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Utilizing Mobile Phone Technology to Optimize Cardiovascular Disease Risk Screening by Health Extension Workers in Ethiopia

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Abstract

Introduction: Ethiopia is witnessing an unprecedented rise in cardiovascular disease (CVD) largely due to an epidemiological transition from an agrarian to urban lifestyle coupled with an aging society. Evidence-based screening strategies for CVD prevention are limited due to manpower shortages. Health extension workers (HEWs) in surrounding sub-Saharan countries have successfully screened for CVD risk using mobile phone technology, but this strategy has had limited testing in Ethiopia. The purpose of this study was to determine the feasibility and acceptability of utilizing HEWs to evaluate CVD risk using mobile phone technology in community settings in Ethiopia. **Methods:** A cross-sectional design was utilized that employed a validated mobile phone application to implement a CVD risk assessment based on the Framingham non-laboratory risk score. We enrolled 10 female HEWs (mean age 28) who received training in CVD risk assessment and blood pressure screening. Each HEW screened 30 community members (N = 300) from 10 different community settings or woredas in Ethiopia under the supervision of nurses. **Results:** HEWS identified with equal accuracy as master's prepared nurses those in the community at high, moderate and low CVD risk using the non-laboratory risk score algorithm via a mobile health app. Among all participants, (N = 144, 48.5%) were at low risk, (N = 95, 32%) at moderate and (N = 58, 19.5%) were at high risk for CVD. By gender, men were significantly older, more likely diabetic, current smokers and at almost twice as likely to be at moderate to high risk (70.5%) than women (36.9%). Referrals for CVD risk > 20% occurred in 13% of participants. The HEWs reported easy use and high satisfaction with the mobile phone app. **Conclusion:** Use of a HEWs and non-laboratory risk score is pragmatic and cost effective and has the potential to significantly improve early detection and management of CVD risk in Ethiopia.

Keywords

Cardiovascular Disease Risk Score, Health Extension Workers, Mobile Phone Technology, Ethiopia

1. Introduction

Cardiovascular disease (CVD) is responsible for approximately 18 million annual deaths worldwide, with approximately 75% of CVD deaths occurring in low to middle income countries (LMICs) [1] [2]. Premature CVD death rates in high-income countries have steadily declined over the last several decades and are likely due to lowered risk factors associated with positive lifestyle changes, earlier screening, risk reduction programs, and improvements in medical management [3]. CVD incidence and prevalence, however, are rapidly rising in LMICs [2] [4].

Ethiopia is undergoing an epidemiologic transition largely driven by demographic and lifestyle changes. Sociodemographic factors and a shift from a more rural lifestyle to industrialized, urban settings provide some explanation for the rapid rise in CVD in Ethiopia. For example, rural agriculture workers are reported to have a lower prevalence of hypertension, overweight and obesity than those residing in urban areas [1].

Although mortality from CVD most often occurs later in life in high-income countries, it occurs much earlier in LMICs during working age adults, which increases healthcare costs, years of disability, and financial insecurity [4].

The rising CVD epidemic will likely continue to escalate in LMICs as these countries undergo epidemiologic transition and as the population ages [5]. It is well-established that premature CVD deaths are often preventable through lifestyle behavioral changes such as controlling blood pressure, maintaining a healthy weight, eating a healthy diet, participating in routine physical activity, and avoiding smoking, but these risk reduction strategies are still in their infancy in most LMICs [6] [7]. Ethiopia is experiencing one of the most rapid increases in non-communicable diseases (NCDs), yet it is among the least prepared to address this challenge, largely due to the shortage of healthcare manpower resources [8] [9]. Although Ethiopia is the second most populous country in Sub-Saharan Africa, it also has one of the lowest numbers of health professionals in Africa. There is approximately 1 physician for every 50,000 citizens, and this supply is heavily tipped to the capital city (Addis Ababa) and to the private sector, despite 80% of the population residing in rural areas. Nurses, on the other hand have increased in number and now meet the WHO recommended minimum ratio of 1 nurse per 5000 citizens, but this number is lower in rural geographic locations where there remains a shortage of nursing manpower [10].

One strategy that aligns with Ethiopia's Ministry of Health is to utilize the Health

Extension Program (HEP) to deliver primary care services in geographic locations where health professionals are scarce [11]. Initiated in 2003, the HEP has made substantial contributions to improving health care access and coverage of key primary healthcare services with an emphasis on preventive, promotional, and selective treatment provisions with a special focus on maternal and child health. Task shifting assigns health care tasks to less trained individuals, or when certain tasks are moved from highly qualified to less-qualified health workers who have limited training [11]. The HEP facilitates the use of diagnostic services in community settings, saving time and transportation costs to regional health centers.

Health extension workers (HEWs) are a well-established and vital cornerstone of the HEP in Ethiopia. They have little formal training and provide basic preventative care such as vaccinations, maternal and child healthcare, hygiene and sanitation to their community [11] [12]. HEWs spend half of their time providing care at health posts and the remainder making household visits for health monitoring and delivering educational information [11] [13]. The focus of the Ethiopian health care system has been the treatment and management of communicable diseases, so HEWs lack training in NCD control and specifically in identifying CVD risk, preventative strategies, or when to refer high-risk individuals for further diagnostic tests and treatment. Recently, to support universal health coverage through primary healthcare, the prevention and control of NCDs are being addressed within the HEP policy [10] [14] [15]. The change in direction towards greater NCD treatment and control will provide HEWs more opportunities in the future to educate the community on CVD risk factors, to identify and intervene for those at highest risk to improve outcomes and lowering the growing cardiovascular burden in Ethiopia.

1.1. Laboratory versus Non-Laboratory CVD Risk Prediction

Several prediction models have been created globally to assess the overall risk of CVD over a 10-year period [16]. Among them, some are laboratory-based, requiring a venipuncture, laboratory facility and personnel for processing and are costly especially in LMICs where costs are often paid out of pocket by the patient. Whereas other CVD risk assessment tools are non-laboratory-based do not require blood processing or storage and are particularly pragmatic in low resource settings where laboratory personnel and facilities are limited. Across different studies and in different settings including sub-Saharan Africa, high reliability is consistently reported between the laboratory-based and non-laboratory-based Framingham risk prediction score tools that estimate 10-year risk of fatal and non fatal CVD events [16]-[20].

The reliability of the Framingham non-laboratory-based score with commonly used laboratory-based approaches has been validated in the United States [19]. In a follow-up study, Gaziano and colleagues [20] compared 10-year CVD risk for 14,772 adults from thirteen cross-sectional South African populations. Risk characterization was assessed by comparing rankings of risk with six laboratory-based scores (three versions of Framingham risk, SCORE for high- and low-risk countries, and CUORE) and ranked as "high" or "low" risk. Approximately 18% were characterized as "high CVD risk" (10-year CVD death risk > 20%) using the non-laboratory-based score. A high level of correlation between a simple, non-laboratory-based CVD risk score and commonly used laboratory-based risk scores was reported. The policy and clinical implications are that fast, low-cost screening tools can lead to similar risk assessment results compared to time and resource intensive approaches. Until setting-specific cohort studies can derive and validate country-specific risk scores, non-laboratory-based CVD risk assessment could be an effective and efficient primary CVD screening approach in Ethiopia. The ability to assess risk without the requirement of expensive laboratory blood tests is important in many low-income settings for multiple reasons. The first includes its ability to correctly classify patients at the thresh olds that most prevention guidelines choose for initiating treatment. Other considerations include practicality, cost and feasibility, in particular providing clinicians with the opportunity to make a treatment decision during a single clinic visit. This prevents the need for a labora tory test and a second patient visit to review the results and plan management, resulting in a reduction of costs and the potential for non-attendance at the follow-up visit.

The non-laboratory Framingham risk prediction (non-laboratory FRS) tool is used to determine sex-specific CVD risk prediction with the use of inputs of eight CVD risk factors including age, body mass index (BMI), systolic blood pressure (SBP), blood pressure (BP) treatment, smoking, and presence of diabetes [16]-[19]. The two tools use the same inputs with the exception that total cholesterol (T-C) and high-density lipoprotein cholesterol (HDL-C) are replaced by BMI in the non laboratory-FRS risk score algorithm [19]-[21]. We have previously compared CVD risk prediction scores between two Framingham tools among 367 students and officers attending the Ethiopian Police University College, a public institution of higher education. Point of care testing using Polymer Systems Technology CardioChek PA (Indianapolis, USA) [22] was employed to collect and analyze the TC and HDL samples on site from participants. Data was collected from 2021-2022 and participants were aged 25 - 56, with a mean age of 35.8 ± 5.2 years. The laboratory and non-laboratory predictive values for high CVD risk were essentially the same for both methods. The non laboratory-FRS predicted less moderate risk (18.2% versus 20.4) but were not significantly different. In contrast, a study conducted in Rwanda showed that the nonlaboratory FRS algorithms detected more people at moderate and high risk than the laboratory-based algorithms regardless of sex [23]. Based on the reliability and cheaper costs of the non-laboratory FRS risk score, we are in agreement with other investigators who recommend it be usedin low-resource settings [17] [20] [23]. Targeting early identification of high-risk individuals through effective CVD screening is a critical strategy to reduce CVD burden in LMICs. This can be accomplished through task-shifting, referral support and communication, and mobile phone technology [24].

Evidence suggests that HEWs can be trained to use the non-laboratory Framingham CVD risk prediction tool. For example, a study conducted in four countries—Bangladesh, Guatemala, Mexico, and South Africa demonstrated that trained HEWs successfully used non-laboratory tools for cardiovascular disease risk and produced results that were highly consistent with physicians and nurses [14] [16] [20] [24] [25]. A recent study in Nepal reported that a community CVD risk screening by health volunteers reported high concordance between CVD risk scores generated by volunteers and physicians [17]. HEWs have shown that with training they are able to identify individuals at high cardiovascular risk using the non-labora tory-FRS algorithm and have similar accuracy as health professionals providing blood pressure screening in surrounding sub-Saharan countries [14] [16], but both have had very limited testing in Ethiopia [25].

1.2. Mobile CVD Risk Screening

Most Ethiopians own a cellular device, increasing the portability of mobile phone technology as a potentially powerful tool for data collection, health monitoring, and disease surveillance. Despite the availability of mobile devices, very few studies have reported mobile health technology use in Ethiopia. Among those that have, most have included maternal child, infectious and communicable disease surveil lance with few targeting NCDs [26] [27]. The few studies that have utilized mobile health technology in chronic illnesses in Ethiopia have found high acceptance among participants and have exclusively focused on diabetes [28]. The use of electronic data collection compared to hand-written reports minimizes data loss, increases rapid information analysis and is associated with fewer errors [29]-[31]. Surrounding countries have been successful in utilizing HEWs for CVD risk screening using mobile phone apps with high patient satisfaction but have yet to be reported in Ethiopia [27] [32] [33].

This study aimed to examine the feasibility and acceptability of a HEW led CVD risk prediction program using a mobile phone app in 300 community participants at risk for CVD events using the non-laboratory FRS algorithm [19]-[21].

2. Materials and Methods

A descriptive, cross-sectional design was utilized to examine the feasibility and acceptability of using mobile phone technology for CVD risk screening. The mobile phone cardiovascular disease (CVD) risk assessment application was developed based on the non-laboratory FRS prediction risk model, previously developed and validated else where [20] [21]. The CommCareHQ platform was used to develop the mobile phone app. CommCareHQ is a well-validated and open-source software application with mobile phone and cloud organization that enables field data collection, tracking of HEW performance and follow-up for community participants. CommCareHQ has been used extensively in LMICs and in poor resource settings. This platform was selected over others because of the userfriendly interface, ease of data entry, and ability to capture and store data if connectivity was unstable or unavailable, a frequently occurring issue in Ethiopia. Relevant data entry fields were organized and programmed into the mobile phone application. The application was tested for question logic, ease of data entry, error messaging and calculation accuracy.

2.1. Setting and Participants

The Ethiopian healthcare system is structured in three-tiers, similar to the models seen in many other sub-Saharan African countries. The first level is primary health care and includes the primary hospital, health center and health posts where most HEWs are employed, serving as the initial point of contact and entry into the health system. The second and third tiers are general hospitals, and specialized hospitals, respectively, each providing progressively higher and more specialized levels of medical care and services. This study was conducted in two communities: Lemi Kura and Yeka. Five woredas were selected from Lemi Kura and Yeka, for a total of 10 woredas.

In Ethiopia 2 HEWs are assigned to each health post and serve approximately 3000 - 5000 people in each woreda [12]. HEWs are all females and are recruited based on nationally agreed-upon criteria such as living in the village, 18 years of age, ability to speak the local language, completion of 10 - 12th grade, and willingness to remain in the village and to serve the local community. All HEWs receive a year of training in educational institutions and are taught practical skills in health centers [13]. A total of 2 HEWs with no prior experience in CVD risk screening or using a mobile phone application for data collection were recruited purposively from each of the selected woredas where they served.

For the community participant selection, HEWs outlined the woreda where the sample population would be drawn. A comprehensive list of community participants from each catchment area who met eligibility requirements was used to determine the sample population in each woreda. A lottery method was used to select participants with every third household (k = 3) as a participant. Based on the size of the woreda, the sampling interval varied; in 4 woredas we selected every third household and every ninth house hold in 6 woredas.

The community participant inclusion criteria included adults aged 30 - 75 years of age who lived in the study area for at least 6 months and were able to speak the local language and had no prior history of CVD such as ischemic heart disease, heart failure, or acute myocardial infarction.

2.2. Ethical Considerations

This study was granted ethical approval from the Institutional Review Board at Addis Ababa University College of Health Sciences and adhered to the principles of the Helsinki declaration. To access the study participants, official letters of cooperation were obtained from the Addis Ababa Health Office, as well as the Yeka and Lemi-Kura health offices, addressed to the respective woreda (district) health offices that were used for data collection. Informed consent from community participants was obtained after the HEW explained the study purpose, the importance of CVD risk assessment, and how the data would be archived to ensure the participants' privacy. All HEWs received protection of human subjects training prior to data collection from community participants.

2.3. Data Collection

Prior to data collection, the HEW's underwent a 16-hour face to face training session and were assigned reading materials prior to the educational intervention. This training session had previously been used to train nurses on CVD risk screening for university staff, faculty, and police officers. The training was conducted by two PhD and one master's prepared nurse with expertise and experience in cardiovascular nursing practice. The educational training included the following content on CVD risk factors: 1) CVD disease pathology and clinical symptoms of acute coronary syndrome, 2) modifiable and nonmodifiable CVD risk factors, 3) lifestyle and behavioral risk factors, and 4) clinical measures required for conducting CVD risk assessment (blood pressure, height, weight, and BMI calculation). Educational sessions were also provided about the non-laboratory FRS risk assessment algorithm. The algorithm was calculated based on data input from the respondant. The CommCare HQ application platform was downloaded during the educational session on each of the HEWs phone for data entry purposes. Additionally, five trained nurse supervisors were paired with two HEWs to ensure data accuracy during practice sessions and on home visits in the community. Practice sessions were conducted during the training sessions and HEWs were required to have 75% accuracy on the written tests and 80% agreement for the blood pressure reading with the nurse supervisor before they were approved for screening.

The data collection tool on the mobile phone application was comprised of three sections: 1) *Baseline survey form*, which included socio-demographic, clinical, and past medical history information, depressive symptoms using the 2 item Patient Health Questionnaire; the PHQ-2 has been shown to be highly correlated with the PhQ-9 and previously validated as a depressive screening instrument in Ethiopia as well as with other screening tools [34]; knowledge of CVD risk factors and treatment decision; 2) *non-laboratory FRS algorithm assessment form*, which consisted of gender, age, systolic blood pressure, BMI, smoking status, and history of diabetes. The CVD risk score and level of risk categories were automatically calculated as low (<6%), moderate (6% - 19%) or high (> 20%) [20] [21]; and 3) *referral form*, which included clinical criteria for referring participants for additional assessment. The HEWs practiced using the mobile phone app prior to implementation among community participants for up to 4 weeks to ensure they were comfortable and understood how to complete data entry correctly. Feasibility and acceptability were also assessed from the perspectives of the HEWs and the community participants on the mobile phone app.

2.4. Data Quality

The completeness and accuracy of the data collected were ensured by the study supervisors who reviewed all data entries completed by the HEWs. Additionally, an electronic data collection system was utilized, which minimized the risk of errors during the data entry process by enabling real time observation of data entered by the HEW supervisors. To ensure the participants' comprehension, the questionnaires were available in both the local language (Amharic) and English.

2.5. Statistical Analyses

Data were entered into an Excel spreadsheet and then exported to SPSS version 26 statistical package for analysis. The distribution of continuous data was evaluated using box-plots and histograms. Descriptive statistics mean ± SD (mean and standard deviation) were used for continuous variables. Frequency (%) was used for categorical variables. Chi-square (χ^2) test was conducted to assess for significant differences in the categorical variables. Given the feasibility and acceptability component of the study, we did not conduct a power analysis. The sample size was determined by the number of community participants that could be reasonably screened based on HEW work loads.

3. Results

The mean age of the female HEWs was 28 years (range 21 - 35). All HEW participants had completed the 12th grade and held a one-year college diploma in clinical nursing. The HEWs all owned and were familiar with cell phone usage. Most community participants were female (N = 170, 56%) with a mean age of 49 ± 13.9 years compared to males, who were Females were less educated, more often divorced or widowed ($p < 0.004$) and unemployed than their male counterparts ($p < 0.001$). Most rated their overall health status as good, and over half of the sample had check-ups only if they were ill. Notably over half of the participants indicated they had no health problems, and over 60% were not taking any medications (**Table 1**).

Women had higher BMIs, were more often receiving treatment for hypertension than men ($p < 0.001$). Being a current smoker was higher among men ($p < 0.001$) and diabetes was more common than in women (**Table 2**). Participants were categorized into the following 10-year cardiovascular risk based on established FRS categories: low risk: [<6%], moderate risk: [6% - 19%], and high risk: [>20%] as shown in **Figure 1**. The overall 10-year CVD risk score was 12% ± 14.5 among participants indicating moderate risk level. Significantly higher mean risk scores than women with a mean score of 18% ± 17.7 compared to 7.5% ± 9.3 among women. High risk for CVD was found among 58 participants (19.5%), 95 participants were at moderate risk (32%) and 144 (48.5%) were at low risk for CVD over the next 10 years.

When evaluated by gender, men had significantly higher CVD risk as shown in

Figure 1. Men (N = 91) were almost twice as likely to be at moderate to high risk (70.5%) than women (N = 62, 36.9%).

Table 1. Sociodemographic and general health characteristics.

Variable	Female (N = 170)	Male (N = 131)	Total (N = 301)	p-value
Age (M ± SD)	49.01 ± 13.95	54.61 ± 13.39	51.45 ± 13.96	<0.001
Education (N, %)				
Literate	125 (73.5%)	114 (87%)	239 (79.4%)	0.004
Illiterate	45 (26.5%)	17 (13%)	62 (20.6%)	
Marital status (N, %)				
Married	106 (62.4)	106 (80.9)	212 (70.4)	<0.001
Divorced	13 (7.6)	4 (3.1)	17 (5.6)	
Single (never married)	9 (5.3)	15 (11.5)	24 (8.0)	
Separated	6 (3.5)	5 (3.8)	11 (3.7)	
Widowed	36 (21.2)	1 (0.8)	37 (12.3)	
Perceived health status (N, %)				
Poor	5 (29)	10 (7.6)	15 (5.0)	0.092
Fair good excellent	33 (19.4)	17 (13.0)	50 (16.6)	
Good	82 (48.2)	57 (43.5)	139 (42.2)	
Excellent	50 (29.4)	47 (35.9)	97 (32.2)	
Health check-up visits (N, %)				
Monthly	26 (15.3)	26 (19.8)	52 (17.3)	0.497
Every 3-months	28 (16.5)	29 (22.1)	57 (18.9)	
Every 6-months	3 (1.8)	4 (3.1)	7 (2.3)	
Annually	1 (0.6)	1 (0.8)	2 (0.7)	
Only if sick	103 (60.6)	65 (49.6)	168 (55.8)	
Current health problems (N, %)				
Yes	72 (42.4)	62 (47.3)	134 (44.5)	0.38
No	98 (57.6)	69 (52.7)	167 (55.5)	
Currently taking medications (N, %)				
Yes	57 (33.5)	57 (43.5)	114 (37.9)	0.077
No	113 (66.5)	74 (56.5)	187 (62.1)	

Table 2. Cardiovascular clinical risk factors, non-laboratory framingham risk scores and provider referrals.

Variable	Female (N = 170)	Male (N = 131)	Total (N = 301)	p-value
BMI (M ± SD)	24.7 ± 4.8	23.5 ± 3.5)	24.2	0.029
Systolic blood pressure (mm/Hg) (M ± SD)	116 ± 26.5	117.2 ± 25.6)	116.5 ± 26.1	0.7
Blood pressure treated (N. %)				
Yes	43 (25.6)	38 (29.2)	81 (27.2)	0.7
No	125 (74.4)	92 (70.8)	217 (72.8)	
Diabetes (N, %)				
Yes	23 (13.7)	25 (19.2)	48 (16.1)	0.19
No	145 (86.3)	105 (80.8)	250 (83.9)	
Current smoker (N, %)				
Yes	0	9 (6.9)	9 (3)	0.001
No	168 (100)	121 (93.1)	289 (97)	
CVD risk score (M ± SD)	7.5 ± 9.3	18 ± 17.7	12 ± 14.5	0.001
Referrals for further evaluation (N, %)				
CVD risk score > 20%	7 (28)	31 (68.9)	38 (54.3)	0.001
SBP > 160 mm/Hg	5 (20)	3 (6.7)	8 (11.4)	
Intervention at referral area (N, %)	3 (12)	8 (17.8)	11 (15.7)	
Pill re-fill	6 (35.2)	10 (28)	16 (30)	
Medication added	5 (29.0)	2 (6.0)	7 (13)	
Change previous medication	2 (12.0)	3 (8.0)	5 (9.0)	
Advise on excise, medication adherence & diet	2 (12.0)	11 (31)	13 (25)	
Decline to go to referred centre	2 (12.0)	10 (30)	12 (25)	
PHQ-2 score > 3 (N, %)				
Yes	6 (3.5)	0	6 (2.0)	0.03
No	164 (96.5)	131(100)	295 (98.0)	
Referred for further depressive symptom evaluation				
Yes	6 (3.5)	0 (0.0)	6 (2.0)	0.03
No	164 (69.5)	131(100)	29.5 (98.0)	

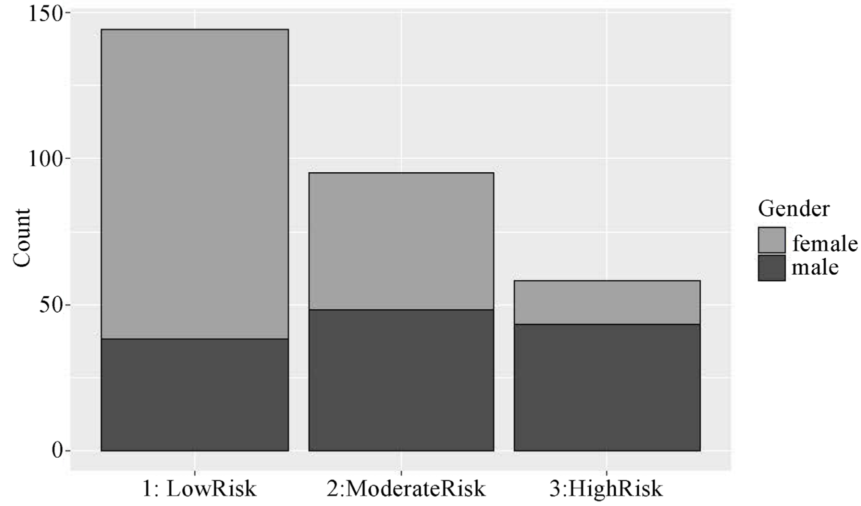

Figure 1. Gender differences in CVD risk using the non-laboratory framingham risk score model.

Among all participants, 13% were referred to a local primary health facility for a high >20% CVD risk score. Of that number, 69% were men and 28% women refer to **Table 2**. Females were more likely to experience depressive symptoms than males with a score of 3 or higher on the 2-item Patient Health Questionnaire.

Table 3. Patient knowledge about CVD symptoms, treatment decisions, perceptions of CVD screening preferences for future educational information.

Variable (N, %)	Yes	No	Don't know
Which of the following are symptoms of a heart attack?			
Chest pain	44 (14.9)	152 (51.5)	99 (33.5)
Being tired	133 (44.7)	99 (33.3)	65 (21.8)
Pain radiating down arm or shoulder	30 (10.1)	151 (50.8)	116 (39.0)
Headache	35 (11.7)	165 (55.5)	97 (32.6)
Slurred speech	52 (17.5)	142 (47.8)	103 (34.6)
If you thought you were having a heart attack, what would you do? (N = 297)			
Wait to see if symptoms improved	24 (14.1)	20 (15.3)	NA
Go to nearest health center or hospital	122 (71.8)	100 (76.3)	NA
Call a family or friend to take me to the hospital	20 (11.8)	8 (6.1)	NA
Call an ambulance	1 (0.6)	2 (1.5)	NA

When asked about chest pain as a symptom of a heart attack, only 15% (N = 44) replied yes with the majority indicating no (N = 152, 51.5%) or don't know (N = 99, 33.5%) (**Table 3**). In the event they thought they were having a heart attack, most participants (N = 222, 74%) responded they would visit their nearest health care facility relying on a relative or friend to drive them rather than calling an ambulance (N = 3, 1%) (**Table 3**). Community participants found symptoms of a heart attack and lifestyle behaviors as the most useful information presented during their home screening visit (**Figure 2**).

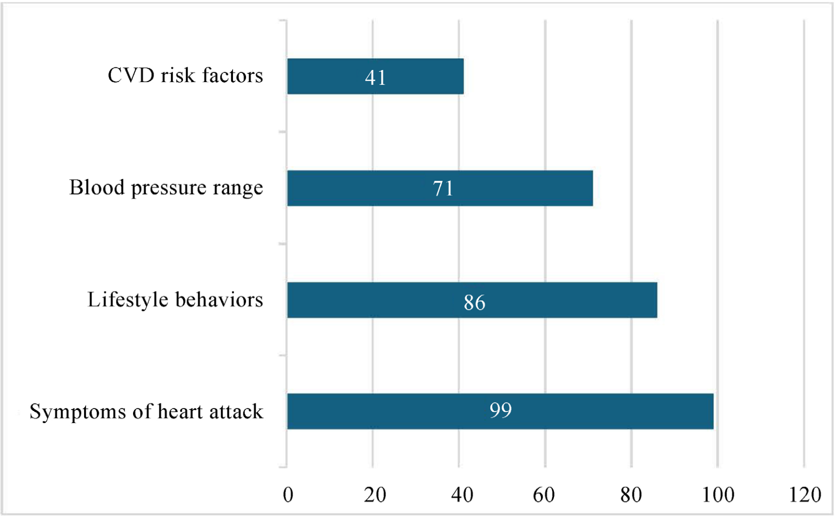

Figure 2. Most useful information for community participants during HEW home visit.

Table 4. Feasibility and applicability of mobile phone application (N = 10).

Variable	N (%)
Did the training/orientation adequately prepare you to screen the community?	
Yes	8 (80)
No	2 (20)
How do you evaluate the training session, what do you want to change?	
Entire length of the of the training was short	3 (27.3)
Entire length of training was long	1 (9.1)
Enough time was spent to train on how to use mobile application	2 (18.1)
Length of training was on how to use mobile application was long	1 (9.1)
Training was well-done and did not require any changes	4 (36.4)
Which of the following was most difficult for you to understand? Calculating BMI	
Calculating BMI	1 (9.1)
Using phone application	2 (18.2)
Nothing	8 (72.7)
How do you rate the applicability of the mobile app in scale (1 to 5)?	
Less difficulty and time consuming than paper	3 (27.3)
Less difficult and time consuming than paper and much easier to use than paper made data entry easy and quicker	1 (9.1)
More time consuming than paper	1 (9.1)
Much easier to use than paper made data entry, easy and quicker	6 (54.5)

Prior to beginning the HEW educational session, a pre-test Knowledge assessment was administered to test their knowledge of CVD risk and follow-up evaluation completed afterwards. There were improvements in knowledge gained from pre-to-post test, with the HEWs scores increasing by 2 to 6 points; one HEW scored 26 points higher on the post-test. The majority, 9 (82%) of HEWs, described receiving adequate orientation on how to use the mobile phone app for online data entry. Additionally, the majority of the HEWs indicated the mobile phone technology was easy to use and identified connectivity as the major barrier (**Table 4**).

4. Discussion

This study is the first to describe a HEW led CVD risk screening program using mobile phone technology for data collection for community participants in Ethiopia. A major finding was that HEWs with little training in CVD risk screening using mobile phone technology was able to successfully screen community participants accurately which is consistent with other reports in LMICs and in the sub-Saharan region of Africa. There was also high acceptability and satisfaction among the HEWs who reported that the mobile app was simple to use with minimal training required and is consistent with other studies utilizing this technology in other LMICs [16]. Another major finding was 19.5% of participants were at high CVD risk (>20%), with men having significantly higher risk than women. CVD risk factors also differed between men and women. Males tended to be older, more likely to have diabetes and be current smokers. Females had a greater likelihood of being hypertensive, overweight and to experience depressive symptoms. The findings of high CVD risk in sub–Saharan Africa are consistent with previous studies [16]. Evidence also shows that although women have lower rates of CVD risk than men, the prevalence of heart disease is rapidly rising and is likely to continue as the population ages [35] [36].

Clear guidelines were established for community participant refer-rals to health care facilities. The mobile phone app for each HEW had the contact information for the referral facility for participants with a CVD risk score of > 20%, blood pressure > 160 mm/Hg systolic, chest pain or other cardiovascular symptoms. Men were more commonly referred to a local health facility due to high CVD risk score > 20% and women more often for an elevated blood pressure. The community participants at high risk for CVD or with elevated blood pressure were unaware of their individual risks for CVD, the need for CVD risk screening, normal blood pressure ranges or common symptoms of an adverse cardiac event such as a myocardial infarction further supporting the need for routine screening in community settings. Despite reporting a lack of concern about the cost of emergency transportation, very few participants were willing to call an ambulance if they were experiencing symptoms of a heart attack instead preferring to call a family member or friend to transport them to the local hospital or clinic. Previous studies have shown that in LMICs the lack of adequate EMS services, equipment and having to pay out of pocket are major reasons cited for pre-hospital treatment delays. Even in urban areas where EMS has been more fully developed and is more readily available, it is estimated that only 5% of patients utilize these services in LMICs [36] [37].

4.1. Mobile Phone Technology

The HEWs found the mobile phone app easy to use and simplified the screening process, particularly calculation of BMI and CVD risk scores. Other studies have reported that online entry of CVD risk scores was quicker with fewer calculation mistakes [29] [32]. The majority of the HEWs were positive about the orientation and practice sessions using the phone app and indicated in the survey they felt adequately prepared to perform CVD screening. The HEWs practiced CVD screening and understanding what the non-laboratory FRS scores meant based on participant responses. The majority of the HEWs perceived no barriers using the mobile phone app. Among those that did, poor connectivity was the most common barrier. Importantly, no data was lost since the platform stores data entry and uploads occurred when connectivity was restored. Use of mobile phone technology for CVD risk screening was feasible and acceptable among the 10 HEWs who participated in this study and warrants future study as a practical and cost-effective method to improve CVD burden in Ethiopia and in other LMICs.

Because HEWs are trusted members of the community they understand the cultural nuances and are in a positive position to provide CVD screening and education to the community they serve. A recent study reported for example, that community members in Ethiopia prefer to be screened by HEWs for hypertension [38]. In addition, a systematic review that examined the role of HEWs in adult diabetic patients showed greater knowledge and better self-care skills (diet, exercise and blood glucose monitoring) than those with no contact with a HEW. [28] These reports suggest that a HEW-led CVD risk prediction screening and referral study may be an important strategy in Ethiopia to identify community members at high CVD risk and improve outcomes by increasing awareness of their risk and seeking treatment earlier when more amenable to treatment. Increasing national educational campaigns to improve knowledge about typical and atypical CVD symptoms and the importance of seeking early treatment is central to reducing the high morbidity and mortality in LMICs.

4.2. Policy Implications

Culturally relevant interventions that include community participation and engage stakeholders to support CVD risk factor prevention in low- and middle-income countries (LMICs) are needed [39]. Perceived CVD risk in LMICs extend beyond those considered traditional (sedentary, poor dietary intake, smoking, etc). The main perceived causes of CVD in all communities in several sub-Saharan countries were substance use, food-insecurity, and litter, followed by physical inactivity, psychological factors, poverty, crime, and violence [40]. These findings suggest that community-specific health education programs are often viewed as the preferred CVD prevention strategies. Identifying community perceptions, barriers and facilitators of CVD prevention, and prioritizing and implementing of locally-relevant strategies in different settings are important considerations.

Effective screening programs and early management of high-risk individuals can raise awareness, support early diagnosis, and reduce cardiovascular diseases in resource-poor community settings [40]. The evidence for the effectiveness of primary prevention interventions targeting CVD and other noncommunicable diseases (NCDs) such as diabetes and hypertension however, is very limited in LMICs. Our findings suggest that HEW led primary prevention interventions have the potential to provide an effective health delivery system for CVD risk factor identification and prevention in low resource communities. Scaling up HEW training to include prevention strategies has important policy implications for preventing the rising epidemic of CVD and may help guide future resources toward prevention and promotion strategies.

Prevalence studies for CVD and other NCDs are limited and inconsistent in Ethiopia which makes it very challenging to report precise estimates by region. To adequately monitor and track CVD in Ethiopia, a population-level data collection system is critically needed. This would enable population-level policies and targeted, evidence-based intervention strategies for high-risk individuals to lower the burden of CVD in Ethiopia [1] [3] [41].

The duration from symptom onset to the decision to seek medical attention and receipt of reperfusion therapy are critically important time points often used to quantify treatment delays [42]. In LMICs, transportation and the lack of adequate EMS services are major reasons for pre-hospital treatment delays. In addition, a lack of an organized system for collaboration between hospitals and physicians are reported as important barriers for more timely treatment for CVD symptoms [43]. The presence of hypertension and diabetes are prominent risk factors for ACS and are more likely to go undiagnosed and undertreated in LMICs. Public campaigns and screenings to increase awareness of these risk factors may be beneficial. Greater recognition of these issues by policymakers may help identify alternative strategies that increase the likelihood of earlier treatment decisions.

4.3. Strengths and Limitations

The were several strengths of the study including the ability to train and mobilize HEWs for CVD screening over a 2-month period indicating the feasibility of conducting future screening in much larger populations. HEWs owned and used smartphones routinely, which made the mobile app easier to apply to CVD risk screening and for online data entry. The data collection process involved intensive training for the HEWs on CVD risk the mobile phone app, coupled with adequate practice sessions and supervision from experienced supervisors with expertise in cardiovascular nursing. The nurses also served as field supervisors and was a strength since data acquisition and entry could be verified in real time. Data collection in community settings allowed the HEWs to get feedback from the community participants on CVD screening which may be useful for designing future programs. Collection of data across 10 woredas increased generalizability, which is less densely populated than Addis Ababa, Ethiopia's capital city, but may not accurately reflect rural geographic locations. The study also included adequate representation from men and women with gender differences observed in CVD risk and patterns which has had limited attention in previous reports and is an area for future research.

4.4. Conclusion

Health extension workers, with adequate training and supervision, can perform CVD risk screening as effectively as master's prepared nurses and offer a pragmatic and cost-effective strategy for the current health manpower shortage in Ethiopia. The coordination of services between the different levels of health services provided are needed to better ensure that high risk patients identified during screening receives the care needed at the appropriate level. As the CVD burden continues to rise in Ethiopia, alternative strategies are needed to identify those at moderate to high risk to initiate therapies earlier when they are more amenable to intervention. HEWs are the backbone of Ethiopia's health care system and may conduct CVD risk screening and deploy educational and lifestyle strategies to reduce risk. Combined with mobile phone technology, HEWs have the capability to serve as first line preventative care and potentially lower CVD burden in Ethiopia.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [RG], upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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