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GUIDELINES

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2021 Asia Pacific Heart Rhythm Society (APHRS) practice guidance on atrial fibrillation screening

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1 | INTRODUCTION

Atrial fibrillation (AF) is the most common sustained arrhythmia, and the global prevalence is estimated to be 46.3 million.[1] With an aging population worldwide and increased detection, the prevalence of AF has been increasing. Notably, the prevalence has increased by 20-fold over a period of 11 years in China and is projected to double in the European Union by 2060.[2,3] Despite the fact that 70% of AF-related stroke can be prevented by oral anticoagulation (OAC) therapy,[4] over 70% of AF-related strokes or transient ischemic attacks occur in nonanticoagulated patients in Hong Kong.[5]

Ischemic stroke rates in Asia vary widely.[6] In Japanese AF patients, the annual incidence has been reported at 1.3%,[7] while a rate of 10.4% was reported in hospitalized Chinese AF patients in Hong Kong.[8] Higher rates of 13% have been reported in Southeast Asia and the Far East.[9]

AF screening is recommended by a number of guidelines, but not all. Remarkable controversy exists as to the optimal approach for AF screening which is evident in the recommendations of different international guidelines. In the European Society of Cardiology (ESC) guidelines, for primary stroke prevention, it is a class I recommendation to perform opportunistic AF screening by pulse taking or electrocardiogram (ECG) rhythm strip in patients aged ≥65 years and a class IIa recommendation for systematic ECG screening in individuals aged ≥75 years.[10] In the American College of Cardiology (ACC) guidelines, no recommendation has been put forward for AF screening.[11,12] The United States Preventive Services Task Force (USPSTF) concluded that there was inadequate evidence to assess whether AF screening with electrocardiography identifies older adults with previously undiagnosed AF more effectively than usual care.[13] In Australia, the Heart Foundation and Cardiac Society of Australia and New Zealand (CSANZ) included a recommendation for opportunistic screening in people aged ≥65 years and a practice point that a single-lead ECG rhythm strip might be preferred.[14] In the Asia Pacific region, there is no specific guidance on screening, although Asia Pacific Heart Rhythm Society (APHRS) supported the consensus document of the European Heart Rhythm Association (EHRA) in 2018 which recommended opportunistic screening.[15]

Importantly, there is huge heterogeneity in AF epidemiology, ethnicity, socioeconomic status, access to technologies, and healthcare system among different countries in the Asia Pacific region. To embrace the heterogeneity in the Asia Pacific region, three levels of recommendations according to the applicability to different countries are created in this APHRS AF Screening Practice Guidance (Table 1). To further address this heterogeneity, a special section on AF screening in APHRS countries is included in the Online Appendix. This Online Appendix includes information on the healthcare system, AF epidemiology, current status, and challenges in AF screening and future perspectives in different countries in the Asia Pacific region. Furthermore, since chronic rheumatic heart disease (RHD) remains prevalent in some Asia Pacific countries, special emphasis is placed in this condition in the preparation of this APHRS AF Screening Practice Guidance (Figure 1).

2 | EPIDEMIOLOGY OF ATRIAL FIBRILLATION

2.1 | Prevalence and incidence of AF

The reported prevalence of AF in Asia Pacific countries varies from 0.49% to 5.4% (Table 2). The prevalence of AF in those aged >70 or 80 years was 4.6%–8.2%. The prevalence of AF progressively increased more than twofold for the last 10 years[16,17] and is significantly greater in men than in women for all years (Figure 2A). AF prevalence in Thailand has been reported to be 1.9% for those aged ≥65 years, and 2.2% in rural areas for those aged ≥60 years.[18] AF prevalence in Korea is expected to be 5.8% in 2060, and 4.0% in Taiwan by 2050.[16] Although the prevalence of AF is increasing steeply in Asia, it remains lower than in many Western countries. The prevalence increased over the study period, mainly among those >70 years (Figure 2B).

In terms of incidence, annual trends in Asia were more stable. The 10-year overall incidence was 1.51–1.77 per 1000 person-years[16,17] and was higher for men than women.[17]

The proportion of patients with high stroke risk (CHA_2DS_2-VASc score ≥2) increased progressively, and was more than 80%.[16,17] The proportion of patients with high bleeding risk (HAS-BLED score ≥3) increased to about 60%.[16,17]

TABLE 1 Levels of recommendation for AF screening

Level 1	Recommended in all countries
Level 2	Recommended in most countries
Level 3	Recommended in some countries

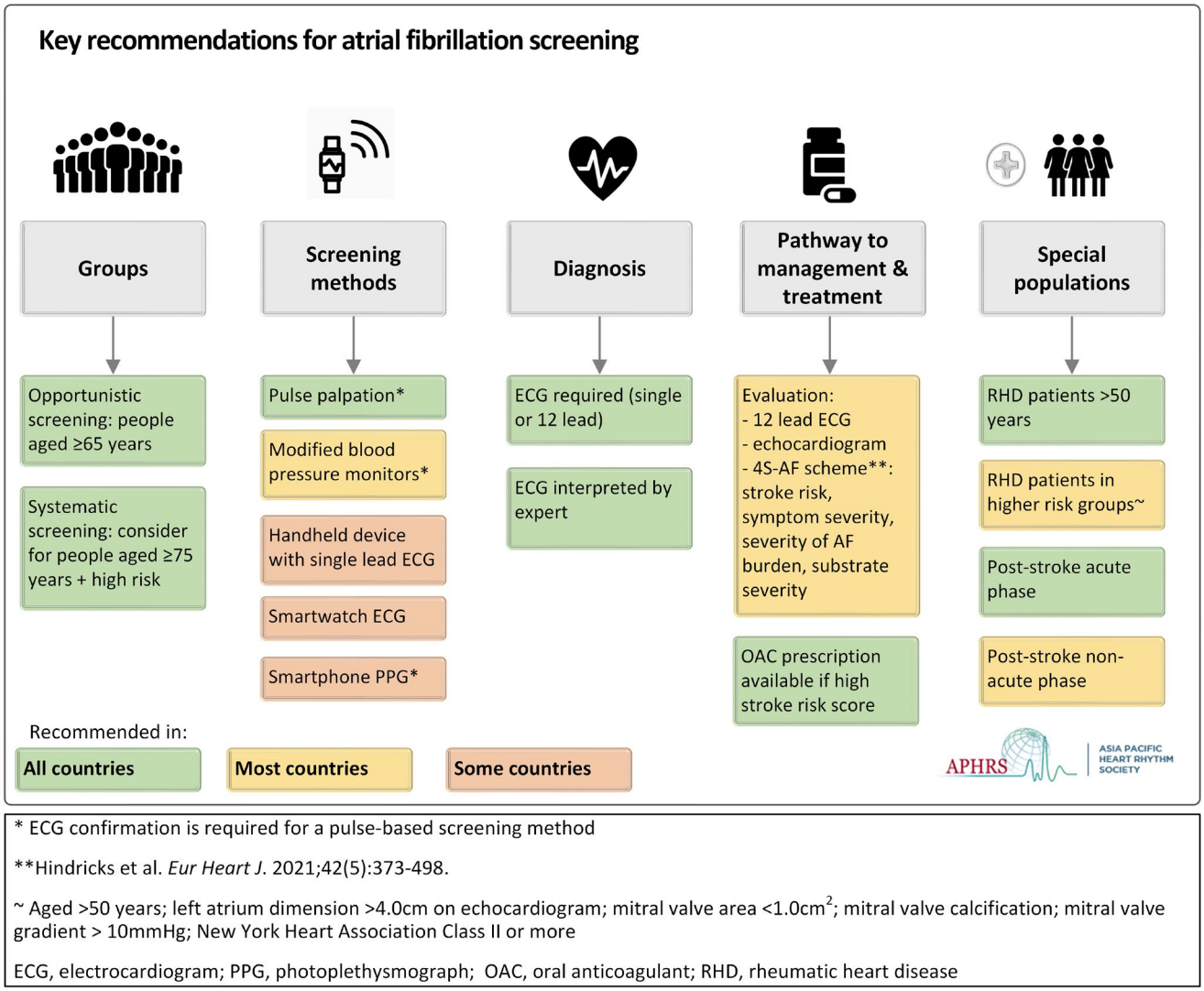

FIGURE 1 Summary of key practice recommendations for atrial fibrillation screening

2.2 | Healthcare burden of AF

The hospitalization and healthcare burden of AF increased in many Asian countries over the past decade.[16,17,19] Hospitalizations for AF increased by 420% from 2006 to 2015 in Korea. Most admissions occurred in patients aged ≥70 years, and the most frequent coexisting conditions were hypertension, heart failure, and chronic obstructive pulmonary disease (COPD). Hospitalizations due to major bleeding and AF rate control increased, whereas those due to ischemic stroke and myocardial infarction decreased.[17,20] The risks of ischemic stroke, heart failure, and mortality were higher compared with patients without AF in the initial period (approximately 6 months) after AF was first diagnosed.[16]

In Korea, the total cost of care related to AF was equivalent to 0.78% of the Korean National Health Insurance Service total expenditure. In comparison, in the United States, the national incremental AF cost was estimated as $6–26 billion, and in the United Kingdom, the direct cost of AF in 2000 was £459 million which was the equivalent of 1% of the national healthcare budget.[21–23]

2.3 | AF prognosis

Over the last 5 decades, AF-associated mortality decreased by 25% in the Framingham Heart Study.[24] Among AF patients, annual event rates for all-cause mortality, ischemic stroke, intracranial bleeding, heart failure admission, and myocardial infarction significantly declined for a decade. AF-associated mortality decreased by 20% over a decade from 5.0%/year in 2006 to 4.0%/year in 2015 in Korea.[17,25] Improvement in survival might be related to a 52% reduction of heart failure and a 9% reduction of ischemic stroke.[17,25] Better treatment of risk factors like hypertension might be playing a role.

TABLE 2 Prevalence of AF in the Asia Pacific region

Country/ region	Year(s) data-obtained	Sample size (n)	Study population	Age	Prevalence (%) total (men, women)	Study
Australia	June 2014	6,140,651	Seven international epidemiology studies	≥55	5.4 (6.0, 4.8)	Ball et al. (2015)[124]
China	2014–2015	726,451	Nationally representative cross-sectional study.	≥40 ≥70	2.3 (1.9, 2.7) 4.6 (ND, ND)	Wang et al. (2008)[125]
China	2015–2017	12,013	Population-based study, the Guangzhou Heart Study	≥35 ≥80	1.5 (2.0, 1.2) 5.0 (ND, ND)	Deng et al. (2018)[126]
Hong Kong	2014–2015	13,122	Territory-wide, community-based screening program	≥15 ≥80	1.8 (1.6, 2.0) 5.0 (3.9, 6.1)	Chan et al. (2017)[82]
India	2016–2017	2100	Indian adults living in the rural region of Anand district, Gujarat, India.	≥40	1.6 (2.3, 1.0)	Soni et al. (1995)[127]
Indonesia	1990	2073	Random selection of people from three districts in Jakarta	25–64	0.2	Boedhi-Darmojo R[128]
Iran	2001	463	Two general practitioners serving the National Iranian Oil Company‡	50–79	2.8 (1.3, 4.3)	Habibzadeh et al. (2004)[129]
Japan	2012	630,138 123,425	Iwate Prefecture	≥40 ≥80–89	1.3 (1.9, 0.5) 4.7 (6.0, 3.8)	Tamaki et al. (2017)[130]
Japan	2013–2014	108,951	Data from the periodic health examinations, Tochigi Prefecture, Japan	≥40 ≥80	0.9 (1.5, 0.4) 4.5 (5.5, 3.4)	Yonezawa et al. (2009)[131]
Malaysia	2007–2014	10,805	18 urban, 22 rural communities across Malaysia	≥30	0.5	Lim et al. (2016)[132]
Singapore	Prospective	1,839	Community-based study, health screening project	≥55 ≥80	1.5 (2.6, 0.6) 5.8	Yap et al. (2008)[133]
South Korea	2013	819,948	Korean National Health Insurance Data Sample Cohort	≥15	1.4 (0.7, 0.7)	Lee et al. (2018)[20]
South Korea	2015	41,701,269 1,371,423	Korean National Health Insurance Service database	≥20 ≥80	1.5 (1.6, 1.4) 8.2 (ND, ND)	Kim et al. (2018)[17]
Taiwan	2011	289,559	Taiwan National Health Insurance Research Database	≥20 ≥80~90	1.1 (0.6, 0.4) 5.9 (ND, ND)	Chao et al. (2018)[16]
Thailand	Prospective	1,277	Cross section of Maerim District, Chiang Mai	≥65	1.9	Phrommintikul et al. (2016)[18]
Thailand	Prospective	13,864	Communities in Phetchaburi and Lopburi provinces	≥65	2.8	Suwanwela et al (2020)[114]

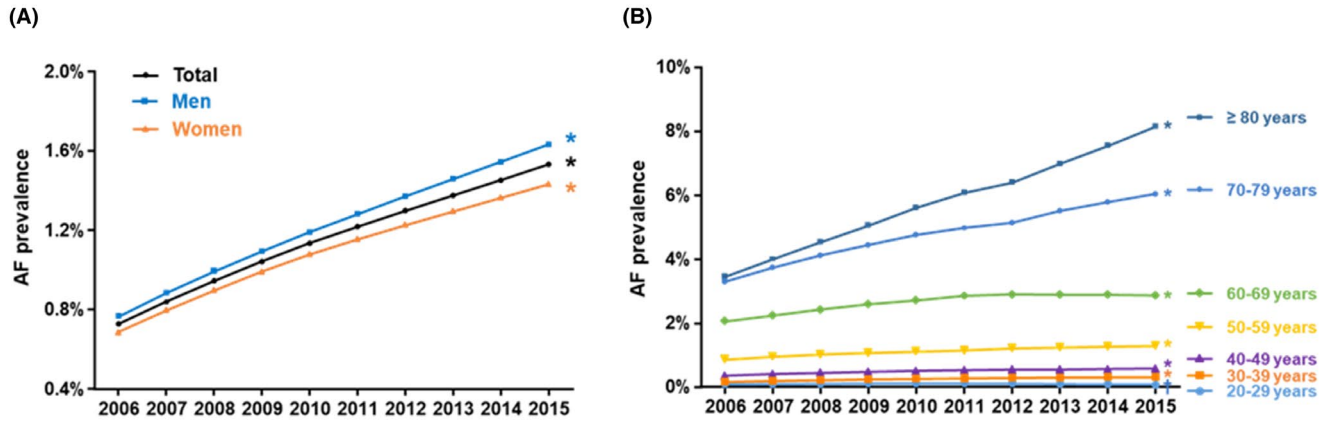

FIGURE 2 Annual prevalence of atrial fibrillation between 2006 and 2015 stratified according to gender (A) and age (B). *P value for increasing trends <0.001. †P value for decreasing trends <0.001. AF, atrial fibrillation. Source: Kim DH, et al. 2018,[17] reproduced with permission

2.4 | Epidemiology of AF in rheumatic heart disease

The prevalence of RHD has declined in the developed world since the industrial revolution. However, RHD is still a common health burden in some Asian and African countries. In 2015, 73% of global RHD cases were located in India, China, Pakistan, Indonesia, and the Democratic Republic of the Congo,[26] demonstrating that RHD continues to be a significant health problem for developing countries. Lower socioeconomic status and overcrowding are associated with higher prevalence of RHD, particularly for children living in households of >8.[27,28] Prevalence in the Indian population has been reported as 6 per 1000. RHD also remains a substantial problem for first nations people, such as Indigenous Australians (prevalence up to 15 per 1000 in the Top End of the Northern Territory)[29] and Māori and Pacific Islanders.[30,31]

It is estimated that 15.6 million people suffer from RHD and 3–7.5% of all strokes in developing countries are directly related to RHD.[32–34] Estimates of the prevalence of AF in the rheumatic population vary widely because of differing periods of study, diagnostic methods employed, and in different countries. An Indian study found that those with tricuspid regurgitation had the highest prevalence of AF (34.9%) as compared with mitral stenosis (31.7%) and mitral regurgitation (25.3%).[35]

Native valvular AF is mainly due to rheumatic mitral stenosis. Mechanical outflow obstruction because of mitral stenosis results in higher left atrial (LA) pressure that in turn causes LA enlargement which is associated with AF. The Canadian Registry of AF (CARAF) found that a larger baseline LA dimension is associated with progression to chronic AF. In addition, patients with no or paroxysmal AF recurrence had no change in LA dimension over a 4-year period.[36]

Age is also a major determinant of AF in mitral stenosis. Rates of persistent AF are <20% in cohorts with a mean age <35 years, while rates of persistent AF range between 30% and 60% for cohorts with age >45 years.[37] In a global hospital-based RHD registry, the REMEDY study, that included some African countries, Yemen and India, AF was found in 21.8% of 3343 RHD subjects.[38] In the Asia Pacific region, AF prevalence was reported to be between 10% and 36% of patients with rheumatic mitral stenosis who underwent percutaneous mitral commissurotomy.[39–41]

2.5 | Key points

1. The prevalence of AF is increasing steeply in Asia but remains lower than in many Western populations. The prevalence increased mainly among elderly populations.
2. The hospitalization and healthcare burden of AF increased in many Asian countries over the past decade.
3. RHD is still a common health burden in some Asian and African countries, and in first nations people.

3 | PRIMARY STROKE PREVENTION BY ATRIAL FIBRILLATION SCREENING

3.1 | Primary stroke prevention by AF screening

3.1.1 | International recommendations on screening

At present, none of the US ACC/AHA AF guidelines have clear recommendations for AF screening,[11,12] although the AHA/American Stroke Association guideline states that "active screening" for AF in primary care "can be useful."[42] The USPSTF[13] concluded that while systematic ECG screening can detect previously unknown cases of AF, it has not been shown to detect more cases than screening based on routine pulse palpation followed by ECG assessment if the pulse is irregular. Based on a comprehensive literature review published in 2018,[43] the task force concluded that there was insufficient evidence that systematic screening for AF with ECG in asymptomatic older adults led to better health outcomes than usual care or waiting until after symptoms have developed ("I" recommendation). The 2021

draft Evidence Review for the USPSTF still has an "I" recommendation for AF screening.[44] To generate this evidence would require large randomized controlled trials of screening for AF with stroke as an outcome as recommended by the AF-SCREEN International Collaboration.[45] There are numerous such trials underway:

- the Screening for Atrial Fibrillation with ECG to Reduce stroke (SAFER) study in the United Kingdom (ISRCTN16939438);
- the US Heartline study (NCT04276441); and
- the US ReducinG stroke by screening for UndiAgnosed atRial fibrillation in elderly inDividuals (GUARD-AF) study (NCT04126486).

Two landmark randomized trials have recently published their results: the Danish LOOP study[46] and the STROKESTOP study.[47] The LOOP study included 6000 participants aged 70–90 years (without AF), who were randomly assigned in a 1:3 ratio to receive implantable loop recorder (ILR) monitoring or usual care. After a median follow-up of just over 5 years, AF (>6 min) was detected in 32% of participants in the ILR group versus 12% in the usual care group. In total, 4.5% in the ILR group experienced a stroke or systemic arterial embolism versus 5.6% in the usual care group (HR 0.80, $p = .11$).[48] In summary, this large, well-executed study showed a nonsignificant relative risk reduction in stroke/systemic arterial embolism in the ILR group, compared with control, over 5 years.[49] In addition, it demonstrates the higher detection rate of intensive monitoring, as almost a third of participants in the ILR group had AF detected.

The STROKESTOP study is the largest randomized trial of AF screening using a handheld ECG. Almost 30,000 people aged 75–76 years were randomly assigned to receive an invitation for AF screening or registry follow-up (without screening or contact).[50] Just over 50% of those invited for screening participated, and screened themselves with a thumb ECG twice daily for 14 days. This resulted in a small increase in AF in the invited-to-screen group (12.1%–14%). While the study was well-conducted, the main limitation is that the 49% of people who did not take up the invitation for screening were different to the group who participated: those who did not participate had a lower socioeconomic profile, higher stroke risk, and higher baseline AF prevalence.[51] This issue will be clarified by the study design of SAFER, although the study will not report for another 5 years. The economic analysis of STROKESTOP is awaited.

The 2020 ESC guidelines recommend opportunistic screening by pulse pulsation or ECG rhythm strip in patients ≥65 years (Class I).[10] The ESC guidelines now state that a 30 second rhythm strip showing AF is diagnostic if read by someone who is expert in ECG interpretation. This is also the basis of the 2018 recommendation in the Australian Heart Foundation guideline, which also recommends use of a single-lead ECG rhythm strip. In the 2017 EHRA consensus statement on AF screening in 2017,[15] which is endorsed by the APHRS, the same recommendation was made. Most recently, the Canadian Cardiovascular Society (CCS) has also recommended opportunistic screening for people aged ≥65 years using pulse check or rhythm-based devices.[52] Primary systematic ECG screening may be considered in patients ≥75 years or in those at high stroke risk (Class IIa). This APHRS practice guideline endorses all of these recommendations (Table 3).

3.1.2 | Opportunistic versus systematic screening

AF screening can either be opportunistic or systematic. Opportunistic screening is where a health professional checks for AF during a routine consultation or attendance (e.g., during a routine visit to a family physician). Systematic screening is where all people in a particular age group are invited to attend a location (e.g., pharmacy) for screening.

However, in reality, there may not be a substantial difference in the proportion of people screened under a systematic or opportunistic program.[53] The two largest studies of systematic AF screening achieved an uptake of around 50%,[47,54] which is similar to what may be achievable in an opportunistic program in primary care. Importantly, whichever method is adopted, a clear pathway to treatment is required for those diagnosed, the benefits must outweigh the harms of screening in the given population, and cost-effectiveness is an important consideration.[55] A summary of the rationale for screening is provided in Table 4.

3.1.3 | Recommendations

Recommendations are summarized in Table 3.

3.2 | Primary stroke prevention by AF screening in CIED patients

Atrial tachyarrhythmias including AF episodes, are often incidentally detected by the atrial lead in cardiac implantable electronic devices (CIEDs). These are recorded as atrial high-rate episodes (AHREs). CIEDs include bradycardia pacemakers, implantable cardioverter

TABLE 3 Recommendations on primary stroke prevention by AF screening

	Consensus Statement/recommendation	Level
1.	Opportunistic screening for AF is recommended for people aged ≥65 years by pulse palpation followed by an ECG confirmation. Alternatively, a 30 second rhythm strip could be used as the primary method of screening	1
2.	Systematic screening may be considered to detect AF in people aged ≥75 years or those with at high stroke risk	2
3.	Consideration of healthcare and social economic issues, patients' concerns and proper management of screen-detected AF is important	1
4.	An ECG (12-lead or single-lead ≥30 s) showing AF analyzed by a physician with expertise in ECG rhythm interpretation is required to establish a definitive diagnosis of AF	1

TABLE 4 Rationale for AF screening

1.	AF is highly prevalent and often without symptoms, and increases the risk of stroke
2.	Strokes in AF is more severe than strokes without AF
3.	Thrombolysis in AF-related stroke is less effective
4.	In-hospital mortality for patients with AF-related stroke is double that for stroke patients without AF
5.	Strokes with AF have higher permanent disability
6.	About one in five of patients with stroke have AF discovered for the first time
7.	Preventive therapy such as oral anticoagulation can reduce stroke risk in AF in patients at risk
8.	Careful management, and rhythm and rate therapy may also reduce heart failure, adverse atrial remodeling, tachycardiomyopathy, and other AF-related mortality and morbidity

Note: Hypothesis: If persons with undiagnosed AF can be detected earlier, some strokes can be prevented and other adverse consequences of AF can be reduced.

defibrillators (ICDs), and cardiac resynchronization therapy devices (CRTs). AHREs in devices implanted for a clinical reason are not really screening, as the intent of the device implantation was not to screen for AF. Therefore, AF detected in this way is more akin to clinically detected AF than screen-detected AF. Patients with AHREs are often asymptomatic, and AHREs occur more frequently in patients with the following risk factors: older age, male gender, heart failure, sinus node disease, a high percentage of right ventricular pacing, and an enlarged left atrial volume.

The reported incidence of AHREs is relatively high, although it depends on the definition used. The 2017 EHRA consensus statement defines an AHRE as an atrial rate >190 bpm recorded from an implanted atrial lead in a CIED.[55] Studies from Asia[56,57] show a high prevalence of AHREs in pacemaker recipients (44%–48%) that were associated with a prior history of AF. Patients with AHREs had a 2–3.7 times higher risk of major cardiovascular events compared to those without. These data are similar to other international cohorts.

In patients without a prior history of AF, an AHRE lasting ≥5 min confirmed by device atrial electrograms, is termed subclinical AF (SCAF). For the purpose of this guidance, SCAF is defined as validated AHREs of at least 5–6 min in duration independent of prior AF. The presence of SCAF increases the likelihood of future clinical (ECG-documented) AF and increases the risk of stroke and thromboembolism. In the Registry of Atrial Tachycardiac and Atrial Fibrillation Episodes (RATE),[58] 54.1% of those with pacemakers and 72.4% of those with ICDs had SCAF. Data from Asymptomatic Atrial Fibrillation and Stroke Evaluation in Pacemaker Patients and the Atrial Fibrillation Reduction Atrial Pacing Trial (ASSERT)[59] showed that the presence of SCAF at 3 months increased the risk of ECG-documented AF by 5.6 times. However, 75% of these patients did not have clinical AF detected during the follow-up period. Importantly, SCAF increased the annual risk of stroke and thromboembolism from 0.69% to 1.78%.[59] The risk is higher for those with an underlying stroke risk ($CHADS_2$ score ≥2) and a significant SCAF duration/burden (with >5.5 h /day burden often defined as significant).[55,60,61] However, the stroke/systemic thromboembolism risk is still lower for SCAF than for ECG-detected AF,[62,63] and OAC may not reduce the risk or the net clinical gain may not be in favor of OAC therapy.[64] Importantly, the temporal relationship between SCAF and stroke/systemic thromboembolism in both the Prospective Study of the Clinical Significance of Atrial Arrhythmias Detected by Implanted Device Diagnostics (TRENDS)[60] and ASSERT[59] is not well established, suggesting that SCAF may be a risk marker rather than an immediate cause of stroke/thromboembolism.

3.2.1 | Key points

1. AHREs are commonly detected in CIEDs, and when lasting for ≥5 min are termed SCAF.
2. Use of bipolar atrial sensing, and appropriate device programming to optimize SCAF detection are important.
3. Validation by device stored atrial electrograms is essential especially for shorter durations of SCAF.
4. The risk of clinical AF is higher in those with SCAF than those without. The risk is increased by progression of SCAF over time.
5. Risk of stroke/systemic thromboembolism is increased by longer episodes of SCAF, and strongly influenced by the underlying stroke/systemic thromboembolism risk.
6. The role of OAC remains unconfirmed without the documentation of clinical AF or a high risk of stroke/systemic thromboembolism.

3.2.2 | Practical management of SCAF

Four recent major international guidelines have commented on the management of SCAF detected by CIEDs.[11,55,65,66] The 2017 ESC consensus document[55] on device-detected SCAF, endorsed by the APHRS, forms the basis of the current guidance. In a patient with prior AF, the occurrence of SCAF should only serve as a reminder to consider OAC, which should have been initiated before based on their CHA_2DS_2-VASc score.

The fundamental question is whether SCAF detected by a CIED alone represents clinical AF and be managed as such. The risks of future ECG-documented AF and stroke/systemic thromboembolism are higher in those with SCAF detected than for those without, but the stroke/systemic thromboembolism risks are substantially lower than clinical AF. There is also evidence of progression of SCAF duration and burden over time. Transition to clinical AF, a higher risk of stroke/systemic thromboembolism and heart failure are also observed in patients with SCAF.[67,68]

3.2.3 | Key points

1. When SCAF is detected, it is recommended to document AF on an ECG including the use of ambulatory recording. When

present, the strategy becomes standard AF management, and OAC will be recommended according to the balance between clinical bleeding risk and stroke risk.

2. For patients with prior stroke/systemic thromboembolism or transient ischemic attack (TIA), it is recommended that if SCAF is documented, OAC would be required. The same will probably apply to a patient with significant mitral stenosis even if no ECG documented AF is yet available.
3. For patients without prior stroke/systemic thromboembolism or TIA, and without ECG documented AF, there is no evidence that OAC has any benefit (and may be harmful). If AF burden is ≤5.5 h/day (TRENDS) or the longest AF episode is <24 h (ASSERT), it is recommended to continue to monitor SCAF progression over time and to document AF with ECG. If thresholds for AF burden/episode duration are exceeded, then OAC is considered in patients with high stroke/systemic thromboembolism risk such as when CHA_2DS_2-VASc score ≥2 for men and ≥3 for women, as suggested in the 2019 AHA consensus statement.[66] For intermediate risk individuals, a monitoring strategy is recommended for SCAF progression and clinical AF occurrence.
4. A clinical guidance flow chart is shown (Figure 3).

3.2.4 | Recommendations

Recommendations are summarized in Table 5.

3.3 | Primary stroke prevention by AF screening in chronic rheumatic heart disease

AF in the rheumatic population results in greater morbidity and mortality compared with the nonrheumatic population. Silent AF poses a particular risk for thromboembolic events, with one study showing

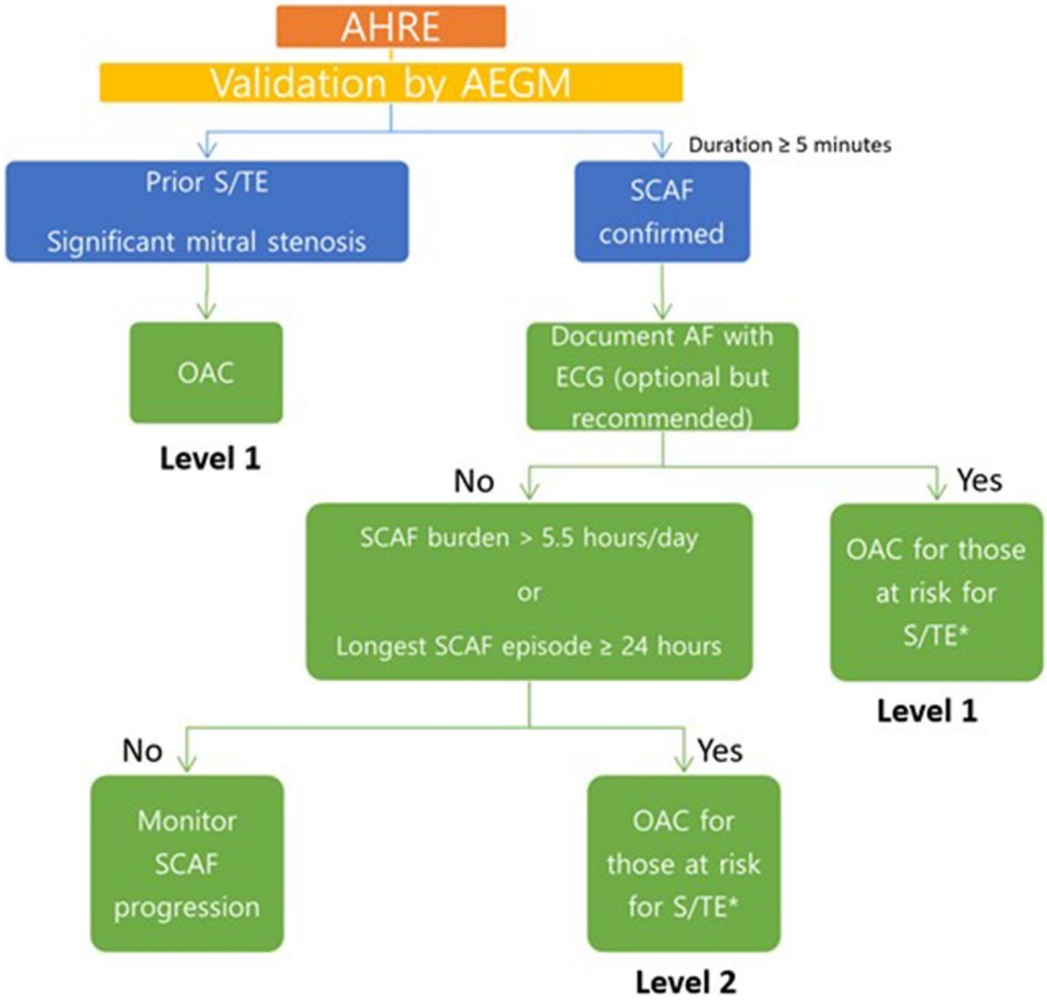

FIGURE 3 Management of subclinical atrial fibrillation (SCAF) in patients with either pacemakers, implantable cardioverter defibrillators, or cardiac resynchronization therapy devices without prior documented AF. Level of recommendations for use of oral anticoagulation (OAC) is included. *CHA2DS2-VASc score ≥2 in men and ≥3 in women. Initiation of OAC, including nonvitamin K antagonist oral anticoagulant will also depend on bleeding risk and local health authority recommendation. AHRE =Atrial high-rate episode; S/TE =Stroke and thromboembolism

>20% of patients with RHD presenting with ischemic stroke for the first time were in sinus rhythm. Therefore, they are likely to have had periods of AF that predisposed them to embolic events.

Evidence is lacking regarding predictors of AF in native RHD. Current studies show:

- Patients aged >50 years at presentation have been found to have a high prevalence of AF (33%–57%).[35,56–61]
- Left atrial diameter >4.0 cm on echocardiogram has shown to be an important predictor of AF.[62,63]
- Mitral valve calcification is found in 35% of patients with mitral valve disease and has been found to be a significant predictor of AF.[64,65] It is an important marker for embolic events and may well be a manifestation of the length of time the disease process has been established.[65,66]
- The severity of mitral valve stenosis is correlated with AF, with a mitral valve area <1.0 cm^2 linked to increased risk of AF.[67,68]

AF in RHD patients poses a significant risk for comorbidities that affect not only the individual but also poses a burden on healthcare system. Therefore, AF screening to prevent stroke is recommended for higher risk groups of RHD patients (Table 6).

4 | WHAT METHODS AND TOOLS SHALL WE USE TO SCREEN FOR ATRIAL FIBRILLATION?

Pulse palpation is a simple and time-honored method for AF screening. In the 2020 ESC guidelines, pulse palpation is a Class I recommendation for opportunistic AF screening in people ≥65 years of age.[10] The recommendation originates from the SAFE study which concluded that opportunistic screening with pulse palpation detected more patients with newly diagnosed AF than routine practice and was more cost-effective than systematic screening.[69] Pulse palpation has been shown to be a rather sensitive but less specific method for AF screening.[70,71] More importantly, the compliance rate of physicians to opportunistic screening by pulse palpation is poor. Opportunistic AF screening in primary care varied from 5% to 42% in a healthcare survey involving 1000 physicians across 20 countries.[72] In some countries screening was done by an ECG, although in most we presume it was done by pulse palpation.

With technological advancement, many smartphone-based, smartwatch-based, handheld and other devices have been introduced for AF screening (Table 7). A single-lead ECG showing AF of duration ≥30 s is now accepted as being diagnostic.[10] This has important implication for using ECG devices over other non-ECG devices in AF screening in that a confirmatory ECG is not required, as is the case for pulse-taking or pulse-based devices. The accuracy of ECG devices for detecting AF and other arrhythmias has been validated in a number of studies.[73–77] Moreover, the requirement for a single-lead ECG obtainable from a handheld device instead of a 12-lead ECG may improve applicability to more countries. Automatic ECG diagnostic algorithms for AF are available in these devices with varying sensitivity and specificity.

Single-lead ECG can be performed by handheld or wearable devices. The AliveCor (Kardia) Heart Monitor is a handheld device which works with a smartphone application to produce a lead I ECG. It was used in a community-based AF screening program involving 11,574 citizens in Hong Kong.[74] The automatic diagnostic

TABLE 5 Recommendation on management of subclinical atrial fibrillation (SCAF)

	Consensus Statements/recommendations	Level
1.	It is important to consider bipolar atrial sensing and device programming to optimize SCAF detection	1
2.	Validation of SCAF by stored AEGMs is recommended if available	1
3.	Progression of SCAF burden/episode duration should be monitored	2
4.	SCAF burden >5.5h/day or a SCAF episode ≥24h are considered significant. For significant SCAF, clinical AF documentation with ECG, including the use of ambulatory external recordings is recommended	2
5.	OAC is recommended in a person with prior stroke/systemic thromboembolism or significant mitral stenosis when SCAF is detected	1
6.	No OAC will be necessary if CHA_2DS_2-VASc score =0 in men and =1 in women	1
7.	In the absence of stroke/systemic thromboembolism, if CHA_2DS_2-VASc score =1 in men or =2 in women, observation for SCAF progression and clinical AF documentation with ECG, including the use of ambulatory external recordings, is recommended	2
8.	In the absence of stroke/systemic thromboembolism and ECG documented AF, significant SCAF detection in patients with CHA_2DS_2-VASc score ≥2 for men and ≥3 for women, OAC can be considered	2
9.	Bleeding risk and patient preference should be considered when OAC is recommended	1

Abbreviations: AEGM, atrial electrogram; AF, atrial fibrillation; OAC, oral anticoagulation.

TABLE 6 Screening for AF in patients with RHD

Screening for AF is recommended for patients with RHD in the following higher risk groups:	Level
• Patients aged >50 years	1
• LA dimension >4.0cm on echocardiogram	2
• Mitral valve area <1.0cm^2	2
• Mitral valve calcification	2
• Mitral valve gradient >10 mmHg	2
• NYHA Class II or higher	1

Abbreviation: NYHA, New York Heart Association.

algorithm for AF was shown to be highly specific (98%) and fairly sensitive (75%). In another study in pharmacies, the sensitivity and specificity were 98.5% and 91.4%, respectively, which may be related to changes in the algorithm over time.[78] In contrast, in the STROKESTOP study, the Zenicor handheld device was used to produce a lead I ECG and the automatic diagnostic algorithm achieved a sensitivity of 98% and specificity of 88% for AF.[75] Other examples of handheld single-lead ECG devices include Mydiagnostick[76,79] and Omron Monitor.[77] A 6-lead smartphone-based handheld ECG device, with three conducting surfaces (AliveCor Kardia 6L), has recently become available.[80,81] The diagnostic accuracy for AF may be significantly improved, although the inconvenience of requiring electrical contact with the left leg may make it less feasible for screening and the current algorithm uses only a single lead.

Hypertension and AF are common comorbidities[82] and modified blood pressure monitors have been used in AF screening.[83–85] One of these modified blood pressure monitors (Microlife WatchBP Home A) was studied for AF screening in 5,969 patients in a primary healthcare setting in Hong Kong.[85] In this device, an irregularity index represented by the ratio of the standard deviation of successive R-R intervals to the mean R-R intervals is calculated and AF is diagnosed if a certain cut-off is exceeded. The sensitivity and specificity of the algorithm was reported to be 83% and 99%, respectively.

Smartphone-based and smartwatch-based photoplethysmographic (PPG) waveform analysis has been introduced for AF screening.[86–89] A smartphone camera-based pulse PPG waveform measurement algorithm (Cardiio Rhythm) was studied for AF screening in 1,013 patients with hypertension, diabetes, and/or aged ≥65 years in a primary healthcare setting in Hong Kong.[86] PPG waveforms can be acquired when a patient's finger is placed over the camera of the smartphone and illuminated by the LED flash. The reflected light captured by the camera changes according to the arterial blood volume pulsations. AF is diagnosed by a lack of repeating patterns in the PPG waveforms. A high sensitivity of 93% and high specificity of 98% were achieved with this algorithm. More recently, facial pulsatile PPG signals (Cardiio Rhythm) were tested for contact-free AF screening in 217 patients admitted to a cardiology ward.[88] The patients faced the front camera of a smartphone and the camera detected subtle beat-to-beat variations of skin color by the changes in the amount of reflected light according to the arterial blood volume pulsations. Similar to pulse PPG, AF was diagnosed by a lack of repeating patterns in the facial PPG waveforms. Again, a high sensitivity of 95% and high specificity of 96% were observed in this study. In addition, a smartwatch-based algorithm using PPG signals was used for AF screening in 672 hospitalized patients.[89] The performance of this device, however, was limited by suboptimal quality in 22% of PPG signals. Ring-type wearable devices with deep learning analysis of PPG signals have also been used to detect AF with high accuracy.[90,91]

The AliveCor ECG technology was incorporated in Apple Watch via the Kardia band and tested in patients before and after electrical cardioversion for AF.[92] Notably, 34% of ECGs were classified as uninterpretable by the Kardia band algorithm and were excluded from analysis. For the remaining ECGs, the sensitivity and specificity of the diagnostic algorithm for AF were 93% and 84%, respectively. Apple now has its own inbuilt smartwatch ECG and algorithm but is not available in every country, and there are several other smartwatch ECGs with algorithms now in the market. A similar issue of nondiagnostic watch traces and greater false positives may occur given the demographic of those using smartwatches and the inability of the algorithm to diagnose at higher heart rates. These devices can be used in individual patients to screen for AF, as event monitors, or to screen for AF using the PPG function of the smartwatch to alert the user to possible AF.

As well as the remarkable disparity in disease epidemiology, ethnicity, and socioeconomic status among different countries in the Asia Pacific region, access to technology is also largely unequal. Therefore, the adoption of methods and tools for AF screening in patients or citizens without prior history of stroke should be individualized (Table 8).

4.1 | Key points

1. Pulse palpation is a simple, time-honored and guideline-recommended method for AF screening. It has been shown to be rather sensitive but less specific. However, the compliance rate of physicians with opportunistic screening by pulse palpation is poor.
2. Different tools, namely handheld or wearable single-lead ECG devices, modified blood pressure monitors and plethysmographic devices, have been used in different settings for AF screening with differing sensitivity and specificity.
3. A single-lead ECG showing AF of duration ≥30 s is currently accepted as being diagnostic and this provides an important advantage of ECG devices over non-ECG devices in AF screening.
4. The use of tools for AF screening in the Asia Pacific region should be individualized since there is remarkable disparity in disease epidemiology, ethnicity, socioeconomic status, and access to technology.

TABLE 7 Diagnostic performance of different methods and tools for atrial fibrillation screening

Methods/Tools	Authors	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Reference standard for comparison	Remarks
Pulse palpation	Taggar et al[70]	92 (85–96)	82 (76–88)	N/A	N/A	12-lead ECG	
	Cooke et al[71]	94 (84–97)	72 (69–75)	N/A	N/A	12-lead ECG	
Handheld or wearable single-lead ECG device							
AliveCor (Kardia) Heart Monitor	Chan NY et al[74]	75 (70–80)	98 (98–98.4)	65 (59–71)	99.5 (99.4–99.6)	Single-lead ECG interpretation by cardiologists	7% of ECGs were uninterpretable by cardiologists and were excluded from analysis
Zenicor II	Svennberg et al[75]	98 (96–100)	88.2 (88–88.4)	2.8 (2.5–3.1)	100	Single-lead ECG interpretation by specially trained nurses and physicians	1% of ECGs were of poor quality and were excluded from analysis
Mydiagnostick	Tieleman et al[76]	100 (93–100)	96 (91–98)	90 (82–98)	100	12-lead ECG	
	Vaes et al[79]	94 (87–98)	93 (85–97)	94 (89–99)	93 (88–98)	12-lead ECG	
Omron HCG–801 Monitor	Kearley et al[77]	99 (93–100)	76 (73–79)	26 (21–32)	99.9 (99–100)	12-lead ECG	
Apple Watch AliveCor Kardia Band	Bumgarner et al[92]	93 (86–98)	84 (73–95)	90 (83–97)	88 (78–98)	12-lead ECG	34% of ECGs were uninterpretable by Kardia Band algorithm and were excluded from analysis
Modified blood pressure monitor							
Microlife WatchBP Home A	Chan PH et al[85]	83 (68–98)	99 (98–99)	43 (29–57)	99.8 (99.6–100)	12-lead ECG	
Microlife BPA 200 plus	Marazzi et al[83]	92 (87–97)	95 (93–97)	83 (76–90)	98 (97–99)	12-lead ECG	
Omron M6	Marazzi et al[83]	100	94 (92–97)	82 (75–88)	100	12-lead ECG	
Omron M6 Comfort	Wiesel et al[95]	30 (15–49)	97 (93–99)	69 (44–94)	88 (83–93)	12-lead ECG	
Plethysmographic device							
iPhone photo-plethysmography	McManus et al[87]	97 (94–100)	94 (89–98)	92 (87–97)	97 (95–100)	12-lead ECG or 3-lead telemetry	
Cardiio Rhythm	Chan PH et al[86]	93 (77–99)	98 (97–99)	53 (38–67)	99.8 (99–100)	Single-lead ECG interpretation by cardiologists	
Cardiio Rhythm facial photo-plethysmography	Yan et al[88]	95 (87–98)	96 (91–98)	92 (84–96)	97 (93–99)	12-lead ECG	
Samsung Gear Fit 2 smartwatch (1-minute pulse plethysmography analysis)	Dörr et al[89]	94 (90–96)	98 (96–99)	98 (95–99)	95 (91–97)	Single-lead ECG interpretation by cardiologists	22% of PPG signals were of insufficient quality for algorithmic diagnosis and were excluded for analysis
CART CardioTracker	Kwon et al[90]	99	94	96	99	Simultaneous single-lead ECG interpreted by cardiologists	

Note: Numbers in parentheses represent 95% confidence intervals

Abbreviations: ECG, electrocardiogram; N/A, not applicable; NPV, negative predictive value; PPV, positive predictive value.

4.2 | Recommendations

Recommendations are shown in Table 8.

5 | SCREENING FOR ATRIAL FIBRILLATION FOLLOWING A STROKE

5.1 | Background

Studies show that up to one third of all ischemic stroke patients had underlying AF.[93] In addition, patients with AF-related strokes suffer more severe neurological syndromes.[94,95] A possible explanation is that AF-related stroke is more likely due to large vessel occlusion by virtue of comparatively larger thrombus with resultant larger volumes of infarcted brain parenchyma.[95] The consequence of a more severe stroke syndrome is a heightened risk for hemorrhagic transformation.[96] This inherent risk for hemorrhage has therapeutic implications for the timing of commencement of OACs.

AF prevalence poststroke has not been extensively investigated in the Asia Pacific region. A global survey of AF suggested a discrepancy in prevalence between Western stroke populations (33%–35%) and Asian populations (22% in East Asia and Pacific region).[93] A substantially lower rate was demonstrated in the large China National Stroke Registry of 20 000 stroke patients, with a reported rate of AF of only 5.5%.[97] Therefore, a different approach to screening for AF poststroke in the Asia Pacific region may be justified given the different epidemiological profile, especially considering the heterogeneous healthcare systems and resources.

5.2 | Screening tools for detection of AF poststroke

There are no randomized trials showing that AF screening improves outcomes following a stroke. However, the fact that prior stroke is a powerful predictor of future stroke in those with clinical AF suggests that a strategy of searching for AF is reasonable and is supported by current guidelines with the initiation of OAC if AF is detected.[10,98] The optimal timing and duration of monitoring for AF is unclear and will be dependent on the patient population and availability of testing and healthcare resources.[99]

Although the diagnostic yield for the detection of AF increases with the duration of monitoring,[100] a single timepoint 12-lead ECG detects previously unknown AF in 4%–8% presenting with stroke.[100,101] More prolonged monitoring, whether by handheld ECG,[102] inpatient telemetry, 24–72-h Holter monitors, repeated assessment by ambulatory monitoring,[103] prolonged external monitors,[104] or the use of implantable loop recorders,[105] is associated with increased detection of AF but with marked heterogeneity of detection rates. A systematic review and meta-analysis showed an AF detection rate of 7.7% on presentation, increasing to 23.7% with sequential monitoring.[100] More recently, a study has been published supporting the use of handheld ECG devices in the stroke unit to screen for AF poststroke,[106,107] which may be of particular relevance to the Asia Pacific region and could be used in places without telemetry.

Widespread prolonged poststroke screening may be difficult in many countries in the Asia Pacific region. However, the diagnostic yield of a screening program can be increased by selective screening of those most at risk of AF.[99] Following stroke, age is the only consistent clinical predictor of AF.[108] However, ECG abnormalities such as a prolonged PR interval,[108] frequency of premature atrial contractions on a Holter,[104] elevated levels of natriuretic peptides,[109] evidence of atrial myopathy[110] or the presence of co-existing acute and chronic infarction on brain imaging[111] may all help in selecting patients more at risk of AF. Risk factors such as heart failure, obesity, hypertension, alcohol intake, and physical inactivity increase the risk of AF and may be used to risk-stratify patients.[112]

TABLE 8 Recommendations for different methods and tools for AF screening in patients without prior history of stroke

The following methods are recommended for AF screening in patients without a prior history of stroke:	Level
• Pulse palpation	1*
• Modified blood pressure monitors	2*
• Smartphone-based single-lead or multi-lead ECG devices	3
• Smartphone-based photoplethysmographic devices	3*

*Where an ECG confirmation is required for a pulse-based screening method, a handheld single-lead ECG may be a practical alternative to a 12-lead ECG.

5.3 | Screening for AF poststroke in the Asia Pacific Region

Registry data showed that AF detection rate poststroke was much lower in the Asia Pacific region compared with that of Western countries.[97] This may reflect low rates of AF screening. Although the choice of method and duration of screening for AF will be different in each country, influenced by cultural, socioeconomic, and healthcare system factors (Table 9), it is suggested that all countries adopt a clearly defined recommendation for screening based on availability of resources.

Pulse palpation and 12-lead ECGs are recommended in all countries. Early telemetry, either inpatient or 24–72-h Holter monitoring, is recommended for the majority of countries within the Asia Pacific region. As an alternative, nurse-led handheld ECG would be relatively easy to implement.[16] In the nonacute phase, repeat testing with serial handheld ECGs and/or outpatient ambulatory monitoring should be considered where possible, either for all patients or in high-risk patients. More invasive and prolonged screening using serial multi-day recording devices or implantable loop recorders can be considered in high-risk patients in some countries with sufficient resources.

TABLE 9 Recommendations for different methods and tools for AF screening in patients with prior history of stroke

Screening for AF poststroke is recommended using the following methods in the acute phase and nonacute phase:		Level
Acute phase	Pulse palpation	1
	12 lead ECG	1
	Inpatient Holter monitor or telemetry	2
Nonacute phase	Serial ECG	2
	Ambulatory monitoring	2
	Smartphone or smartwatch-based ECG	3
	Serial multi-day recording devices	3
	Implantable loop recorder	3

5.4 | Key points

1. The prevalence of AF after stroke appears to be lower in the Asia Pacific region compared with that of Western countries. This may be a result of a lower rate of AF screening.
2. Various approaches with differing screening tools and duration of monitoring for AF have been studied. The method of choice will be different in each country in the Asia Pacific region and depends on a combination of cultural, socioeconomic, and healthcare system factors.

5.5 | Recommendations

Recommendations are shown in Table 9.

6 | SETTING AND SOCIOECONOMIC CONSIDERATIONS

AF screening can be undertaken in a range of settings (Table 10). For example, in Pakistan, AF screening by pulse palpation has been included as part of a diabetes screening program. In Taiwan, AF screening has been successfully performed in pharmacies using an oscillometric device during the blood pressure measurements for patients refilling prescriptions for long-term medications. In India, village health workers were able to successfully implement a screening program with the advantage of having an immediate diagnostic ECG available.[113] A recent study in Thailand used local primary care nurses and village health volunteers to screen people aged ≥65 years for AF using a blood pressure device with AF algorithm. Those requiring follow-up were given appointments at a hospital in their province. However, there were challenges in this model as only 58% of those requiring follow-up actually attended the appointment, which was up to 3 months after their screening.[114] Another model using handheld ECG performed opportunistic single-timepoint screening in patients attending several outpatient clinics in Hong Kong.[115] They found an incidence of 2.3% for screen-detected AF, and importantly demonstrated a similar stroke risk to those with known AF attending the same clinics when AF was untreated by OAC.

TABLE 10 Settings for opportunistic and systematic AF screening

Opportunistic	
A.	Visits to medical-related facilities
	1. Family practice/primary care
	2. Pharmacy
	3. Vaccination center
	4. Rehabilitation center
	5. Health/insurance attendance
	6. Regular complications evaluation service such as in a diabetic clinic
B.	Visits to nonmedical facilities
	1. Elderly centers
	2. Recreational centers
C.	Created opportunities
	Health promotion/awareness program
Systematic	
A.	Population based
B.	Community based
C.	Workplace based

As may be expected, there are large regional variations throughout the Asia Pacific region, both in terms of AF screening and the availability of further diagnosis and medical management. Overall, it is suggested that the clinic or primary care setting is often the preferred setting for an opportunistic single-timepoint program as it often has nursing support and a clear pathway to treatment.[45,116,117] However, in some countries, primary care centers are unable to prescribe OAC, as in community centers in China.[118] This results in suboptimal anticoagulation and emphasizes the need for a clear pathway to treatment.

Different settings may be preferred for continuous or intermittent programs, which would require a different workflow. For example, one study in India adopted a model where a health worker from each village in a rural area used a smartphone single-lead ECG to screen participants for AF three times on three separate days.[113] If an ECG-based method is used, one advantage is that the trace can be sent elsewhere for interpretation in a "hub and spoke" model.[119]

Whatever the setting, a clear pathway to management must exist, including diagnosis, evaluation, OAC prescription, and other pharmacological management (Figure 4).[45,120] Practically, this is easier to facilitate in some settings than others.

6.1 | Key points

1. Opportunistic AF screening can be implemented in medical-related facilities, nonmedical facilities, or during ad hoc occasions like health promotion and disease awareness programs.

2. Systematic AF screening can be population based, community based, or workplace based.
3. Whichever setting for AF screening is used, a clear pathway to management must exist.
4. In general, the primary care clinic setting is the preferred approach for an opportunistic screening program since there is often existing nursing support and a clear pathway to treatment.

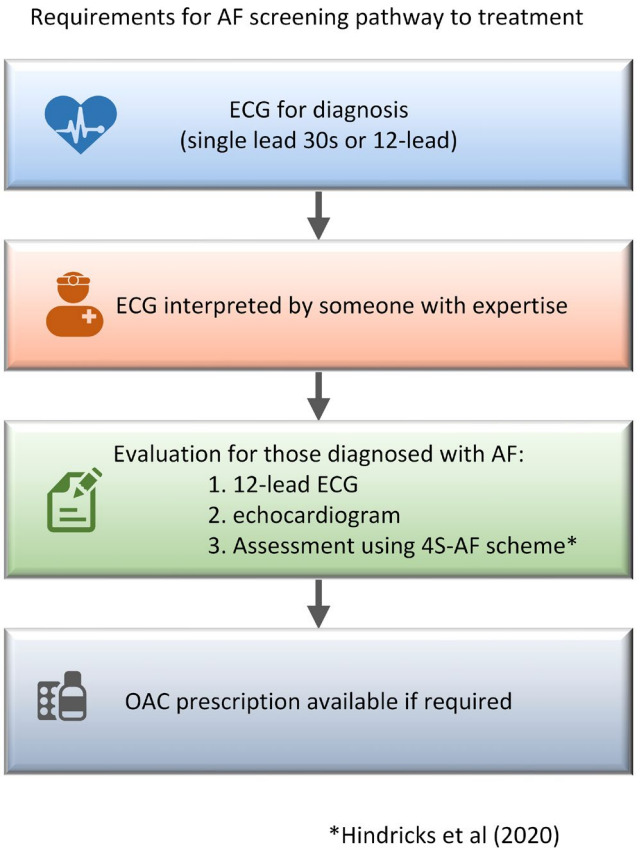

FIGURE 4 Requirements for AF screening pathway to treatment. *Hindricks et al (2020)[10]

6.2 | Recommendations

Table 11 presents the recommendations for AF screening.

7 | HEALTH ECONOMICS AND AFFORDABILITY OF SCREENING

It is acknowledged that there is a wide variability of health resources available in different countries in the Asia Pacific region. The affordability of the screening process is quite cheap, for example, screening by pulse palpation, PPG, or single-lead ECG by a health worker. However, there are more substantial costs involved for the pathway to treatment for those with an abnormal result, including evaluation and treatment for those diagnosed, which may be more difficult to afford for some populations.

Numerous studies have shown AF screening to be cost effective or even cost saving.[121,122] Importantly, these studies show that increasing the proportion screened prevents many more strokes with minimal change to the incremental cost-effectiveness ratio.[78,121] However, these analyses are heavily dependent on the features of each country's health system. For example, these models often assume relatively high OAC treatment rates, which is probably not the case in low- and middle-income countries.[118,123] Nonvitamin K antagonist OACs (NOACs) were added to the World Health Organization essential medicines list in 2019, which may assist with ensuring access in future.

8 | CONCLUSIONS

Similar to other parts of the world, the prevalence of AF is increasing in the Asia Pacific region and there is a consequent rise in AF-related hospitalization and burden to the healthcare system. Chronic rheumatic heart disease, an important underlying cause for AF, remains a common condition in some Asia Pacific countries. In this practice

TABLE 11 Recommendations for AF screening

Recommendation	Explanation	Level
An ECG is required for diagnosis	Whichever method of screening is used, an ECG (single lead or 12 lead) is required for diagnosis.[10]	1
The ECG should be interpreted by someone with expertise	The ECG should be interpreted by someone with appropriate expertise (this could be done by someone located elsewhere if the ECG is transmitted electronically).	1
For those diagnosed with AF, an evaluation including 12-lead ECG, echocardiogram and assessment using the 4S-AF scheme is recommended	Once diagnosed, the patient should be evaluated, including a 12-lead ECG, echocardiogram and assessed using the 4S-AF scheme (stroke risk, symptom severity, severity of AF burden, and substrate severity).[10] The 12-lead ECG used for evaluation is recommended to add extra leads for the diagnostic workup. In addition, for patients with paroxysmal AF where AF is documented on a single-lead ECG but the 12-lead ECG shows sinus rhythm, a comparison can be made between the p-waves and regularity of the rhythm on the single-lead ECG and lead I of the 12-lead ECG.[134]	2
OAC prescription should be available if required	If the diagnosis is confirmed and stroke risk score is sufficiently high, there should be a clinician medically available to prescribe OAC treatment.	1

guidance, the heterogeneity in different Asia Pacific countries is acknowledged and three levels of recommendations are made according to the applicability to different countries.

In patients with cardiac implantable electronic devices, SCAF is common and the risk of developing clinical AF is higher when it is present. Furthermore, the risk of stroke is increased with longer episodes of SCAF and in patients with higher CHA_2DS_2-VASc score. However, the role of OACs in the management of SCAF when clinical AF is not documented remains controversial.

In patients with chronic rheumatic heart disease, AF screening is recommended for patients with high-risk features like age above 50 years, LA dimension greater than 4 cm, mitral valve area less than 1 cm^2, mitral valve calcification, mitral valve gradient over 10 mmHg, and NYHA Class II or above.

Opportunistic screening for AF in patients aged 65 years or above by pulse palpation is affordable and recommended in all Asia Pacific countries while systematic screening for individuals aged 75 years or above and with high risk for stroke or thromboembolic events may only be applicable in countries with adequate healthcare resources. Various tools including modified blood pressure monitors, smartphone-based single-lead or multi-lead ECG devices, and smartphone-based PPG devices may be applicable to different Asia Pacific countries for AF screening depending on available healthcare resources and access to technologies, however, an ECG rhythm strip read by a health professional with appropriate expertise is always required to make the diagnosis.

In patients with ischemic stroke, AF screening by pulse palpation and 12-lead ECG is recommended in all Asia Pacific countries in the acute setting. Inpatient monitoring with Holter or telemetry is recommended in most countries. After the acute phase, serial or ambulatory ECG monitoring are recommended in most countries while smartphone or smartwatch-based ECG, serial multi-day recordings, and implantable loop recorder would only be applicable in some countries.

AF screening has been studied under various settings but the crucial component in each program is a clear pathway to management including diagnosis, evaluation, and treatment. Although many studies have shown that AF screening is cost-effective, high treatment rates with OAC for stroke prevention were often assumed. In Asia Pacific countries with limitations in health resources, the situation may be different. With the wide variability in AF epidemiology, ethnicity, socioeconomic development, and health care systems, the most appropriate model for AF screening in different Asia Pacific countries should be tailored to the country and healthcare setting.

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CONFLICT OF INTEREST

All other authors declared no conflict of interest related to this paper.

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REFERENCES

1. Benjamin EJ, Muntner P, Alonso A, Bittencourt MS, Callaway CW, Carson AP, et al. Heart disease and stroke statistics-2019 update: a report from the American Heart Association. Circulation. 2019;139(10):e56–528.
2. Guo Y, Tian Y, Wang H, Si Q, Wang Y, Lip GYH. Prevalence, incidence, and lifetime risk of atrial fibrillation in China: new insights into the global burden of atrial fibrillation. Chest. 2015;147(1):109–19.
3. Krijthe BP, Kunst A, Benjamin EJ, Lip GY, Franco OH, Hofman A, et al. Projections on the number of individuals with atrial fibrillation in the European Union, from 2000 to 2060. Eur Heart J. 2013;34(35):2746–51.
4. Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. Ann Intern Med. 2007;146(12):857–67.
5. Soo Y, Chan N, Leung K, Chen X, Mok V, Wong L, et al. Age-specific trends of atrial fibrillation-related ischaemic stroke and transient ischaemic attack, anticoagulant use and risk factor profile in Chinese population: a 15-year study. J Neurol Neurosurg Psychiatry. 2017;88:744–8.
6. Chiang CE, Okumura K, Zhang S, Chao TF, Siu CW, Wei Lim T, et al. 2017 consensus of the Asia Pacific Heart Rhythm Society on stroke prevention in atrial fibrillation. J Arrhythm. 2017;33(4):345–67.
7. Suzuki S, Yamashita T, Okumura K, Atarashi H, Akao M, Ogawa H, et al. Incidence of ischemic stroke in Japanese patients with atrial fibrillation not receiving anticoagulation therapy–pooled analysis of the Shinken Database, J-RHYTHM Registry, and Fushimi AF Registry. Circ J. 2015;79(2):432–8.
8. Ho CW, Ho MH, Chan PH, Hai JJ, Cheung E, Yeung CY, et al. Ischemic stroke and intracranial hemorrhage with aspirin, dabigatran, and warfarin: impact of quality of anticoagulation control. Stroke. 2015;46(1):23–30.
9. Guo Y, Lip GY, Apostolakis S. The unmet need of stroke prevention in atrial fibrillation in the far East and South East Asia. Malays J Med Sci. 2012;19(3):1–7.

10. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomstrom-Lundqvist C, et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): the task force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J. 2021;42(5):373–498.
11. January CT, Wann LS, Calkins H, Chen LY, Cigarroa JE, Cleveland JC Jr, et al. 2019 AHA/ACC/hrs focused update of the 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society in collaboration with the society of thoracic surgeons. Circulation. 2019;140(2):e125–51.
12. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC Jr, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. 2014;64(21):e1–76.
13. U. S. Preventive Services Task Force, Curry SJ, Krist AH, Owens DK, Barry MJ, Caughey AB, et al. Screening for atrial fibrillation with electrocardiography: US Preventive Services Task Force recommendation statement. JAMA. 2018;320(5):478-84.
14. Nhfa Csanz Atrial Fibrillation Guideline Working Group, Brieger D, Amerena J, Attia J, Bajorek B, Chan KH, et al. National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand: Australian clinical guidelines for the diagnosis and management of atrial fibrillation 2018. Heart Lung Circ. 2018;27(10):1209–66.
15. Mairesse GH, Moran P, Van Gelder IC, Elsner C, Rosenqvist M, Mant J, et al. Screening for atrial fibrillation: a European Heart Rhythm Association (EHRA) consensus document endorsed by the Heart Rhythm Society (HRS), Asia Pacific Heart Rhythm Society (APHRS), and Sociedad Latinoamericana de Estimulacion Cardiaca y Electrofisiologia (SOLAECE). Europace. 2017;19(10):1589–623.
16. Chao TF, Liu CJ, Tuan TC, Chen TJ, Hsieh MH, Lip GYH, et al. Lifetime risks, projected numbers, and adverse outcomes in asian patients with atrial fibrillation: a report from the Taiwan Nationwide AF cohort study. Chest. 2018;153(2):453–66.
17. Kim D, Yang PS, Jang E, Yu HT, Kim TH, Uhm JS, et al. 10-year nationwide trends of the incidence, prevalence, and adverse outcomes of non-valvular atrial fibrillation nationwide health insurance data covering the entire Korean population. Am Heart J. 2018;202:20–6.
18. Phrommintikul A, Detnuntarat P, Prasertwitayakij N, Wongcharoen W. Prevalence of atrial fibrillation in Thai elderly. J Geriatr Cardiol. 2016;13(3):270–3.
19. Rahman F, Kwan GF, Benjamin EJ. Global epidemiology of atrial fibrillation. Nat Rev Cardiol. 2014;11(11):639–54.
20. Lee H, Kim TH, Baek YS, Uhm JS, Pak HN, Lee MH, et al. The trends of atrial fibrillation-related hospital visit and cost, treatment pattern and mortality in Korea: 10-year nationwide sample cohort data. Korean Circulat J. 2017;47(1):56–64.
21. Kim MH, Johnston SS, Chu BC, Dalal MR, Schulman KL. Estimation of total incremental health care costs in patients with atrial fibrillation in the United States. Circ Cardiovasc Qual Outcomes. 2011;4(3):313–20.
22. Lee WC, Lamas GA, Balu S, Spalding J, Wang Q, Pashos CL. Direct treatment cost of atrial fibrillation in the elderly American population: a medicare perspective. J Med Econ. 2008;11(2):281–98.
23. Stewart S, Murphy NF, Walker A, McGuire A, McMurray JJ. Cost of an emerging epidemic: an economic analysis of atrial fibrillation in the UK. Heart. 2004;90(3):286–92.
24. Chugh SS, Jui J, Gunson K, Stecker EC, John BT, Thompson B, et al. Current burden of sudden cardiac death: multiple source surveillance versus retrospective death certificate-based review in a large U.S. community. J Am Coll Cardiol. 2004;44(6):1268–75.
25. Kim D, Yang PS, Jang E, Yu HT, Kim TH, Uhm JS, et al. Increasing trends in hospital care burden of atrial fibrillation in Korea, 2006 through 2015. Heart. 2018;104(24):2010–7.
26. Watkins DA, Johnson CO, Colquhoun SM, Karthikeyan G, Beaton A, Bukhman G, et al. Global, regional, and national burden of rheumatic heart disease, 1990–2015. N Engl J Med. 2017;377(8):713–22.
27. Gordis L, Lilienfeld A, Rodriguez R. Studies in the epidemiology and preventability of rheumatic fever. II. Socio-economic factors and the incidence of acute attacks. J Chronic Dis. 1969;21(9):655–66.
28. Dingle JH, Rammelkamp CH Jr, Wannamaker LW. Epidemiology of streptococcal infections and their non-suppurative complications. Lancet. 1953;1(6763):736–8.
29. Roberts KV, Maguire GP, Brown A, Atkinson DN, Remenyi B, Wheaton G, et al. Rheumatic heart disease in Indigenous children in northern Australia: differences in prevalence and the challenges of screening. Med J Aust. 2015;203(5):221 e1–7.
30. Wilson N. Rheumatic heart disease in indigenous populations–New Zealand experience. Heart Lung Circ. 2010;19(5–6):282–8.
31. White H, Walsh W, Brown A, Riddell T, Tonkin A, Jeremy R, et al. Rheumatic heart disease in indigenous populations. Heart Lung Circ. 2010;19(5–6):273–81.
32. Awada A. Stroke in Saudi Arabian young adults: a study of 120 cases. Acta Neurol Scand. 1994;89(5):323–8.
33. Banerjee AK, Varma M, Vasista RK, Chopra JS. Cerebrovascular disease in north-west India: a study of necropsy material. J Neurol Neurosurg Psychiatry. 1989;52(4):512–5.
34. Luijckx GJ, Ukachoke C, Limapichat K, Heuts-van Raak EP, Lodder J. Brain infarct causes under the age of fifty: a comparison between an east-Asian (Thai) and a western (Dutch) hospital series. Clin Neurol Neurosurg. 1993;95(3):199–203.
35. Negi PC, Sondhi S, Rana V, Rathoure S, Kumar R, Kolte N, et al. Prevalence, risk determinants and consequences of atrial fibrillation in rheumatic heart disease: 6 years hospital based-Himachal Pradesh- Rheumatic Fever/Rheumatic Heart Disease (HP-RF/RHD) Registry. Indian Heart J. 2018;70(Suppl 3):S68–73.
36. Parkash R, Green MS, Kerr CR, Connolly SJ, Klein GJ, Sheldon R, et al. The association of left atrial size and occurrence of atrial fibrillation: a prospective cohort study from the Canadian Registry of Atrial Fibrillation. Am Heart J. 2004;148(4):649–54.
37. Iung B, Leenhardt A, Extramiana F. Management of atrial fibrillation in patients with rheumatic mitral stenosis. Heart. 2018;104(13):1062–8.
38. Zuhlke L, Engel ME, Karthikeyan G, Rangarajan S, Mackie P, Cupido B, et al. Characteristics, complications, and gaps in evidence-based interventions in rheumatic heart disease: the Global Rheumatic Heart Disease Registry (the REMEDY study). Eur Heart J. 2015;36(18):1115–22.
39. Arora R, Kalra GS, Singh S, Mukhopadhyay S, Kumar A, Mohan JC, et al. Percutaneous transvenous mitral commissurotomy: immediate and long-term follow-up results. Catheter Cardiovasc Interv. 2002;55(4):450–6.
40. Farman MT, Khan N, Sial JA, Saghir T, Ashraf T, Rasool SI, et al. Predictors of successful percutaneous transvenous mitral commissurotomy using the Bonhoeffer Multi-Track system in patients with moderate to severe mitral stenosis: can we see beyond the Wilkins score? Anatol J Cardiol. 2015;15(5):373–9.
41. Song JK, Kim MJ, Yun SC, Choo SJ, Song JM, Song H, et al. Long-term outcomes of percutaneous mitral balloon valvuloplasty versus open cardiac surgery. J Thorac Cardiovasc Surg. 2010;139(1):103–10.

42. Meschia JF, Bushnell C, Boden-Albala B, Braun LT, Bravata DM, Chaturvedi S, et al. Guidelines for the primary prevention of stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2014;45(12):3754–832.
43. Jonas DE, Kahwati LC, Yun JDY, Middleton JC, Coker-Schwimmer M, Asher GN. Screening for atrial fibrillation with electrocardiography: evidence report and systematic review for the US Preventive Services Task Force. JAMA. 2018;320(5):485–98.
44. USPSTF. Draft evidence review: screening for atrial fibrillation. US Preventive Services Task Force. 2021. Available from https://www.uspreventiveservicestaskforce.org/uspstf/document/draft-evidence-review/screening-atrial-fibrillation (accessed 29 April 2021).
45. Freedman B, Camm J, Calkins H, Healey JS, Rosenqvist M, Wang J, et al. Screening for atrial fibrillation: a report of the AF-SCREEN international collaboration. Circulation. 2017;135(19):1851–67.
46. Diederichsen SZ, Haugan KJ, Kober L, Hojberg S, Brandes A, Kronborg C, et al. Atrial fibrillation detected by continuous electrocardiographic monitoring using implantable loop recorder to prevent stroke in individuals at risk (the LOOP study): rationale and design of a large randomized controlled trial. Am Heart J. 2017;187:122–32.
47. Svennberg E, Engdahl J, Al-Khalili F, Friberg L, Frykman V, Rosenqvist M. Mass screening for untreated atrial fibrillation: the STROKESTOP study. Circulation. 2015;131(25):2176–84.
48. Svendsen JH, Diederichsen SZ, Hojberg S, Krieger DW, Graff C, Kronborg C, et al. Implantable loop recorder detection of atrial fibrillation to prevent stroke (The LOOP Study): a randomised controlled trial. Lancet. 2021;398(10310):1507–16.
49. Freedman B, Lowres N. High-intensity atrial fibrillation screening to prevent stroke. Lancet. 2021;398(10310):1465–7.
50. Svennberg E, Friberg L, Frykman V, Al-Khalili F, Engdahl J, Rosenqvist M. Clinical outcomes in systematic screening for atrial fibrillation (STROKESTOP): a multicentre, parallel group, unmasked, randomised controlled trial. Lancet. 2021;398(10310):1498–1506.
51. Freedman B, Lowres N. Population screening for atrial fibrillation to prevent stroke. Lancet. 2021;398(10310):1463–5.
52. Andrade JG, Aguilar M, Atzema C, Bell A, Cairns JA, Cheung CC, et al. The 2020 Canadian Cardiovascular Society/Canadian Heart Rhythm Society comprehensive guidelines for the management of atrial fibrillation. Can J Cardiol. 2020;36(12):1847–948.
53. Orchard J, Lowres N, Neubeck L, Freedman B. Atrial fibrillation: is there enough evidence to recommend opportunistic or systematic screening? Int J Epidemiol. 2018;47(5):1372–8.
54. Fitzmaurice DA, Hobbs FD, Jowett S, Mant J, Murray ET, Holder R, et al. Screening versus routine practice in detection of atrial fibrillation in patients aged 65 or over: cluster randomised controlled trial. BMJ. 2007;335(7616):383.
55. Neubeck L, Orchard J, Lowres N, Freedman SB. To screen or not to screen? Examining the arguments against screening for atrial fibrillation. Heart Lung Circ. 2017;26(9):880–6.
56. Hernandez R, Banuelos C, Alfonso F, Goicolea J, Fernandez-Ortiz A, Escaned J, et al. Long-term clinical and echocardiographic follow-up after percutaneous mitral valvuloplasty with the Inoue balloon. Circulation. 1999;99(12):1580–6.
57. Wang A, Krasuski RA, Warner JJ, Pieper K, Kisslo KB, Bashore TM, et al. Serial echocardiographic evaluation of restenosis after successful percutaneous mitral commissurotomy. J Am Coll Cardiol. 2002;39(2):328–34.
58. Multicenter experience with balloon mitral commissurotomy. NHLBI balloon valvuloplasty registry report on immediate and 30-day follow-up results. The National Heart, Lung, and Blood Institute Balloon Valvuloplasty Registry Participants. Circulation. 1992;85(2):448–61.
59. Palacios IF, Sanchez PL, Harrell LC, Weyman AE, Block PC. Which patients benefit from percutaneous mitral balloon valvuloplasty? Prevalvuloplasty and postvalvuloplasty variables that predict long-term outcome. Circulation. 2002;105(12):1465–71.
60. Tomai F, Gaspardone A, Versaci F, Ghini AS, Altamura L, De Luca L, et al. Twenty year follow-up after successful percutaneous balloon mitral valvuloplasty in a large contemporary series of patients with mitral stenosis. Int J Cardiol. 2014;177(3):881–5.
61. Neumayer U, Schmidt HK, Fassbender D, Mannebach H, Bogunovic N, Horstkotte D. Early (three-month) results of percutaneous mitral valvotomy with the Inoue balloon in 1,123 consecutive patients comparing various age groups. Am J Cardiol. 2002;90(2):190–3.
62. Henry WL, Morganroth J, Pearlman AS, Clark CE, Redwood DR, Itscoitz SB, et al. Relation between echocardiographically determined left atrial size and atrial fibrillation. Circulation. 1976;53(2):273–9.
63. Diker E, Aydogdu S, Ozdemir M, Kural T, Polat K, Cehreli S, et al. Prevalence and predictors of atrial fibrillation in rheumatic valvular heart disease. Am J Cardiol. 1996;77(1):96–8.
64. Kitchin A, Turner R. Calcification of the mitral valve. Results of valvotomy in 100 cases. Br Heart J. 1967;29(2):137–61.
65. Acar J, Michel PL, Cormier B, Vahanian A, Iung B. Features of patients with severe mitral stenosis with respect to atrial rhythm. Atrial fibrillation in predominant and tight mitral stenosis. Acta Cardiol. 1992;47(2):115–24.
66. Coulshed N, Epstein EJ, McKendrick CS, Galloway RW, Walker E. Systemic embolism in mitral valve disease. Br Heart J. 1970;32(1):26–34.
67. Sharma SK, Verma SH. A clinical evaluation of atrial fibrillation in rheumatic heart disease. J Assoc Physicians India. 2015;63(6):22–5.
68. Gupta A, Bhatia R, Sharma G, Prasad K, Singh MB, Vibha D. Predictors of ischemic stroke in rheumatic heart disease. J Stroke Cerebrovasc Dis. 2015;24(12):2810–5.
69. Hobbs FD, Fitzmaurice DA, Mant J, Murray E, Jowett S, Bryan S, et al. A randomised controlled trial and cost-effectiveness study of systematic screening (targeted and total population screening) versus routine practice for the detection of atrial fibrillation in people aged 65 and over. The SAFE study. Health Technol Assess. 2005;9(40):iii-iv, ix-x, 1-74.
70. Taggar JS, Coleman T, Lewis S, Heneghan C, Jones M. Accuracy of methods for detecting an irregular pulse and suspected atrial fibrillation: a systematic review and meta-analysis. Eur J Prev Cardiol. 2016;23(12):1330–8.
71. Cooke G, Doust J, Sanders S. Is pulse palpation helpful in detecting atrial fibrillation? A systematic review. J Fam Pract. 2006;55(2):130–4.
72. The Economist Intelligence Unit. Preventing stroke: uneven progress. A global policy research programme. The Economist. 2017;21:1–28.
73. Kwon S, Lee SR, Choi EK, Ahn HJ, Song HS, Lee YS, et al. Validation of adhesive single-lead ECG device compared with holter monitoring among non-atrial fibrillation patients. Sensors (Basel). 2021;21(9):3122.
74. Chan NY, Choy CC, Chan CK, Siu CW. Effectiveness of a nongovernmental organization-led large-scale community atrial fibrillation screening program using the smartphone electrocardiogram: an observational cohort study. Heart Rhythm. 2018;15(9):1306–11.
75. Svennberg E, Stridh M, Engdahl J, Al-Khalili F, Friberg L, Frykman V, et al. Safe automatic one-lead electrocardiogram analysis in screening for atrial fibrillation. Europace. 2017;19(9):1449–53.
76. Tieleman RG, Plantinga Y, Rinkes D, Bartels GL, Posma JL, Cator R, et al. Validation and clinical use of a novel diagnostic device for screening of atrial fibrillation. Europace. 2014;16(9):1291–5.
77. Kearley K, Selwood M, Van den Bruel A, Thompson M, Mant D, Hobbs FR, et al. Triage tests for identifying atrial fibrillation in

primary care: a diagnostic accuracy study comparing single-lead ECG and modified BP monitors. BMJ Open. 2014;4(5):e004565.
78. Lowres N, Neubeck L, Salkeld G, Krass I, McLachlan AJ, Redfern J, et al. Feasibility and cost-effectiveness of stroke prevention through community screening for atrial fibrillation using iPhone ECG in pharmacies. The SEARCH-AF study. Thromb Haemost. 2014;111(6):1167–76.
79. Vaes B, Stalpaert S, Tavernier K, Thaels B, Lapeire D, Mullens W, et al. The diagnostic accuracy of the MyDiagnostick to detect atrial fibrillation in primary care. BMC Fam Pract. 2014;15:113.
80. Stavrakis S, Garabelli PJ, Smith L, Albert D, Po SS. Abstract 15576: clinical validation of a smartphone based, 6-lead ECG device. Circulation. 2017;136(suppl_1):A15576-A.
81. Orchard JJ, Orchard JW, Raju H, La Gerche A, Puranik R, Semsarian C. Comparison between a 6lead smartphone ECG and 12lead ECG in athletes. J Electrocardiol. 2021;66:95–7.
82. Chan NY, Choy CC. Screening for atrial fibrillation in 13 122 Hong Kong citizens with smartphone electrocardiogram. Heart. 2017;103(1):24–31.
83. Marazzi G, Iellamo F, Volterrani M, Lombardo M, Pelliccia F, Righi D, et al. Comparison of Microlife BP A200 Plus and Omron M6 blood pressure monitors to detect atrial fibrillation in hypertensive patients. Adv Ther. 2012;29(1):64–70.
84. Wiesel J, Arbesfeld B, Schechter D. Comparison of the Microlife blood pressure monitor with the Omron blood pressure monitor for detecting atrial fibrillation. Am J Cardiol. 2014;114(7):1046–8.
85. Chan PH, Wong CK, Pun L, Wong YF, Wong MM, Chu DW, et al. Diagnostic performance of an automatic blood pressure measurement device, Microlife WatchBP Home A, for atrial fibrillation screening in a real-world primary care setting. BMJ Open. 2017;7(6):e013685.
86. Chan PH, Wong CK, Poh YC, Pun L, Leung WW, Wong YF, et al. Diagnostic performance of a smartphone-based photoplethysmographic application for atrial fibrillation screening in a primary care setting. J Am Heart Assoc. 2016;5(7).
87. Mc MD, Chong JW, Soni A, Saczynski JS, Esa N, Napolitano C, et al. PULSE-SMART: pulse-based arrhythmia discrimination using a novel smartphone application. J Cardiovasc Electrophysiol. 2016;27(1):51–7.
88. Yan BP, Lai WHS, Chan CKY, Chan SC, Chan LH, Lam KM, et al. Contact-free screening of atrial fibrillation by a smartphone using facial pulsatile photoplethysmographic signals. J Am Heart Assoc. 2018;7(8).
89. Dorr M, Nohturfft V, Brasier N, Bosshard E, Djurdjevic A, Gross S, et al. The WATCH AF trial: smartWATCHes for detection of atrial fibrillation. JACC Clin Electrophysiol. 2019;5(2):199–208.
90. Kwon S, Hong J, Choi EK, Lee B, Baik C, Lee E, et al. Detection of atrial fibrillation using a ring-type wearable device (CardioTracker) and deep learning analysis of photoplethysmography signals: prospective observational proof-of-concept study. J Med Internet Res. 2020;22(5):e16443.
91. Kwon S, Hong J, Choi EK, Lee E, Hostallero DE, Kang WJ, et al. Deep learning approaches to detect atrial fibrillation using photoplethysmographic signals: algorithms development study. JMIR Mhealth Uhealth. 2019;7(6):e12770.
92. Bumgarner JM, Lambert CT, Hussein AA, Cantillon DJ, Baranowski B, Wolski K, et al. Smartwatch algorithm for automated detection of atrial fibrillation. J Am Coll Cardiol. 2018;71(21):2381–8.
93. Perera KS, Vanassche T, Bosch J, Swaminathan B, Mundl H, Giruparajah M, et al. Global survey of the frequency of atrial fibrillation-associated stroke: embolic stroke of undetermined source global registry. Stroke. 2016;47(9):2197–202.
94. Kimura K, Minematsu K, Yamaguchi T, Japan Multicenter Stroke Investigators C. Atrial fibrillation as a predictive factor for severe stroke and early death in 15,831 patients with acute ischaemic stroke. J Neurol Neurosurg Psychiatry. 2005;76(5):679–83.
95. Tu HT, Campbell BC, Christensen S, Desmond PM, De Silva DA, Parsons MW, et al. Worse stroke outcome in atrial fibrillation is explained by more severe hypoperfusion, infarct growth, and hemorrhagic transformation. Int J Stroke. 2015;10(4):534–40.
96. Paciaroni M, Bandini F, Agnelli G, Tsivgoulis G, Yaghi S, Furie KL, et al. Hemorrhagic transformation in patients with acute ischemic stroke and atrial fibrillation: time to initiation of oral anticoagulant therapy and outcomes. J Am Heart Assoc. 2018;7(22):e010133.
97. Wang Y, Cui L, Ji X, Dong Q, Zeng J, Wang Y, et al. The China National Stroke Registry for patients with acute cerebrovascular events: design, rationale, and baseline patient characteristics. Int J Stroke. 2011;6(4):355–61.
98. Adams HP Jr, del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, et al. Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups: The American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. Circulation. 2007;115(20):e478–534.
99. Schnabel RB, Haeusler KG, Healey JS, Freedman B, Boriani G, Brachmann J, et al. Searching for atrial fibrillation poststroke: a white paper of the AF-SCREEN international collaboration. Circulation. 2019;140(22):1834–50.
100. Sposato LA, Cipriano LE, Saposnik G, Ruiz Vargas E, Riccio PM, Hachinski V. Diagnosis of atrial fibrillation after stroke and transient ischaemic attack: a systematic review and meta-analysis. Lancet Neurol. 2015;14(4):377–87.
101. Bansil S, Karim H. Detection of atrial fibrillation in patients with acute stroke. J Stroke Cerebrovasc Dis. 2004;13(1):12–5.
102. Doliwa Sobocinski P, Anggardh Rooth E, Frykman Kull V, von Arbin M, Wallen H, Rosenqvist M. Improved screening for silent atrial fibrillation after ischaemic stroke. Europace. 2012;14(8):1112–6.
103. Wachter R, Groschel K, Gelbrich G, Hamann GF, Kermer P, Liman J, et al. Holter-electrocardiogram-monitoring in patients with acute ischaemic stroke (Find-AFRANDOMISED): an open-label randomised controlled trial. Lancet Neurol. 2017;16(4):282–90.
104. Gladstone DJ, Spring M, Dorian P, Panzov V, Thorpe KE, Hall J, et al. Atrial fibrillation in patients with cryptogenic stroke. N Engl J Med. 2014;370(26):2467–77.
105. Sanna T, Diener HC, Passman RS, Di Lazzaro V, Bernstein RA, Morillo CA, et al. Cryptogenic stroke and underlying atrial fibrillation. N Engl J Med. 2014;370(26):2478–86.
106. Tu HT, Chen Z, Swift C, Churilov L, Guo R, Liu X, et al. Smartphone electrographic monitoring for atrial fibrillation in acute ischemic stroke and transient ischemic attack. Int J Stroke. 2017;12(7):786–9.
107. Yan B, Tu H, Lam C, Swift C, Ho MS, Mok VCT, et al. Nurse led smartphone electrographic monitoring for atrial fibrillation after ischemic stroke: SPOT-AF. J Stroke. 2020;22(3):387–95.
108. Thijs VN, Brachmann J, Morillo CA, Passman RS, Sanna T, Bernstein RA, et al. Predictors for atrial fibrillation detection after cryptogenic stroke: results from CRYSTAL AF. Neurology. 2016;86(3):261–9.
109. Fonseca AC, Brito D, Pinho e Melo T, Geraldes R, Canhao P, Caplan LR,, et al. N-terminal pro-brain natriuretic peptide shows diagnostic accuracy for detecting atrial fibrillation in cryptogenic stroke patients. Int J Stroke. 2014;9(4):419–25.
110. Yaghi S, Moon YP, Mora-McLaughlin C, Willey JZ, Cheung K, Di Tullio MR, et al. Left atrial enlargement and stroke recurrence: the Northern Manhattan Stroke Study. Stroke. 2015;46(6):1488–93.
111. Bernstein RA, Di Lazzaro V, Rymer MM, Passman RS, Brachmann J, Morillo CA, et al. Infarct topography and detection of atrial fibrillation in cryptogenic stroke: results from CRYSTAL AF. Cerebrovasc Dis. 2015;40(1–2):91–6.

112. Lau DH, Nattel S, Kalman JM, Sanders P. Modifiable risk factors and atrial fibrillation. Circulation. 2017;136(6):583–96.
113. Soni A, Karna S, Fahey N, Sanghai S, Patel H, Raithatha S, et al. Age-and-sex stratified prevalence of atrial fibrillation in rural Western India: results of SMART-India, a population-based screening study. Int J Cardiol. 2019;280:84–8.
114. Suwanwela NC, Chutinet A, Autjimanon H, Ounahachok T, Decha-Umphai C, Chockchai S, et al. Atrial fibrillation prevalence and risk profile from novel community-based screening in Thailand: a prospective multi-centre study. Int J Cardiol Heart Vasc. 2021;32:100709.
115. Sun W, Freedman B, Martinez C, Wallenhorst C, Yan BP. Atrial fibrillation detected by single time-point handheld electrocardiogram screening and the risk of ischemic stroke. Thromb Haemost. 2021.
116. Orchard J, Li J, Gallagher R, Freedman B, Lowres N, Neubeck L. Uptake of a primary care atrial fibrillation screening program (AF-SMART): a realist evaluation of implementation in metropolitan and rural general practice. BMC Fam Pract. 2019;20(1):170.
117. Orchard J, Neubeck L, Freedman B, Li J, Webster R, Zwar N, et al. eHealth tools to provide structured assistance for atrial fibrillation screening, management, and guideline-recommended therapy in metropolitan general practice: the AF - SMART study. J Am Heart Assoc. 2019;8(1):e010959.
118. Chen Y, Huang QF, Sheng CS, Zhang W, Shao S, Wang D, et al. Detection rate and treatment gap for atrial fibrillation identified through screening in community health centers in China (AF-CATCH): a prospective multicenter study. PLoS Medicine. 2020;17(7):e1003146.
119. Freedman B, Hindricks G, Banerjee A, Baranchuk A, Ching CK, Du X, et al. World Heart Federation roadmap on atrial fibrillation–a 2020 update. Glob Heart. 2021;16(1):41.
120. Orchard JJ, Neubeck L, Orchard JW, Puranik R, Raju H, Freedman B, et al. ECG-based cardiac screening programs: legal, ethical, and logistical considerations. Heart Rhythm. 2019;16(10):1584–91.
121. Orchard J, Li J, Freedman B, Webster R, Salkeld G, Hespe C, et al. Atrial fibrillation screen, management, and guideline-recommended therapy in the rural primary care setting: a cross-sectional study and cost-effectiveness analysis of ehealth tools to support all stages of screening. J Am Heart Assoc. 2020;9(18):e017080.
122. Jacobs MS, Kaasenbrood F, Postma MJ, van Hulst M, Tieleman RG. Cost-effectiveness of screening for atrial fibrillation in primary care with a handheld, single-lead electrocardiogram device in the Netherlands. Europace. 2018;20(1):12–8.
123. Chao TF, Chiang CE, Lin YJ, Chang SL, Lo LW, Hu YF, et al. Evolving changes of the use of oral anticoagulants and outcomes in patients with newly diagnosed atrial fibrillation in Taiwan. Circulation. 2018;138(14):1485–7.
124. Ball J, Thompson DR, Ski CF, Carrington MJ, Gerber T, Stewart S. Estimating the current and future prevalence of atrial fibrillation in the Australian adult population. Med J Aust. 2015;202(1):32–5.
125. Wang X, Fu Q, Song F, Li W, Yin X, Yue W, et al. Prevalence of atrial fibrillation in different socioeconomic regions of China and its association with stroke: results from a national stroke screening survey. Int J Cardiol. 2018;271:92–7.
126. Deng H, Guo P, Zheng M, Huang J, Xue Y, Zhan X, et al. Epidemiological characteristics of atrial fibrillation in Southern China: results from the Guangzhou Heart Study. Sci Rep. 2018;8(1):17829.
127. Kaushal SS, DasGupta DJ, Prashar BS, Bhardwaj AK. Electrocardiographic manifestations of healthy residents of a tribal Himalayan village. J Assoc Physicians India. 1995;43(1):15–6.
128. Boedhi-Darmojo R, Setianto B, Sutedjo, Kusmana D, Andradi, Supari F, et al. A study of baseline risk factors for coronary heart disease: results of population screening in a developing country. Rev Epidemiol Sante Publique. 1990;38(5–6):487–91.
129. Habibzadeh F, Yadollahie M, Roshanipoor M, Haghighi AB. Prevalence of atrial fibrillation in a primary health care centre in Fars Province, Islamic Republic of Iran. East Mediterr Health J. 2004;10(1–2):147–51.
130. Tamaki K, Koshiyama M, Ohsawa M. Trend in the prevalence of atrial fibrillation during the past 15 years in Iwate (Northeastern Area of Japan). Circ J. 2017;81(10):1537–9.
131. Inoue H, Fujiki A, Origasa H, Ogawa S, Okumura K, Kubota I, et al. Prevalence of atrial fibrillation in the general population of Japan: an analysis based on periodic health examination. Int J Cardiol. 2009;137(2):102–7.
132. Lim CW, Kasim S, Ismail JR, Chua NY, Najme Khir R, Zainal Abidin HA, et al. Prevalence of atrial fibrillation in the Malaysian communities. Heart Asia. 2016;8(2):62–6.
133. Yap KB, Ng TP, Ong HY. Low prevalence of atrial fibrillation in community-dwelling Chinese aged 55 years or older in Singapore: a population-based study. J Electrocardiol. 2008;41(2):94–8.
134. Orchard JJ, Neubeck L, Freedman B, Webster R, Patel A, Gallagher R, et al. Atrial fibrillation screen, management and guideline recommended therapy (AF SMART II) in the rural primary care setting: an implementation study protocol. BMJ Open. 2018;8(10):e023130.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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