-laboratory-based versus commonly used laboratory-based cardiovascular disease risk scores in the NHANES III population. *PLoS One* 2011; **6**: e20416.
- Cohen J. Weighted kappa: nominal scale agreement provision for scaled disagreement or partial credit. *Psychol Bull* 1968; **70**: 213.
- Fleiss JL, Cohen J, Everitt B. Large sample standard errors of kappa and weighted kappa. *Psychol Bull* 1969; **72**: 323.
- Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey, 2013–2014: overview. http://www.cdc.gov/nchs/data/nhanes/nhanes_13_14/2013-14_overview_brochure.pdf (accessed Dec 14, 2014).
- South African Medical Research Council. South Africa demographic and health survey 2003. <http://www.mrc.ac.za/bod/sadhs.htm> (accessed Dec 14, 2013).
- Rowe AK, de Savigny D, Lanata CF, Victora CG. How can we achieve and maintain high-quality performance of health workers in low-resource settings? *Lancet* 2005; **366**: 1026–35.
- Baqui AH, Arifeen SE, Rosen HE, et al. Community-based validation of assessment of newborn illnesses by trained community health workers in Sylhet district of Bangladesh. *Trop Med Int Health* 2009; **14**: 1448–56.
- Krantz MJ, Coronel SM, Whitley EM, Dale R, Yost J, Estacio RO. Effectiveness of a community health worker cardiovascular risk reduction program in public health and health care settings. *Am J Public Health* 2013; **103**: e19–27.
- Hou S-I, Sealy D-A, Kabiru CW. Closing the disparity gap: cancer screening interventions among Asians—a systematic literature review. *Asian Pac J Cancer Prev* 2011; **12**: 3133.
- Fernández ME, Gonzales A, Tortolero-Luna G, et al. Effectiveness of Cultivando la Salud: a breast and cervical cancer screening promotion program for low-income Hispanic women. *Am J Public Health* 2009; **99**: 936–43.
- Godecker AL, Harrison PA, Sidebottom AC. Nurse versus Community Health Worker Identification of Psychosocial Risks in Pregnancy through a Structured Interview. *J Health Care Poor Underserved* 2013; **24**: 1574–85.
- Pandya A, Weinstein MC, Salomon JA, Cutler D, Gaziano TA. Who needs laboratories and who needs statins?: comparative and cost-effectiveness analyses of non-laboratory-based, laboratory-based, and staged primary cardiovascular disease screening guidelines. *Circ Cardiovasc Qual Outcomes* 2014; **7**: 25–32.
- Herman AA. Community health workers and integrated primary health care teams in the 21st century. *J Ambul Care Manage* 2011; **34**: 354–61.