Prevalence and risk factors for atrial fibrillation in a semi-rural sub-Saharan African population: The hEart oF ethiopia: Focus on Atrial Fibrillation (TEFF-AF) Study

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BACKGROUND There is a scarcity of reported data on the prevalence of atrial fibrillation (AF) in sub-Saharan Africa.

OBJECTIVES To undertake AF screening in semi-rural Ethiopia.

METHODS The TEFF-AF (The hEart oF Ethiopia: Focus on Atrial Fibrillation) study conducted AF screening using a single-lead electrocardiogram device (KardiaMobile) on willing community participants at the Soddo Christian Hospital, Ethiopia. Participants' clinical parameters and medical history were obtained to characterize their risk factor profile, including calculation of CHARGE-AF (Cohorts for Heart and Aging Research in Genomic Epidemiology Atrial Fibrillation) score.

RESULTS A total of 3000 Ethiopians (median 31 [interquartile range 25–41] years of age; 65% men) were screened. The participants were generally well educated, from the local region and with a low burden of cardiovascular risk factors. A total of 50 participants had a CHARGE-AF score (5-year AF risk) of ≥2%. AF was detected in 13 (0.43%) individuals (median 50 [interquartile range 36–60] years of age; n = 7 men). The prevalence among participants over 40 years of age was 1% (n = 9 of 930). AF prevalence was higher for older age groups, with ≥70 years of age reaching 6.67% (n = 3 of 45). Population prevalence was estimated to be 234 (95% confidence interval 7–460) per 10,000 persons for ≥60 years of age. Four (31%) of the 13 participants with AF had a CHA_2DS_2-VASc (congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65-74 years, sex category) score of ≥2, and others likely had rheumatic valvular AF, but only 2 of the 13 participants with AF were on oral anticoagulation therapy.

CONCLUSION In this semi-rural Ethiopian community of relatively younger participants, AF prevalence was found to be low but increased with increasing age. Mobile single-lead electrocardiogram technology can be used effectively for AF screening in low-resource settings.

KEYWORDS Atrial fibrillation; Screening; Ethiopia; Prevalence; Sub-Saharan Africa; Risk factors

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Introduction

Atrial fibrillation (AF) is a growing public health problem worldwide. The Global Burden of Disease Study estimated that the worldwide age-adjusted prevalence of AF in 2010 was approximately 0.5%, representing a total of 33.5 million individuals.[1] In sub-Saharan Africa, the leading cardiovascular cause of death and disability in 2010 was stroke, and the largest relative increases in cardiovascular disease burden between 1990 and 2010 were in AF and peripheral arterial disease.[1] Furthermore, cardiovascular deaths occur at younger ages in sub-Saharan Africa as compared with the rest of the world. Individuals with AF in Africa have higher mortality rates,[2] although due largely to poor health care access and suboptimal therapy. The Global Burden of Disease Study also highlighted the crucial need for more data from population surveillance studies in sub-Saharan Africa due to the paucity of data from this region.

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KEY FINDINGS

- Overall AF prevalence was 0.43% in a semi-rural Ethiopian community of 3,000 generally younger (median 31 years old) participants.
- AF prevalence was higher with increasing age and in the presence of known structural heart disease.
- Hypertension was the most common risk factor for AF followed by diabetes and valvular heart disease.
- 31% of the participants screened with AF in this study had high CHA_2DS_2-VASc score ($\geq$3 for females, $\geq$2 for males) and were not on oral anticoagulation therapy.

Several factors may contribute to the changing prevalence of AF in developing nations. The burden of communicable disease persists and rheumatic heart disease is associated with higher AF prevalence in younger populations.[3] Additionally, the epidemiological transition in sub-Saharan African regions with gradual adoption of Western lifestyle is likely increasing the impact of modifiable risk factors on AF prevalence. There is significant variation in the prevalence of AF reported across different countries in Africa, and estimates may be skewed by poor health-seeking behaviors and limited access to diagnostic equipment.[4] Better understanding of the cardiovascular risk factor profile in these regions can help guide preventive and management strategies. Given the relative scarcity of AF epidemiology data from sub-Saharan African regions, we undertook the TEFF-AF (The hEart oF Ethiopia: Focus on Atrial Fibrillation) screening study to characterize the prevalence of AF and associated risk factor profile in semi-rural south-central Ethiopia.

Methods

The TEFF-AF study (ACTRN126190011071112) was undertaken from August through December 2019, on the campus of the Soddo Christian Hospital (SCH), which provided institutional research ethics approval. This study complied with the ethical principles of the 2013 Declaration of Helsinki. SCH is a major trauma center situated in the town of Soddo, with a population of around 200,000 individuals in south-central Ethiopia. Eligibility was limited to ambulant adults 18 years of age and above who were able to provide informed consent. Signage in the Amharic language was erected at SCH to invite willing individuals from the community and visitors to the hospital to participate in the screening. Inpatients at SCH were not included in this study. A team of 5 nursing and research support staff from the SCH performed the screening following specialized training on the use of the KardiaMobile (KM) single-lead electrocardiogram (ECG) device (AliveCor, Mountain View, CA) paired to an iPhone application (version 5.7.4, KardiaAI: 1.1.7). Training included tutoring on acquiring the best quality single-lead ECG tracing with the KM device and subsequent hands-on practice.

An online customized REDCap (Research Electronic Data Capture) database was utilized.[5] Baseline demographic and clinical parameters were obtained by a brief structured questionnaire to characterize the cardiovascular risk profile of participating individuals. The CHARGE-AF (Cohorts for Heart and Aging Research in Genomic Epidemiology Atrial Fibrillation) risk model adequately predicts 5-year AF risk among Africans in the United States and Europe (using variables of age, race, height, weight, systolic and diastolic blood pressure, current smoking, use of antihypertensive medication, diabetes, and history of myocardial infarction and heart failure).[6] This score was calculated for each TEFF-AF study participant. Stroke risk was calculated using CHA_2DS_2-VASc (congestive heart failure, hypertension, age $\geq$75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65-74 years, sex category) score for participants found to have AF. A multistage protocol for screening was undertaken, which has previously been described.[7] Height and weight measurements were obtained to calculate body mass index (BMI). Blood pressure measurements were undertaken in the seated position (Omron Intellisense T5 automatic monitor; Omron Corporation, Kyoto, Japan), which was repeated when the initial systolic reading exceeded 130 mm Hg. A 30-second single-lead ECG acquisition using the KM device was then obtained from the participant.

ECG acquisition and AF determination

The KM device records a bipolar lead I ECG tracing when 2 or 3 fingers from each hand of the user are placed in contact with the 2 electrodes. Participants were instructed to relax their arms and hands to reduce noise and artefact. A 30-second single-lead ECG recording can be viewed in real time on the smartphone application and saved as a PDF file. The noise-filtered trace and computer-averaged complex on the smartphone application are then subjected to an automated algorithm for arrhythmia diagnosis using the 2 criteria of P-wave absence and R-R interval irregularity.[8] The outcome of the automated algorithm assessment of rhythm dictated the need for repeat KM tracing or a 12-lead ECG. The screening protocol is deemed complete if the rhythm was assessed as normal by the automated algorithm. A 12-lead ECG was indicated if the rhythm was assessed as possible AF. A repeat KM tracing was required if the rhythm was assessed as bradycardia, tachycardia, unclassified, unreadable, or too short. If the same results or possible AF were obtained after repeat KM tracing, a 12-lead ECG will then be indicated.

The 30-second KM traces obtained by participants were downloaded as PDFs for manual analysis by 2 cardiologists independently (investigators C.X.W. and S.I.) to confirm rhythm diagnosis. The cardiologists also assessed diagnostic limitations for traces categorized automatically as

Table 1 Baseline clinical characteristics (n = 3000)

Demographic and clinical information (n = 3000)	Data
Age, y	31 (25–41)
<30 y	1224 (41)
30–39 y	846 (28)
40–49 y	472 (16)
50–59 y	287 (10)
60–69 y	126 (4)
70+ y	45 (2)
Sex	
Male	1975 (65)
Female	1025 (35)
Home region	
SNNPR	2810 (94)
Oromia	61 (2)
Amhara	17 (1)
Other regions (including, Somalia, B-Gumuz, Addis Ababa, Harar)	47 (2)
Unspecified	65 (2)
Religion	
Orthodox	786 (26)
Protestant	2015 (67)
Muslim	129 (4)
Other religion or no religion	70 (2)
Education	
Illiterate	160 (5)
Primary level school	462 (15)
Secondary level school	1028 (34)
Certificate, diploma, or above	1324 (44)
Unspecified	26 (1)
Occupation	
Unemployed	84 (3)
Employed (worker)	484 (16)
Employed (professional)	836 (28)
Self-employed	737 (25)
Householder/housewife	251 (8)
Retired	22 (1)
Student	472 (16)
Other	114 (4)
Clinical	
BMI, kg/m^2	23.0 (20.5–26.4)
Underweight (<18.5 kg/m^2)	223 (7)
Normal (18.5–24.9 kg/m^2)	1749 (58)
Overweight (25–29.9 kg/m^2)	770 (26)
Obese (≥30 kg/m^2)	258 (9)
Systolic BP, mm Hg	124 (114–135)
Hypertensive (systolic BP >140 mm Hg)	533 (18)

Values are median (interquartile range) or n (%).

BMI = body mass index; BP = blood pressure; SNNPR = Southern Nations, Nationalities, and People's Region.

bradycardia, tachycardia, unclassified, unreadable, or too short into the following: artifact, ectopy, bradycardia, tachycardia, or insufficient sample duration. All 12-lead ECGs were standardized with scale of 1 mV:10 mm and paper speed of 25 mm/s. They were independently adjudicated by 2 physicians (investigators S.-H.C. and D.H.L). Participants in AF were offered transthoracic echocardiogram at SCH to evaluate the presence of any structural heart disease and referred for follow-up by SCH physician.

Statistical analysis

Continuous data are expressed as mean ±SD or median (interquartile range [IQR]) appropriate to data distribution assessed by Shapiro-Wilk test. Binary data are presented as percentage (with numerator and denominator in brackets). Categorical data were analyzed using the chi-square or Fisher exact test. The sensitivity and specificity for the ability of the KM to produce a rhythm decision against the cardiologists' interpretation were calculated. All statistics were performed in SPSS (version 26; IBM, Armonk, NY), with statistical significance set at $P < .05$.

Results

A total of 3000 participants were recruited. The baseline clinical parameters of the participants are shown in Table 1. The median age was 31 (IQR 25–41) years (35% women; median BMI 23.0 [IQR 20.5–26.4] kg/m^2), with 31% being 40 years of age or older. The vast majority (94%) of the participants were from the regional state of Southern Nations, Nationalities, and People's Region, where SCH is located. Seventy-eight percent (n = 2352) had at least secondary-level education, and 44% (n = 1320) reported salaried employment.

Prevalence of AF

There were a total of 13 participants (n = 7 men) determined to have AF, equating to an overall prevalence of 0.43% (Figure 1A). The prevalence of AF increased exponentially with increasing age, from 0.18% in those under 30 years of age to 2.3% in those above 60 years of age. The AF prevalence for participants ≥70 years ofage was 6.67% (n = 3 of 45). The estimation of AF prevalence for each age group is shown in Figure 1B, with 234 (95% confidence interval 7–460) per 10,000 persons among those 60 years of age and above. The clinical parameters of the participants with AF are shown in Table 2. History of known structural heart disease was reported by 6 of these participants, and 4 participants had a systolic blood pressure above 130 mm Hg during screening. The median heart rate of those in AF was 94 (IQR 85–100) beats/min, including 1 individual at 148 beats/min. Transthoracic echocardiogram was obtained for 7 of these participants, demonstrating presence of underlying valvular pathology in all of them.

Associated comorbidities in those with and without AF

Participants with AF were more likely to be older, with a higher proportion with known heart failure, with valvular heart disease, and on regular medications (Table 3). The most prevalent reported risk factor was hypertension (5.2%), although 17.8% (n = 533 of 3000) of the subjects had systolic blood pressure >140 mm Hg during screening. Malaria and typhoid (10% and 14%, respectively) were common among participants but not for those with AF. A total of 50 participants had a CHARGE-AF score (5-year AF risk) of ≥2%. The CHARGE-AF score was on average higher for those with AF than for those without AF (0.84% vs 0.22%;

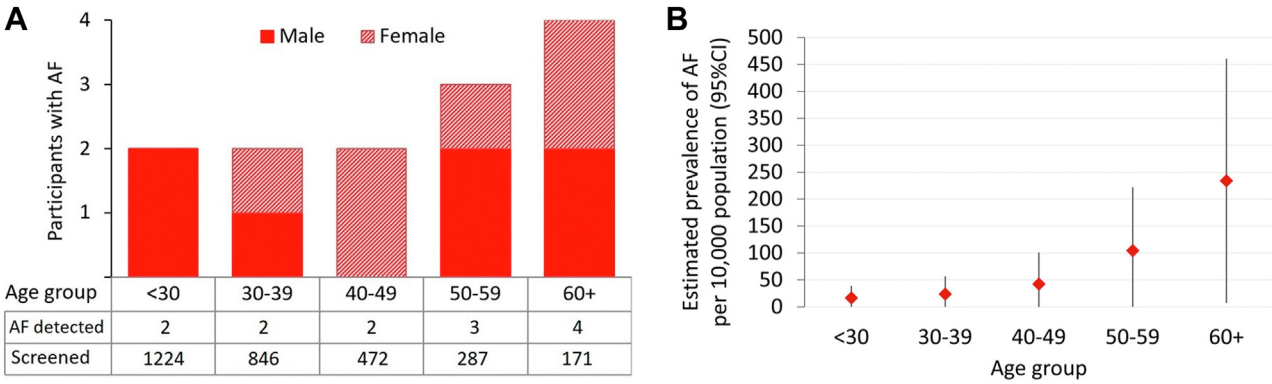

Figure 1 Atrial fibrillation (AF) prevalence. **A:** Frequency of AF detected by screening for men and women by age group and **B:** estimated AF prevalence per age group. CI = confidence interval.

$P = .029$), although only 3 (23%) participants with AF had a CHARGE-AF score of ≥2% (5-year risk of AF) (Figure 2A). Four (31%) of the 13 participants with AF had a CHA_2DS_2-VASc score of 2 or greater (Figure 2B), consisting of 3 women with CHA_2DS_2-VASc score ≥3 and 1 man with CHA_2DS_2-VASc score ≥2, while none of these participants were on oral anticoagulation therapy. Only 2 other participants with AF were on oral anticoagulation therapy, and both were men with congestive heart failure associated with mitral or aortic regurgitation (Table 2).

Outcomes from KM automated algorithm

Of the initial single-lead KM tracings performed on the 3000 participants (Figure 3A), the KM algorithm was unable to

Table 2 Participants with atrial fibrillation

Age (y); sex	BMI (kg/m^2)	Medical history	Medications	BP (mm Hg); heart rate (beats/min)	CHA_2DS_2-VASC Score	Echocardiogram
20; M	20.2	CHF, heart disease	Enalapril, warfarin	100/80; 128	1	Dilated LV with systolic dysfunction, dilated LA, MR, and TR
20; M	16.3	CHF, heart disease (valvular)	Enalapril, metoprolol, warfarin, frusemide	120/70; 100	1	Dilated LV with systolic dysfunction, dilated LA, AR/MR/TR
30; M	23.9	Heart disease (valvular)	Monthly benzylpenicillin	122/90; 88	0	N/A
36; F	23.8	HTN, DM	None	117/86; 99	3	Normal size LV and low-normal systolic function, dilated LA, MR/TR, pulmonary hypertension, RV dilated with poor systolic function
40; F	26.3	Malaria	None	132/92; 94	1	N/A
48; F	19.4	None reported	None	127/86; 83	1	N/A
50; M	18.8	CHF, Heart disease(valvular)	Enalapril, phenytoin, statin, aspirin	120/70; 100	1	Normal size LV, grossly dilated LA, severe MS, severe MR, and severe TR
50; F	24.6	Thyroid disease	None	145/85; 80	1	N/A
58; M	19.8	None reported	None	100/64; 85	0	N/A
60; M	17.0	None reported	None	116/83; 69	0	N/A
70; F	21.3	HTN, DM, CHF	Frusemide, aspirin, enalapril, digoxin, spironolactone	145/83; 108	5	Normal size LV, dilated LA, MR, and TR
75; M	19.1	CHF, Heart disease (valvular)	Enalapril, frusemide, spironolactone	116/88; 148	3	Valvular regurgitation (AR/MR/TR)
80; F	18.2	HTN, currently has pneumonia	None	150/80; 65	4	Normal biventricular size and function; moderate AR/AS and mild MS

AR = aortic regurgitation; AS = aortic stenosis; BMI = body mass index ; BP = blood pressure; CHA_2DS_2-VASc = congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65-74 years, sex category; CHF = congestive heart failure; F = female; DM = diabetes mellitus; HTN = hypertension; LA = left atrium; LV = left venticle; M = male; MR = mitral regurgitation; MS = mitral stenosis; N/A = not available; RV = right ventricle; TR = tricuspid regurgitation.

Table 3 Participant clinical parameters, self-reported medical history, and risk factors

	Participants without AF (n = 2987)	Participants with AF (n = 13)	*P* value
age, y	31 (25–41)	50 (36–60)	.005
age ≥65 y	76 (3)	3 (23)	.18
BMI, kg/m^2	23 (21–26)	20 (19–24)	.007
Measured systolic blood pressure ≥140 mm Hg	530 (18)	3 (23)	.71
Hypertension	153 (5)	3 (23)	.27
Diabetes mellitus	66 (2)	2 (15)	.41
Heart failure	19 (1)	7 (54)	<.001
Stroke	3 (<1)	0 -	-
Valvular heart disease	7 (<1)	4 (31)	.046
Renal failure	5 (<1)	0	—
Chronic lung disease	16 (1)	0	—
Obstructive sleep apnoea	2 (<1)	0	—
Thyroid disease	21 (1)	1 (8)	.79
Smoker			
Current	7 (<1)	0	—
previous	19 (1)	1 (8)	.78
Khat chewing			
Current	11 (<1)	0	—
previous	21 (1)	0	—
Alcohol			
Current	7 (<1)	0	—
previous	17 (1)	0	—
Malaria	409 (14)	0	—
Typhoid	308 (10)	0	—
any infective disease			
Current	50 (2)	2 (15)	.38
previous	233 (8)	2 (15)	.80
Currently taking any medication	128 (4)	7 (54)	.001

Values are median (interquartile range) or n (%).
AF = atrial fibrillation.

provide a rhythm decision in 18% (n = 549) due to being categorized as unclassified (8.6%, n = 258), tachycardia (7.2%, n = 215), unreadable (2.1%, n = 63), too short (0.1%, n = 3), and bradycardia (0.3%, n = 10). A repeat KM tracing was obtained in 70% (n = 383 of 549) of the participants who did not have an initial rhythm decision, which achieved a rhythm decision in 207 additional subjects, with an overall rhythm decision in 89% (n = 2658) (Figure 3B and 3C). The remaining repeat KM tracings showed tachycardia' (n = 79), unclassified (n = 75), unreadable (n = 12), and bradycardia (n = 10). Manual assessment of the KM tracings by cardiologists provided a greater rhythm decision yield than the KM algorithm. Only 2% of KM traces were considered nondiagnostic by manual adjudication. Overall, the AliveCor KM had a sensitivity of 81.3% and specificity of 96.5%, and although the negative predictive value of 99.9% was high, the positive predictive value was only 12.4%.

Twelve-lead ECG analysis

In total, there were 456 (15%) participants who met protocol criteria for a 12-lead ECG, but only 181 ECGs were obtained (Figure 4). This was largely due to participants not wanting to wait for the 12-lead ECG to be performed in the SCH emergency room, or a KM outcome of tachycardia that the screening team assessed as sinus tachycardia not requiring a 12-lead ECG. The majority (n = 160 of 181) of 12-lead ECGs showed sinus rhythm. Twelve-lead ECG was performed in 65% (n = 74) of the 114 possible AF patients. However, manual cardiologists' assessment of the remaining 40 possible AF KM traces without 12-lead ECGs only found 2 AF tracings. There were no 12-lead ECG diagnosis of AF not having a KM outcome of possible AF. A repeat KM attempt without a rhythm decision indicated the need for a 12-lead ECG for 342 participants. However, a 12-lead ECG was obtained for only 74% (n = 17 of 23) of unreadable, 64% (n = 67 of 104) of unclassified, 33% (n = 4 of 12) of bradycardia, and 9% (n = 19 of 203) of tachycardia assessments. Of these 107 ECGs, the majority were adjudicated as sinus rhythm or sinus arrhythmia, and the remainder were found to have intraventricular conduction delay, preexcitation, multiple ectopics, supraventricular tachycardia, complete heart block, or junctional rhythm (Figure 4).

Participant experience and protocol compliance

During the screening protocol, the majority of participants (84%, n = 2531) only performed 1 KM ECG trace without a repeat or a 12-lead ECG. There were additionally 10%

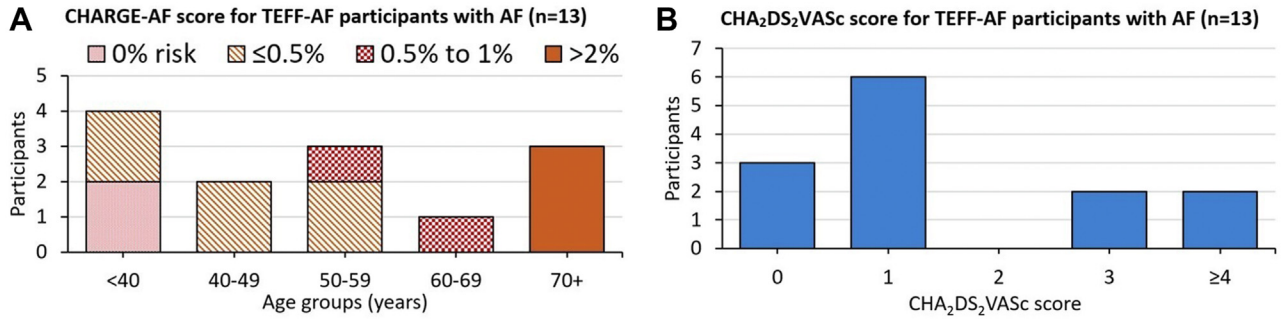

Figure 2 CHARGE-AF (Cohorts for Heart and Aging Research in Genomic Epidemiology Atrial Fibrillation) and CHA_2DS_2-VASc (congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age 65-74 years, sex category) scores. **A:** Calculated CHARGE-AF score for 5-year risk of AF and **B:** calculated CHA_2DS_2-VASc score for AF participants. TEFF-AF = The hEart oF Ethiopia: Focus on Atrial Fibrillation.

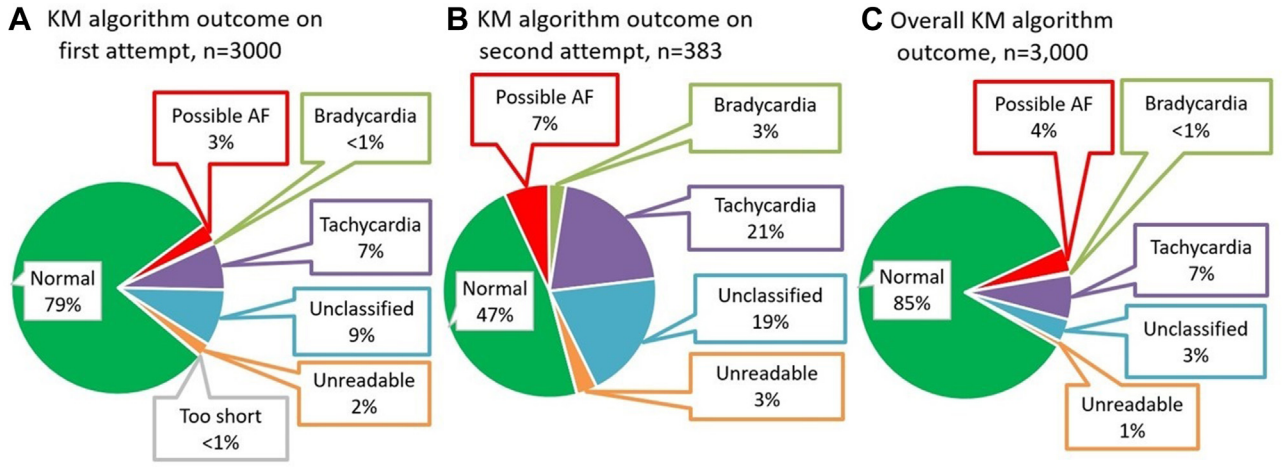

Figure 3 Participants' rhythm assessment by KardiaMobile (KM) automated algorithm. **A:** KM algorithm outcome on first attempt. **B:** KM algorithm outcome on second attempt. **C:** KM algorithm outcome on third attempt. AF = atrial fibrillation.

(n = 288) who completed 2 KM attempts but did not have a 12-lead ECG. A 12-lead ECG was performed in addition to the KM screening for the remaining 6% (n = 181). Overall, 90% (n = 2694) of participants completed the screening protocol as defined. Noncompliancy was due to not having performed a required repeat KM in 5.6% (n = 168) and not having performed a required 12-lead ECG in 3.6% (n = 107). Additionally, there were 31 participants who did not undergo repeat KM ECG acquisition but had a 12-lead ECG performed instead. There were 21 participants who provided an additional KM trace beyond the protocol requirement who did not have a 12-lead ECG performed as required after a KM algorithm result of possible AF. There were only 2 occasions when this repeat KM attempt again returned a result of possible AF.

Discussion

This study is the largest AF screening study from semi-rural Ethiopia. First, we found overall AF prevalence of 0.43% in 3000 generally younger (median 31 years of age) and well-educated participants. Second, AF prevalence was higher with increasing age and in the presence of known structural heart disease. Third, hypertension was the most common risk factor for AF, followed by diabetes and valvular heart disease. Fourth, the KM single-lead ECG technology was suitable for AF screening with the automated algorithm able to detect 85% as normal sinus rhythm. Additional 12-lead ECG and manual assessment was needed for rhythm assessment in the remainder. Last, 31% of the participants screened with AF in this study had CHA_2DS_2-VASc score of more than 2 and were not on oral anticoagulation therapy. Our findings have important public health implications, given the scarcity of such reported data from this community.[9] In a prospective global registry of >15,000 AF patients, it was observed that annual AF mortality in Africa was twice that as compared with North America, Western Europe, and Australia, and the rate of strokes was highest in African patients with AF.[2] Furthermore, as life expectancy in Ethiopia has increased by approximately 22 additional years over the last 2 decades (47 years in 1990 to 69 years by 2019),[10] the impact of aging and chronic diseases such as AF will become more significant.

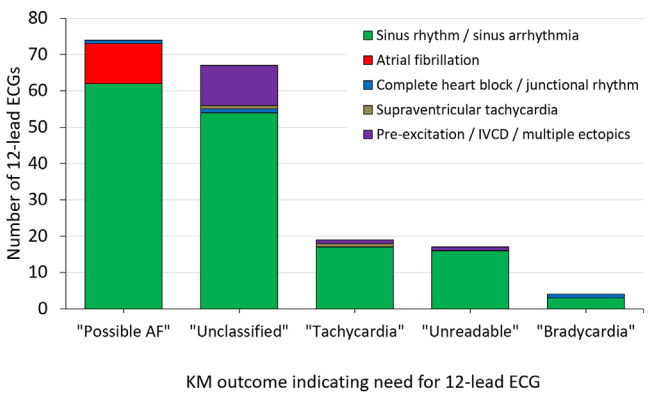

Figure 4 Diagnosis by 12-lead electrocardiogram (ECG). Diagnostic yield of 12-lead ECGs performed for each final KardiaMobile outcome. AF = atrial fibrillation; IVCD = intraventricular conduction delay.,

Ascertaining AF prevalence from screening

It is known that the incidence of detecting previously undiagnosed AF is dependent on the underlying population risk of AF, the intensity or duration of screening, and the method used to detect AF.[9] In a nearby Southwest town from our screening venue, a community-based cross-sectional study with 12-lead ECG in 634 adults (mean 63 years of age) reported an AF prevalence of 4.3%.[11] Consistent with the results of our screening, the prevalence of AF rose steeply with advancing age. They reported a prevalence of 6.9% (n = 4 of 58) in those above 80 years of age, which is comparable to the 6.67% prevalence in those above 70 years of age in this current study. Although our 30-second single-lead ECG screening found an overall low prevalence of AF in a relatively young cohort, it remains in the ballpark of the estimated worldwide age-adjusted prevalence of

~0.5% and the 2010 Global Burden of Disease Study estimation of 0.44%–0.66% in the sub-Saharan African region.[1] However, these estimates may be skewed by the effects of sampling, with known variability in health care infrastructure and services among sub-Saharan African countries and poor health-seeking behavior.[4] Notably, AF patients in sub-Saharan Africa tend to be younger and with higher mortality rates due to poor health care access and suboptimal therapy,[3] and screening may help to identify individuals who can benefit from risk factor modification and medical therapy to reduce the burden of disease and associated morbidities.

Impact of digital technology for AF screening in the low-resource settings

AF screening by palpation is a simple technique that is useful in low-resource settings, but portable digital technology, such as handheld single-lead ECGs or plethysmography devices, are becoming more readily available and have shown greater yield.[12] We used the KM device, which has previously been shown to have high sensitivity and specificity for AF detection in validation study.[8] The utility of this technology for mass screening in low-resource communities has previously been demonstrated.[13] However, we reported a limitation of this technology with the inability of the device algorithm to provide a rhythm decision for ~13% of participants even with repeat tracing.[7] This limitation can be minimized through increased user familiarity and careful execution of the acquisition technique to obtain better-quality ECG signals. One advantage of ECG tracing over plethysmography in low-resource settings is the option of remote manual adjudication by a clinician to enhance diagnostic yield and reduced dependence on automated algorithm performance.[14,15] Our study protocol included repeated tracing attempts, along with select use of 12-lead ECG, to optimize yield from this single-occasion screening strategy. Although mobile digital technology provides the opportunity for continuous monitoring of large cohorts as seen in the Apple Heart and Huawei studies, the affordability of such in low-resource settings and the low sensitivity of AF detection would reduce its utility.[16,17]

Risk factors for AF in sub-Saharan Africa

The risk factors for AF in sub-Saharan Africa are likely to be altered by the high prevalence of rheumatic heart disease, which is also known to be the most common acquired cardiovascular disease in young individuals under 25 years of age.[18,19] Unfortunately, not much is known about the burden of AF related to rheumatic heart disease in this region.[20] A recent meta-analysis has shown the global prevalence of AF in rheumatic heart disease to be 32.8% (range, 4.3%–79.9%).[21] In the Ethiopian capital of Addis Ababa, a retrospective chart review of 500 adult cardiology patients with rheumatic heart disease found that 46.8% had AF.[22] Indeed, valvular heart disease was more common in those with AF in our study, as confirmed with echocardiographic imaging, including the 2 on warfarin, and 1 on monthly benzylpenicillin. It is likely that the burden of valvular heart disease was higher given that 6 of the participants with AF did not undertake an echocardiogram. However, many parts of sub-Saharan Africa are undergoing epidemiological transitions, with gradual adoption of Western lifestyle leading to development of new AF risk factors including hypertension, dyslipidemia, diabetes, and obesity.[23] Others have recently reported smoking, hypertension, and increased BMI as main risk factors associated with AF in Southwest Ethiopia.[11] Our data show that hypertension was the most common risk factor for AF, followed by diabetes and valvular heart disease in a younger cohort in semi-rural Ethiopia. Although no studies have demonstrated that AF screening reduces mortality or incidence of thromboembolic complications,[24] we are able to characterize the risk factor profile of this semi-rural Ethiopian cohort and detect high-risk individuals with AF who are not on anticoagulants and may benefit from long-term oral anticoagulant therapy. More work is necessary to characterize the burden of AF and the associated risk factor profile including rheumatic heart disease in sub-Saharan Africa, where health care resources are scarce and more targeted public health and lifestyle measures would be valuable to curtail the expected significant increase in AF over the coming decades.[3,18,20,25]

Clinical Implications

Our study has important clinical implications for AF screening and highlights opportunities for future research especially in the younger population with underlying structural heart disease as well as more urbanized communities that are undergoing epidemiological transition in sub-Saharan Africa. We have shown that portable digital technology can be utilized for AF screening programs in low-resource settings. Employing a strategic protocol when utilizing such technology for AF screening will ensure optimized diagnostic yield and reduce dependence on physician input to achieve screening accuracy.

Study Limitations

Our screened sample had a low number of participants in the older age group. However, it reflects the demographic of this semi-rural regional hub with higher education institutions and professional employment opportunities. We did not specifically collect data on why a participant had attended the hospital precinct for screening. We cannot rule out inclusion of participants who were screened while they were awaiting treatment. The participant medical history was self-reported and not able to be verified against medical records with potential underestimation of the cardiovascular risk factor profile. AF detection rate would be higher with a longer monitoring period. Low health literacy could have contributed to the inability to distinguish incident new AF from prevalent AF, and explained the relatively low proportion of participants on oral anticoagulation therapy. Echocardiogram examination was mostly qualitative due to the nonavailability of fully trained imaging expertise, and we could not

confidently ascertain the true proportion of valvular disease due to rheumatic vs degenerative changes. Valvular disease may also have been present in the 6 participants who had AF but did not undertake an echocardiogram.

Conclusion

The prevalence of AF from the TEFF-AF screening study in a relatively young semi-rural Ethiopian cohort was <1%. The AF prevalence was higher with increasing age and in those with structural heart disease. Mobile single-lead ECG technology can be used effectively for AF screening in low-resource settings.

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