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ORIGINAL RESEARCH

Screening for Atrial Fibrillation in American Indian Adults in a Tribal Primary Care Clinic

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BACKGROUND: American Indian adults have a higher risk of atrial fibrillation (AF) compared with other racial groups. We implemented opportunistic screening to detect silent AF in American Indian adults attending a tribal health system using a mobile, single-lead ECG device.

METHODS AND RESULTS: American Indian patients aged ≥50 years followed in a tribal primary care clinic with no history of AF underwent a 30-second ECG. A cardiologist overread all tracings to confirm the diagnosis of AF. After AF was confirmed, patients were referred to their primary care physician for initiation of anticoagulation. Patients seen over the same time period, who were not undergoing screening, served as controls. A total of 1019 patients received AF screening (mean age, 61.5±8.9 years, 62% women). Age and sex distribution of those screened was similar to the overall clinic population. New AF was diagnosed in 15 of 1019 (1.5%) patients screened versus 4 of 1267 (0.3%) patients who were not screened (mean difference, 1.2%; 95% CI, 0.3%–2.2%, P=0.002). Eight of 15 with new screen-detected AF were aged <65 years. Those with screen-detected AF were slightly older and had a higher CHA_2DS_2-VASc score than those without AF. Fourteen of 15 patients diagnosed with new AF had a CHA_2DS_2-VASc score ≥1 and initiated anticoagulation.

CONCLUSIONS: Opportunistic, mobile single-lead ECG screening for AF is feasible in tribal clinics, and detects more AF than usual care, leading to appropriate initiation of anticoagulation. AF develops at a younger age in American Indian adults who would likely benefit from earlier AF screening.

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Key Words: American Indian adults ■ atrial fibrillation ■ digital health ■ screening

Atrial fibrillation (AF) is the most common clinically significant arrhythmia and is associated with increased rates of stroke, heart failure, and cognitive decline.[1] Approximately one third of ischemic strokes are attributable to either previously known or newly detected AF at the time of stroke.[2] Moreover, AF is detected in a significant proportion of patients with cryptogenic stroke with prolonged ECG monitoring, suggesting the association between AF and stroke is probably underestimated.[3,4] Many AF episodes are asymptomatic, and stroke is the first manifestation of AF in at least 25% of AF-related strokes.[2] Anticoagulation for AF leads to a reduction in stroke to levels similar to matched individuals without AF[5] and may prevent cognitive decline, even in low-risk patients.[6,7] Therefore, identifying AF in an earlier asymptomatic state (ie, screening for silent AF), with subsequent initiation of anticoagulation, may decrease the risk of future stroke and cognitive decline. Community screening for silent AF using a smartphone-based ECG device at a single time point has been shown to be feasible and cost-effective.[8,9]

American Indian (AI) adults have a higher risk of AF compared with all other racial and ethnic groups[10] and a higher incidence of stroke than White and Black groups.[11] Moreover, in a large population cohort of AI adults with a high prevalence of diabetes mellitus and obesity, AF was

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CLINICAL PERSPECTIVE

What Is New?

- Opportunistic, mobile single-lead ECG screening for atrial fibrillation is feasible in American Indian tribal clinics and detects more atrial fibrillation than usual care, leading to appropriate initiation of anticoagulation.
- American Indian adults, like other indigenous populations, develop atrial fibrillation at a younger age compared with non–American Indian populations.

What Are the Clinical Implications?

- Single–time point screening for atrial fibrillation in tribal clinics has the potential to improve health outcomes among a large number of American Indian adults who have historically endured greater health disparities.
- American Indian adults may benefit from atrial fibrillation screening starting earlier than the recommended age of 65 years.

Nonstandard Abbreviations and Acronyms

AI	American Indian
NCDR PINNACLE-AF	National Cardiovascular Data Registry's Practice Innovation and Clinical Excellence–Atrial Fibrillation
OAC	oral anticoagulation

one of the risk factors for incident stroke.[11] Notably, other indigenous populations, such as Aboriginals in Australia and Maori in New Zealand, develop AF about 10 years earlier than White populations living in the same country.[12,13] Given the high prevalence of risk factors for AF in AI adults, we hypothesized that this population would be at higher risk of undiagnosed AF, starting at a younger age, compared with White populations. Therefore, the aim of this study was to determine the incidence and clinical predictors of silent AF in AI adults seen at a rural tribal primary care health system using opportunistic screening with a mobile, single-lead ECG device, and compare screening with usual care. We also assessed the impact of this approach on initiation of prophylactic anticoagulation according to current guidelines.

METHODS

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

Design and Settings

This was a prospective cohort study. AI individuals who attended a tribal healthcare system in Oklahoma, were at least aged 50 years, and had no prior history of AF were eligible for enrollment in the study. The target population was restricted to those aged >50 years, because the prevalence of AF decreases significantly at younger ages, and thus, the yield of AF screening is low.[2] Patients were recruited by study personnel during regularly scheduled visits to their primary care physician. After informed consent, patients underwent a single–time point ECG recording for 30 seconds using the Kardia Mobile device (AliveCor, San Francisco, CA), paired with an iPad (Apple, Cupertino, CA) (Figure 1). A brief medical history (ie, symptoms, comorbidities, and medications) was also obtained during the encounter. The ECGs were automatically transmitted to a secure Health Insurance Portability and Accountability Act–compliant server, from which they were viewed and analyzed by the study personnel. The recorded ECGs were classified by the device as normal, unclassified, or possible AF on the basis of a validated algorithm that evaluated the presence of P waves and RR irregularity.[14] The ECGs were analyzed by the automated analysis software algorithm and overread by a cardiologist within 24 hours of the visit. When the ECG obtained by the mobile device showed possible AF, a follow-up standard 12-lead ECG was conducted by tribal clinic staff to confirm AF diagnosis. When AF was confirmed, the patient's primary care physician was contacted by the study's principal investigator for further follow-up and initiation of guideline-appropriate anticoagulation for the newly diagnosed patient. Anticoagulation use at follow-up and any adverse events were confirmed from clinical records review. The study protocol was approved by the University of Oklahoma Health Sciences Center Institutional Review Board and the Indian Health Service Oklahoma City Area Institutional Review Board.

Statistical Analysis

Continuous variables are reported as means±standard deviations, and categorical variables as percentages. The Student *t* test was used to compare continuous variables, and the Fisher exact test was used to compare categorical variables. The accuracy of the Kardia mobile ECG device's automated algorithm was calculated using the cardiologist's reading as the gold standard. A 2-sided 0.05 α level was used to define statistical significance. All analyses were performed using SAS 9.4 software (SAS Institute, Cary, NC).

RESULTS

Using electronic health records from the Absentee Shawnee Tribal Health System, a total of 2323 AI

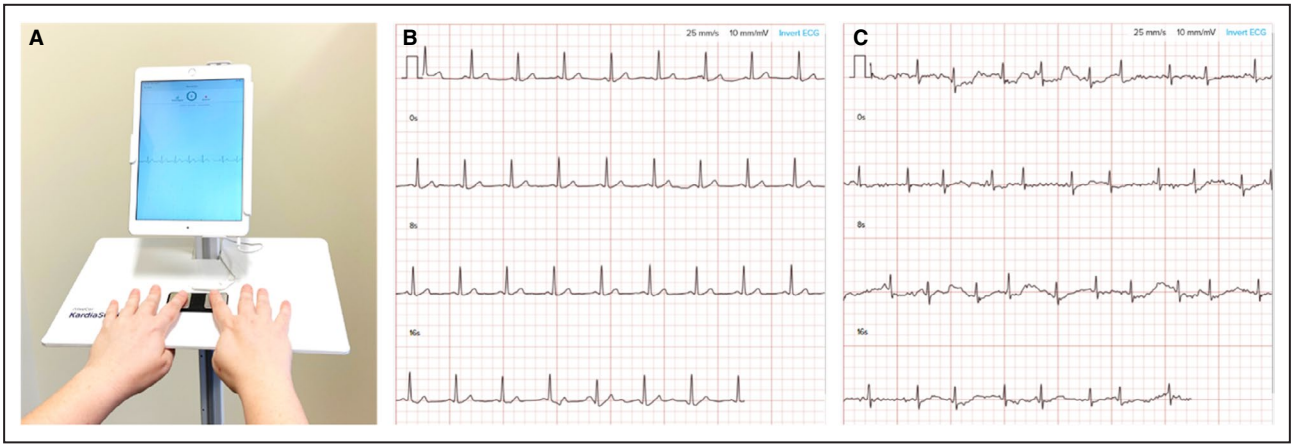

Figure 1. The single-lead ECG device used in our study.
A, When the patient touches each of the metal electrodes with their right and left fingers, respectively, a bipolar ECG lead I is recorded for a period of 30 seconds. Representative examples of ECG tracing in sinus rhythm (**B**) and atrial fibrillation (**C**) using this device.

adults aged ≥50 years had at least one clinic visit to their primary care physician between January 2019 and June 2020. The average age of the clinical population was 61.5±8.9 years, and 62% were women. Previous history of AF was present in 37 (1.6%) patients, who were subsequently excluded from AF screening. The prevalence of AF increased significantly with age (0.9%, 2.4%, and 4.9% for ages 50–64 , 65–74, and ≥75 years, respectively, *P* for trend <0.0001). Study personnel approached 1179 AI patients for participation in the study during their normal clinic visit: 160 (mean age, 62.1±9.4; 61% women) declined to participate, leaving 1019 patients (86.4%) who received AF screening. The screened population had a similar age and sex distribution as the overall clinic population (mean age, 61.4±8.5; 63% women). Patients seen at the same time period who did not undergo screening served as a standard-of-care group (Figure 2). The baseline characteristics of the screened and standard-of-care groups are summarized in Table 1.

In total, new AF was diagnosed in 15 of 1019 (1.5%; 95% CI, 0.9%–2.4%) patients who underwent screening (Figure 3). The mean age of the patients was 65.9±10.3 years, and 7 of 15 (46.7%) were women. There was a nonsignificant trend toward increased incidence of new AF with age (1.1%, 1.7%, and 3.8% for ages 50–64, 65–74, and ≥75 years, respectively, *P* for trend 0.08; Figure 3). Notably, over half of the patients with a new AF diagnosis (8 of 15 [53.3%]), were younger than 65 years, the age of recommended AF screening according to the European Society of Cardiology guidelines.[15] The CHA_2DS_2-VASc score was at least 1 in 14 of 15 (93.3%) patients and at least 2 in 13 of 15 (86.7%) patients. Of the 15 patients with new AF, 6 patients had a ventricular rate >100 bpm, and 9 patients had a ventricular rate between 60 and 100 bpm at the time of screening. Importantly, none of the patients reported having any symptoms related to AF.

During the same time period, 4 of 1267 (0.3%) patients in the usual-care group were diagnosed with new AF (mean difference, 1.2%; 95% CI, 0.3%–2.2%; *P*=0.002). Therefore, screening for AF resulted in a >4-fold increase in the rate of new AF diagnosis (relative risk, 4.7; 95% CI, 1.6–13.3; *P*=0.002), corresponding to a number needed to screen of 86 to identify one patient with new AF.

Those with new AF were slightly older (61.4±8.4 versus 65.9±10.3, respectively; *P*=0.04) than patients

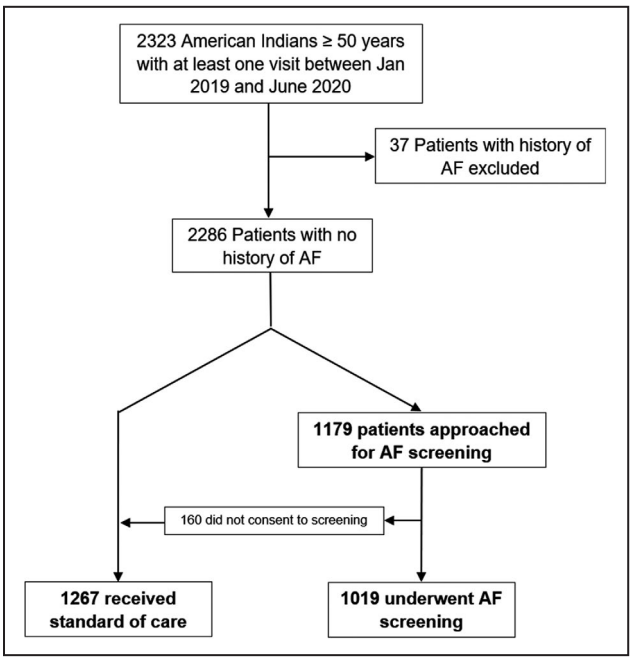

Figure 2. Flowchart of the implementation of the screening strategy among the clinic population.
AF indicates atrial fibrillation.

Table 1. Baseline Characteristics of the Study Population

	Standard of Care, n=1267	Screened, n=1019	*P* Value
Mean age, y	61.5±9.2	61.4±8.5	0.99
Age 50–64 y, n (%)	876 (69.1)	702 (68.9)	0.36
Age 65–74 y, n (%)	258 (20.4)	238 (23.3)	
Age ≥75 y, n (%)	133 (10.5)	79 (7.8)	
Women, n (%)	791 (62.4)	635 (62.3)	0.97
Heart failure, n (%)	12 (0.9)	19 (1.9)	0.07
Coronary artery disease, n (%)	53 (4.2)	89 (8.7)	<0.001
Peripheral vascular disease, n (%)	20 (1.6)	58 (5.7)	<0.001
Hypertension, n (%)	883 (69.7)	691 (67.8)	0.34
Diabetes mellitus, n (%)	512 (40.4)	430 (42.2)	0.39
Stroke/transient ischemic attack, n (%)	28 (2.2)	35 (3.4)	0.09
Hyperlipidemia, n (%)	568 (44.8)	504 (49.5)	0.03
Chronic obstructive pulmonary disease, n (%)	90 (7.1)	73 (7.2)	0.99
CHA_2DS_2-VASc score	2.0±1.6	2.2±1.5	0.002

Table 2. Comparison Between Those With and Without a New Diagnosis of AF

	No AF, n=1004	New AF, n=15	*P* Value
Mean age, y	61.4±8.4	65.9±10.3	0.04
Age 50–64 y, n (%)	694 (69.1)	8 (53.3)	0.08
Age 65–74 y, n (%)	234 (23.3)	4 (26.7)	
Age ≥75 y, n (%)	76 (7.6)	3 (20.0)	
Women, n (%)	628 (62.5)	7 (46.7)	0.28
Heart failure, n (%)	16 (1.6)	3 (20.0)	0.002
Coronary artery disease, n (%)	86 (8.6)	3 (20.0)	0.14
Peripheral vascular disease, n (%)	57 (5.7)	1 (6.7)	0.59
Hypertension, n (%)	679 (67.6)	12 (80.0)	0.41
Diabetes mellitus, n (%)	421 (41.9)	9 (60.0)	0.19
Stroke/transient ischemic attack, n (%)	34 (3.4)	1 (6.7)	0.41
Hyperlipidemia, n (%)	491 (48.9)	13 (86.7)	0.004
Chronic obstructive pulmonary disease, n (%)	68 (6.8)	5 (33.3)	0.003
CHA_2DS_2-VASc score	2.2±1.5	3.1±1.7	0.02

AF indicates atrial fibrillation.

without AF on screening ECG, and had a higher prevalence of certain comorbidities, including heart failure, hyperlipidemia, and chronic obstructive pulmonary disease (Table 2). The higher prevalence of comorbidities of patients with new AF was reflected in their higher mean CHA_2DS_2-VASc score compared with those without AF (3.1±1.7 versus 2.1±1.5, respectively; *P*=0.03).

Anticoagulation with a direct oral anticoagulant was initiated in 14 of 15 (93.3%) patients according to current guidelines,[1,15] after discussion with their primary care physician. One patient with a CHA_2DS_2-VASc score of 0 did not receive anticoagulation. Interestingly, anticoagulant use among patients with known AF increased significantly from 54% (20 of 37) at the beginning of the study to 82% (46 of 56) at the end of the study (*P*=0.002; Figure 4). This increased rate of anticoagulant use was also evident in those with AF at the beginning of the study (Figure 4).

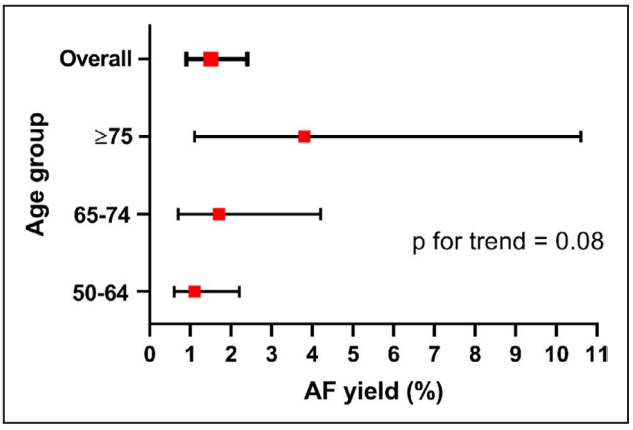

Figure 3. Atrial fibrillation detection rate by age group.
AF indicates atrial fibrillation.

Among all 1019 single-lead ECG recordings obtained in this study, 871 (85.4%) were classified as normal, 17 (1.7%) as possible AF, and 131 (12.9%) were reported as unclassified by the device algorithm (6 premature atrial contractions, 76 sinus tachycardia, 4 sinus bradycardia, 25 bundle branch block). All the single-lead ECGs that were interpreted as AF by cardiology, were also confirmed by the follow-up 12-lead ECGs. Including the unclassified ECGs as non-AF and using a cardiologist's interpretation as the gold standard, the sensitivity and specificity of the AF detection algorithm were 93.3% (95% CI, 70.2%–99.7%) and 99.7% (95% CI, 99.1%–99.9%), respectively. The positive and negative predictive values were 82.4% (95% CI, 59.0%–93.8%) and 99.9% (95% CI, 99.4%–100.0%), respectively (Table 3).

DISCUSSION

In this study, we demonstrated that single–time point, single-lead ECG screening for AF is feasible and well accepted by AI adults aged >50 years in a primary, rural tribal clinic setting. Importantly, AF screening detects significantly more AF than usual care in this population at risk for stroke, with subsequent initiation of anticoagulation. Notably, the AF detection rate in our study (mean age, 61.5 years) is comparable to that of individuals ≥65 years of age, based on a recent patient-level meta-analysis in predominantly

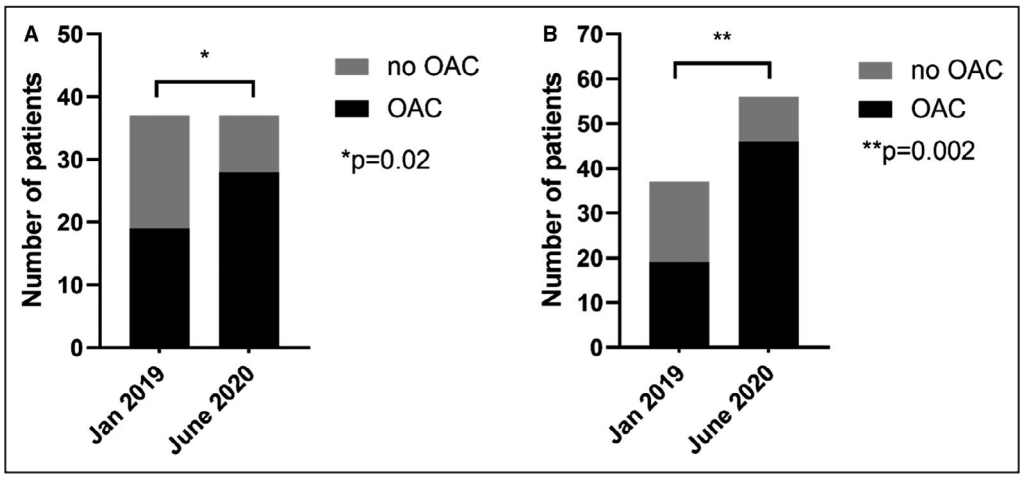

Figure 4. Rate of oral anticoagulation (OAC) initiation among patients with atrial fibrillation (AF) over the course of the study.
A, Among patients with a prior history of AF at the beginning of the study. **B**, Among all patients diagnosed with AF during the course of the study.

White populations (1.44%),[16] suggesting that AI adults, like other indigenous populations,[12,13] develop AF at a younger age compared with non-AI populations. Importantly, the vast majority of those diagnosed with new AF had a class I recommendation for anticoagulation based on their CHA_2DS_2-VASc score, according to current guidelines.[1,15] Therefore, our data suggest that AI adults would benefit from AF screening starting earlier than age 65 years, which is the currently recommended age cutoff for AF screening.[2,15]

Consistent with previous reports,[16] there was a trend of increasing AF detection rate with increasing age in our population, reaching 3.8% for those aged ≥75 years, although CIs were wide, reflecting the small numbers seen with advanced age. For comparison, the reported AF detection rate in White populations is 1.49% and 1.89% for those aged 74 to 79 and 80 to 85 years, respectively.[16] Our results provide the rationale for a randomized clinical trial design to examine the impact of AF screening on clinical outcomes, including stroke and cognitive decline, in this high-risk population. Leveraging the existing resources of ongoing, longitudinal studies in AI adults, such as the Strong Heart Study,[11,17] are likely to increase the cost-effectiveness of this approach.

Table 3. Accuracy of the Single-Lead ECG to Detect AF

AF Diagnosis by Cardiologist Interpretation				
		Yes	No	Total
Single-lead ECG diagnosis	Possible AF	14	3	17
	No AF*	1	1001	1002
	Total	15	1004	1019

AF indicates atrial fibrillation.
*Includes normal and unclassified.

AI adults have a high prevalence of risk factors for AF, including obesity, diabetes mellitus, and hypertension.[11,17] The increased age and comorbidities, reflected in a higher CHA_2DS_2-VASc score between patients detected to have AF compared with those without AF, may explain, at least in part, the increased incidence of silent AF in the former group. However, lifestyle, socioeconomic factors, and a genetic and/or behavioral predisposition may also play a role. Further studies are required to understand factors associated with developing AF in this population.

For AF-screening programs to be successful, it is crucial they provide a clear pathway of referral to a primary care physician and/or cardiologist after AF diagnosis to ensure appropriate treatment with oral anticoagulation.[2] The high rate of guideline-appropriate oral anticoagulation therapy in patients diagnosed with AF as a result of screening in our study was largely attributable to the pathway we established between the university-based investigators and the tribal system healthcare team. As such, we recommend caution when extrapolating our results to clinical settings where this pathway after screening cannot be implemented. In addition, we believe that increasing awareness of AF among healthcare providers in the tribal health system, through participation in this screening program, was the likely reason for a significant increase in the proportion of patients with AF receiving adequate oral anticoagulation, as previously reported in another community-based AF-screening study.[18] The importance of this additional benefit of screening is highlighted by the findings of a recent report from the NCDR PINNACLE-AF (National Cardiovascular Data Registry's Practice Innovation and Clinical Excellence–Atrial Fibrillation) Registry, showing that AI patients with AF were significantly

less likely to be treated with oral anticoagulation than non-AI patients.[19]

Screening for AF remains controversial, because the US Preventive Services Task Force indicated that the evidence is insufficient to support screening with ECG (I recommendation),[20] whereas the European Society of Cardiology and other societies provide a strong recommendation for AF screening in individuals aged ≥65 years.[2,15,21] Several studies have shown that community-based AF screening using a single-lead ECG device is cost-effective[8,22] and may possibly improve outcomes.[8,23,24] Screening individuals aged ≥65 years in pharmacies with a single–time point, smartphone-based ECG, yielded an incremental cost-effectiveness ratio of $4066 per quality-adjusted life year and $20 695 for preventing 1 stroke.[8] The respective values for screening 75-year-old individuals with 2 weeks of intermittent, twice-daily, handheld ECGs, were $5212 per quality-adjusted life year and $7955 per 1 stroke prevented.[22] Multiple approaches have been used for AF screening, including pulse detection, 12-lead ECG, single-lead ECG, photoplethysmography, ambulatory patch ECG, or continuous monitoring through implantable loop recorders.[25] The AF detection rate increases with the intensity of monitoring, but the optimal method, duration, and frequency of screening remain to be determined. Enriching the screened population for AF using age or NT-proBNP (N-terminal pro-B-type natriuretic peptide) increases the yield of AF screening and decreases the number needed to screen to identify AF.[26] Our study supports the notion that targeting a high-risk population, such as AI adults, increases the yield of AF screening, especially at a younger age. Incorporating more sophisticated multivariate AF predictive tools[27] in AF screening may further increase the yield of AF screening and render the approach even more cost-effective.

Opportunistic screening using a 30-second single-lead ECG recording is likely to detect persistent or permanent AF, but miss paroxysmal AF.[28] Notably, the actual prevalence of AF is expected to be even higher in this population than what we found with single–time point screening, given the paroxysmal nature of AF. Therefore, allowing patients to be screened routinely during their repeated clinic visits may help to identify more patients with undiagnosed AF. However, the optimal screening intensity to identify AF of prognostic significance, as well as the cost-effectiveness of this approach, remain to be determined.

The low cost of digital, single-lead ECG devices and the minimal training required for their use allow for implementation of these technologies for AF screening across several community-based, rural, and low-resource clinics.[28] However, the accuracy of the diagnostic tool used in AF screening in these settings is important. Because the prevalence of AF is relatively low in the population screened, it is crucial to have high specificity to minimize the risk of false-positive results.[28] Using a high-specificity algorithm in a population with low prevalence of the disease will invariably yield a high negative predictive value while preserving positive predictive value.[29] In our study, the Kardia mobile ECG device had a sensitivity of 93.3% and specificity 99.7%, and positive and negative predictive values 82.4% and 99.9%, respectively, consistent with previously reported values.[14,25]

Our results should be interpreted in the context of the recently published Apple Heart Study, which examined the use of continuous, smartwatch-based AF screening in ≈420 000 participants with an average age of 41 years.[30] Only 0.5% of participants in the study received an AF alert, and 34% of the subsequently deployed ECG patches in these subjects showed AF, highlighting the notion that using continuous monitoring of photoplethysmography in a low-risk population is likely to yield a high incidence of false positive results and also identify shorter episodes, which do not appear to increase the risk of stroke.[31] As such, a mass screening approach in a low-risk population is not recommended.[31] On the contrary, AF screening in a targeted, high-risk population, such as AI adults, is likely to yield clinical benefit.

Limitations

The assignment to AF screening was not done through a randomized process. Although the age and sex distribution of the screened cohort was similar to the entire clinic population, we cannot exclude that differences in clinical characteristics might explain part of the increased AF detection rate. Although we did not analyze the cost-effectiveness of screening in this study, other studies have shown that single–time point AF screening is cost-effective.[8,22] Our study was not powered to detect adverse clinical outcomes, and these were not reported. Whether AF screening in this population will lead to a decrease in stroke remains to be determined. Nonetheless, recent observational studies have suggested that initiation of anticoagulation in at-risk individuals with incidentally identified AF may lead to improved outcomes.[5] We implemented a process to analyze the ECGs within 24 hours and inform the primary care providers of the results. Therefore, our results may not be extrapolated to clinical settings where this pathway after screening cannot be implemented. Finally, our study also illustrates the fact that unclassified ECGs remain a major caveat in implementing single-lead, digital ECG screening at the population level without manual overread.[28] Refining of the AF detection algorithms to minimize the rate of unclassified ECGs are expected to mitigate this problem.[28]

CONCLUSIONS

Opportunistic screening for AF using mobile, single-lead ECG in AI adults detected significantly more AF than usual care within our partner tribal primary care health system. It is feasible, relatively simple, and well accepted by patients. Moreover, our data suggest that AI adults, like other indigenous populations, develop AF at a younger age compared with non-AI populations and would benefit from AF screening starting earlier than the recommended age of 65 years. In light of the high prevalence of risk factors for development of AF in AI adults, this simple approach to AF screening in other tribal clinics has the potential to improve health outcomes among a large number of individuals who have historically endured greater health disparities.[32]

ARTICLE INFORMATION

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Disclosures

None.

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