Survey of current perspectives on consumer-available digital health devices for detecting atrial fibrillation

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BACKGROUND Many digital health technologies capable of atrial fibrillation (AF) detection are directly available to patients. However, adaptation into clinical practice by heart rhythm healthcare practitioners (HCPs) is unclear.

OBJECTIVE To examine HCP perspectives on use of commercial technologies for AF detection and management.

METHODS We created an electronic survey for HCPs assessing practice demographics and perspectives on digital devices for AF detection and management. The survey was distributed electronically to all members of 3 heart rhythm professional societies.

RESULTS We received 1601 responses out of 73,563 e-mails sent, with 43.6% from cardiac electrophysiologists, 12.8% from fellows, and 11.6% from advanced practice practitioners. Most respondents

(62.3%) reported having recommended patient use of a digital device for AF detection. Those who did not had concerns about their accuracy (29.6%), clinical utility of results (22.8%), and integration into electronic health records (19.8%). Results from a 30-second single-lead electrocardiogram were sufficient for 42.7% of HCPs to recommend oral anticoagulation for patients at high risk for stroke. Respondents wanted more data comparing the accuracy of digital devices to conventional devices for AF monitoring (64.9%). A quarter (27.3%) of HCPs had no reservations recommending digital devices for AF detection, and most (53.4%) wanted guidelines from their professional societies providing guidance on their optimal use.

CONCLUSION Many HCPs have already integrated digital devices into their clinical practice. However, HCPs reported facing challenges when using digital technologies for AF detection,

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and professional society recommendations on their use are needed.

KEYWORDS Atrial fibrillation; Biomedical sensors and wearable technology; Digital health devices; ECG; Pulse plethysmography; Remote monitoring

Introduction

Several consumer-available digital health devices use Food and Drug Administration (FDA)-cleared electrocardiography and pulse photoplethysmography (PPG)-based approaches to detect atrial fibrillation (AF) and are being used by millions of individuals worldwide.[1–6] Most commercially available digital health technologies for AF detection record brief (often 30-second) windows of pulse or electrocardiographic data and then employ algorithms that determine the patient's rhythm status. These algorithms have been shown to be highly accurate when compared to expert review of clinical-grade electrocardiograms (ECGs).[7–9] While the European Heart Rhythm Association recommends systematic AF screening for individuals at highest risk, clinical guidelines set by many other professional and government entities, such as the US Preventative Services Task Force,[10] do not presently recommend widespread use, since the aggregate benefit of this approach has not been established.

Despite the existing wide range of consumer-available devices capable of AF detection, little is known about their actual clinical use. Heart rhythm specialists, cardiologists, and cardiology advanced practitioners are key stakeholders in driving adoption of novel digital technologies for heart rhythm management, yet few studies have explored their perspectives regarding the use of consumer electronics for AF detection or heart rhythm care.

To generate insights into current practices and opinions of healthcare practitioners (HCPs) regarding using digital devices for AF management, we analyzed data from an electronic survey developed and distributed by the Heart Rhythm Society (HRS) to its members, as well as members of the Latin American and Asian Pacific Heart Rhythm Societies. We hypothesized that HCPs have experience using digital devices for AF detection and are using these devices to inform clinical decisions, including the use of oral anticoagulant (OAC) for stroke prevention in patients with AF.

Methods

Study population and setting

The HRS Digital Health Committee independently developed a survey (Appendix A), which was approved for dissemination via e-mail to all members of the HRS, the Latin American Heart Rhythm Society, and the Asian Pacific Heart Rhythm Society by leadership from the respective organizations. More than 36,000 members were sent an initial survey e-mail as well as a second reminder e-mail 2 weeks later. All responses received between February 4 and March 1, 2020 were included for analysis in the present study. The e-mail invitation to participate in the survey included the

following elements: (1) a brief background information regarding digital devices for AF detection, (2) an outline of the study objectives, (3) a direct link to the online survey, and (4) appropriate language denoting that study participation is completely voluntary and anonymous. The recruitment e-mail can be found in Appendix B. The survey was hosted on REDCap, a Health Insurance Portability and Accountability Act–compliant, cloud-based data storage service with survey distribution functionalities embedded within the platform. A direct link to the survey was generated by REDCap and all responses were automatically compiled into a study database hosted by the University of Massachusetts Medical School (UMMS). The survey data management and analysis plan were approved by the UMMS institutional review board (IRB #H00017864). The research reported in this study adhered to the Helsinki Declaration as revised in 2013.

Survey development and content

Given the novel nature of the subject matter and paucity of existing research in the field, the primary authors (E.D., D.M.) generated survey elements that were relevant to practicing HCPs who regularly treat patients with heart rhythm disorders. Questions were adapted from the European Heart Rhythm Association's (EHRA) wEHRAbles survey[11] (E.S., D.D., M.M.) and based on a questionnaire used in the ongoing VITAL-AF study[12] (E.S., D.M., S.L.). Successive drafts of the survey were reviewed by the HRS Digital Health Committee members on a weekly basis, and the committee's input regarding question structure, content, and wording was incorporated. The final survey included demographic questions that assess the context of each practitioner's practice, such as number of years in practice, their role in patient care, and their setting and country of practice. The survey included 17 questions that assessed several major domains: confidence in digital devices for AF detection, use of digital devices for AF detection in clinical practice, clinical decision-making for AF care, barriers to digital device use, and necessary next steps to facilitate their use. The full survey instrument can be found in Appendix A.

Data analysis and banking

The survey interface was generated by REDCap and all data received from participants were transmitted directly into the REDCap server for storage. The server is hosted by the secure and encrypted UMMS network, and it is only accessible by study personnel. Descriptive statistics for all variables are presented as means and standard deviations for continuous variables and proportions for categorical

KEY FINDINGS

- Most heart rhythm practitioners have already recommended a digital health device to patients for atrial fibrillation (AF) detection.

- Device accuracy, uncertainty of the clinical actionability of device-detected AF, and difficulty integrating device-collected heart rhythm data into the electronic health record are barriers to adoption of digital health devices for healthcare practitioners.

- Heart rhythm practitioners desire input from professional societies for guidance on optimal use of digital health devices for AF detection.

Table 1 Healthcare practice demographics of survey respondents

Participant demographics	n = 1601
Healthcare practice setting, %	
University hospital	46.6%
Private hospital	13.9%
District/community hospital	12.0%
Specialized public cardiology center	11.7%
Private practice	11.2%
Other	4.6%
Current position, %	
Cardiac electrophysiologist	43.6%
Cardiologist	9.5%
Electrophysiology fellow	6.2%
Cardiology fellow	6.6%
Physician (other)	3.1%
Advanced practice practitioner	11.6%
Nurse	7.6%
Other	11.8%
Years of practice, mean (SD)	17.3 (11.2)

variables. Logistic regression was used to evaluate the univariate association between respondent characteristics and having recommended a mobile device to patients for AF detection. Response frequencies of select survey elements are presented as bar graphs. All statistical analyses were performed using STATA 13.1.

Results
Demographics of healthcare practice
A total of 73,563 e-mails were sent in 2 waves, resulting in 3653 clicks on the survey link. There were 1601 survey respondents from 77 countries, including 50.3% from the United States. HCP demographics and practice characteristics are presented in Table 1. Among the respondents, 46.6% provided care in an academic setting and 43.6% were cardiac electrophysiologists. Twelve percent of respondents were advanced practice practitioners (nurse practitioners, physician assistants, clinical nurse specialists, etc), 7.6% were nurses, 12.8% were in training, and the average number of years in healthcare practice was 17 (standard deviation 11) years.

Use of digital devices for AF detection in clinical practice
Sixty-two percent of respondents indicated that they had already recommended that their patients use an FDA-cleared mobile device for AF detection (Figure 1), with most recommending the single-lead ECG KardiaMobile (Alivecor, Mountain View, CA) device (58.8%), followed by the Apple Watch (Apple, Cupertino, CA) (35.5%) and FibriCheck (Qompium Imec, Leuven, Belgium) app (4.9%). Compared with HCPs working in an academic or university setting, those in private practice had 1.76 (95% confidence interval: 1.22–2.54; $P = .002$) times higher odds of recommending a mobile device for AF detection. Cardiac electrophysiologists were more likely to recommend a digital device for AF detection than other types of HCPs (Table 2). Among the participants who reported having not recommended a digital device, the most cited reasons were a lack of

confidence in the accuracy of AF detection (29.6%), detection of 30 seconds of AF being insufficient to change patient management (22.8%), a lack of confidence that data will be appropriately integrated into electronic health records (19.8%), and digital devices requiring too much additional time and effort (8.3%) (Figure 2). Differences were noted in HCP confidence by type of digital device used for AF detection. Whereas only 26.8% of respondents reported that they were "likely" or "very likely" to diagnose AF from a 30-second pulse check, 71.8% of respondents reported that they were "likely" or "very likely" to diagnose AF based on a similar-duration ECG recording.

Clinical decision-making and AF management
Less than half of those surveyed (42.7%) reported that they would initiate OAC for a patient at an elevated risk for stroke (CHA_2DS_2VASc score 2+) if AF were detected using a 30-second ECG from a digital device. The clear majority (88.5%) of respondents also indicated that they would reevaluate their stroke prevention strategy if an AF recurrence was diagnosed using a digital device in a patient with prior AF but not on OAC, such as a patient with a remote secondary trigger for AF. When asked "In addition to a consensus document from your scientific society, which further documents or projects would you like to see to facilitate your clinical decisions regarding recordings from wearable devices?" more than half of respondents reported that they would benefit from a "review of validated devices and their potential role in clinical practice (59.4%)," and nearly two-thirds (64.9%) indicated they felt "a clinical trial comparing the sensitivity and specificity of these devices to a clinical gold standard" was needed (Figure 3). Approximately one-third of respondents (34.8%) reported that they had encountered challenges when using digital devices for AF detection. The 3 most commonly cited challenges included "potentially unclear or noisy results" (53.3%), "additional time and effort
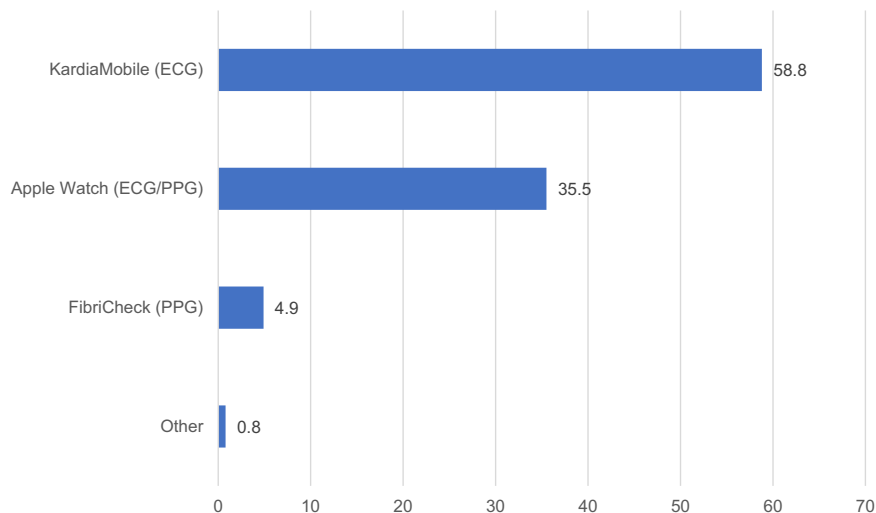
Figure 1   FDA-cleared devices recommended to patients by healthcare providers for atrial fibrillation detection. ECG = electrocardiography; PPG = photoplethysmography.

spent on ECG interpretation" (47.6%), and the "potential need for confirmatory testing" (41.5%) (Figure 4).

Necessary steps for advancement of the field

When asked "What additional steps are needed to encourage you to prescribe mobile or digital devices for AF monitoring to your patients?" more than a quarter (27.3%) of participants had no reservations with recommending a device currently. However, over half of participants (53.4%) reported wanting clinical recommendations from professional and scientific societies regarding the use of digital devices. Though some professional societies have suggested using these devices,

Table 2   Practitioner characteristics associated with recommending digital devices for AF detection

Practitioner characteristics	Unadjusted odds ratio (95% CI)	Sample size
Practice setting		
University hospital	1.00 (Reference)	726
Private hospital	1.34 (0.95–1.89)	216
District/community hospital	0.77 (0.56–1.06)	187
Specialized public cardiology center	1.35 (0.98–1.86)	182
Private practice	1.76 (1.22–2.54)*	175
Other	0.95 (0.57–1.56)	71
Current position, %		
Cardiac electrophysiologist	1.00 (Reference)	694
Cardiologist	0.52 (0.36–0.75)*	151
Electrophysiology fellow	0.59 (0.38–0.91)*	99
Cardiology fellow	0.41 (0.27–0.62)*	105
Physician (other)	0.20 (0.11–0.37)*	50
Advanced practice practitioner	1.36 (0.92–1.99)	185
Nurse	0.38 (0.26–0.56)*	121
Other	0.25 (0.18–0.35)*	188
Duration of clinical practice	1.01 (1.00–1.02)*	-

Statistical significance at $P < .05$ denoted by asterisk (*).

they need to take the lead in establishing regulations and workflow, and push for clear reimbursement strategies. Other critical steps widely cited by survey respondents as influencing their decision to recommend these devices to patients include compensation for data interpretation (36.7%), legislation clarifying medical liability of the physician (30.1%), patient reimbursement toward purchasing a device (26.4%), and paramedical support in management of data obtained from these mobile devices (23.0%) (Figure 5). Only 15.9% of participants were aware of the existence of health insurance plans (including from a Medicare Advantage insurer) subsidizing at least in part the purchase of an Apple Watch, and 18.2% were aware of the ability to bill for single-lead ECG interpretation using existing billing codes.

Discussion

In this study, we conducted the largest survey to date evaluating practitioner perspectives on digital health technologies for AF detection, with data collected from more than 1600 HCPs from a variety of practice settings and countries. The majority had recommended the use of a digital device for AF detection. Cardiac electrophysiologists were more likely to have recommended the use of a digital device compared to other HCPs, and those in private practice were more likely to do so than practitioners in university hospital settings. Two in 5 HCPs reported that they would recommend anticoagulation for a patient at an elevated risk for stroke based on new AF detected from a 30-second ECG monitor without further confirmatory testing. The majority also indicated they would re-evaluate their stroke prevention strategy in a patient with prior AF should an AF recurrence be detected using a digital device.

Use of digital devices for AF detection in clinical practice

A major finding from our study is that most HCPs are recommending the use of digital devices for AF detection.
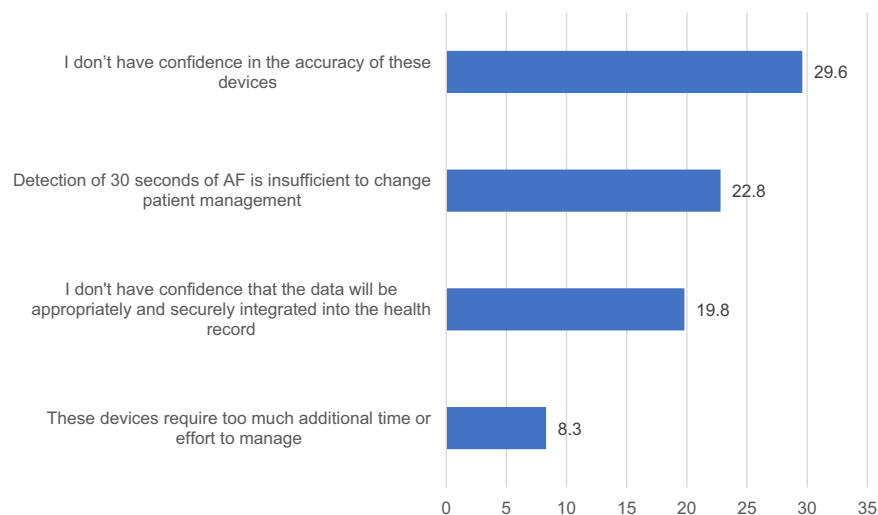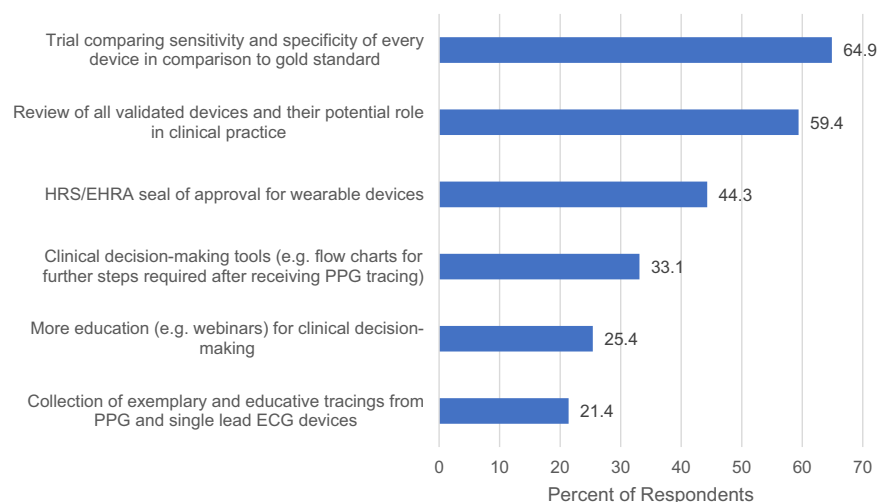
Figure 2 Reasons healthcare providers are not recommending digital devices for atrial fibrillation (AF) detection. (Respondents may only choose 1 answer.)

The widespread penetration of consumer-targeted devices capable of AF detection has likely necessitated that clinicians adapt their practices to accommodate this novel, patient-driven model of AF detection. This is supported by the fact that private practice HCPs reported a higher likelihood than others of having recommended use of a digital device for AF detection, since they may be more able to adapt owing to fewer bureaucratic regulations that are intrinsic to large academic centers. Also, because commercial devices capable of AF detection are infrequently covered by many health insurers, HCPs more likely to treat patients who can afford discretionary out-of-pocket spending on their health might report greater familiarity with consumer devices. We also observed specialist HCPs (cardiac electrophysiologists) who are more likely to treat symptomatic and complex arrhythmia patients have greater familiarity with consumer digital devices for AF detection. This may be due to their increased attention to the stroke risk literature and novel technologies in the field. Interestingly, electrophysiology and cardiology fellows seem to be slower adopters of technology as compared to independently practicing physicians, though this finding may reflect the limited decision-making capacity of trainees and the small number of that subgroup.

We also observed significant reduction in comfort with diagnosing AF based on pulse as compared with ECG-based devices. A larger proportion of survey respondents were comfortable diagnosing AF from 30 seconds of a single-lead ECG tracing as compared to a PPG segment, which likely reflects HCPs' opinion that PPG-based technologies show lower accuracy of AF detection than ECG technologies.[1,13,14] These perspectives are consistent with results from the European Heart Rhythm Society's wEHR-Able survey,[11] which included 417 respondents from >40 countries and similarly found that HCPs are using and recommending digital devices for AF detection and that they would

Figure 3 Necessary steps for healthcare providers to facilitate clinical decision-making regarding atrial fibrillation detected from digital devices. (Response options are not mutually exclusive.) ECG = electrocardiography; EHRA = European Heart Rhythm Association; HRS = Heart Rhythm Society; PPG = photoplethysmography.
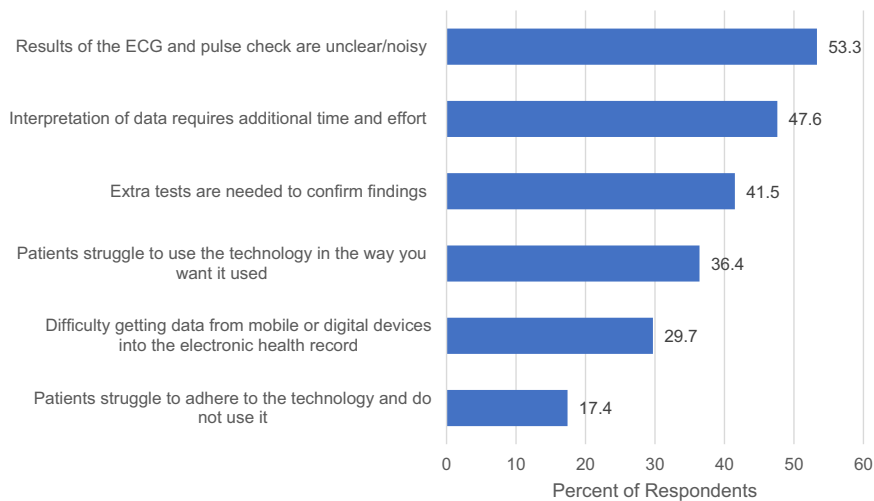
Figure 4   Challenges faced by healthcare providers in using digital devices for atrial fibrillation detection. (Response options are not mutually exclusive.) ECG = electrocardiography.

rather base clinical decisions on ECG recordings rather than PPG findings.

HCP concerns about the "real-world" accuracy of digital devices seem warranted, considering that most studies evaluating performance for AF detection are conducted in controlled laboratory or clinical settings that may not be reflective of real-world use.[15] Further evaluation of device accuracy in large and diverse older patients at risk for AF are needed. Additionally, there is a lack of evidence regarding the clinical significance of short AF episodes with respect to stroke risk owing to the complex relationship between AF duration and stroke risk, and previous literature indicates that the threshold of clinically significant AF may range from 5 minutes to >24 hours.[16–18] The sensitivity of available heart rhythm monitors, including novel wearable devices, may be limited for detecting very short episodes of AF. Furthermore, many mobile devices utilize brief intermittent rhythm windows to determine AF status and are therefore unable to ascertain AF density or burden.

There are several ongoing trials that will contribute evidence validating several digital devices for AF detection, which may alleviate practitioners' concerns regarding accuracy.[19–21] An exploratory sub-study of the mSToPs trial utilizes a wrist-based wearable to measure pulse near-continuously over the course of 4 months, and all AF results will be confirmed by a gold-standard clinical patch for verification.[19] Additionally, the ongoing Heartline study using the Apple Watch, as well as the Fitbit Heart Study utilizing the Fitbit family of wrist-based wearables, similarly aim to validate the clinical utility of the respective devices as a tool for AF screening.[20,21]

Clinical decision-making and AF management
We found that in addition to being widely used, digital devices that detect AF are frequently driving clinical decisions around OAC therapy. Indeed, 2 in 5 respondents would recommend OACs based on a positive intermittent 30-second ECG result alone for a patient at high risk for
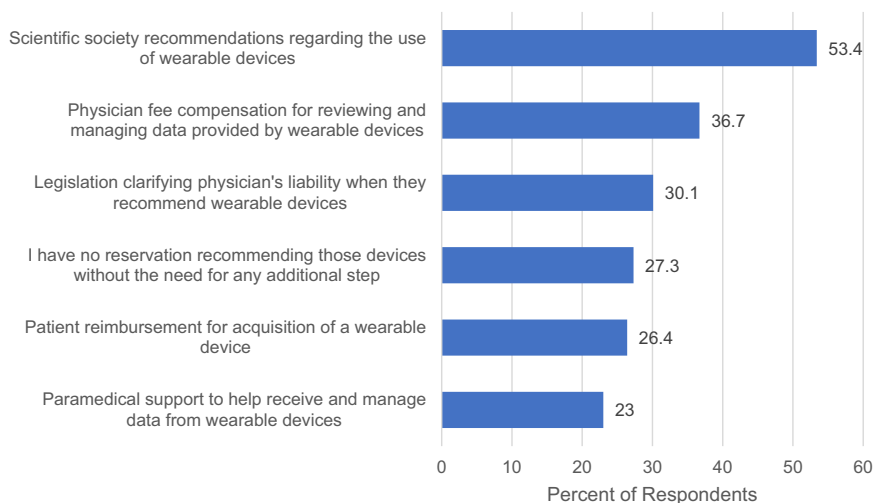
Figure 5   Additional steps needed to encourage healthcare provider prescription of digital devices. (Response options are not mutually exclusive.)

stroke. The large economic impact that an AF diagnosis confers owing to medical expenditures associated with its clinical sequelae is well documented.[22] Multiple studies examining the use of single-lead intermittent ECG recordings to screen for AF in high-risk populations have consistently shown that they are highly cost effective.[23–26] Notably, these studies all operate on the assumption that a positive result from a single-lead ECG device leads to confirmatory testing, and they incorporate these associated costs in their calculations. However, this study supports that routine confirmatory testing may not necessarily be the next step in management of ECG device-detected AF; thus the actual costs associated with screening may be lower from what was assumed by previous studies.[23–26] However, this may come at the cost of overall accuracy, and the potential for serious side effects associated with inappropriate OAC prescription may impact healthcare costs as well.

Challenges in device use and moving forward

The major challenge HCPs reported facing when using mobile devices for AF detection was obtaining unclear results. Many mobile modalities for detecting AF are plagued by factors that may affect rhythm determination, such as motion noise artifact or benign rhythm irregularities such as premature atrial complexes or premature ventricular complexes. Device manufacturers are constantly refining their algorithms as well as hardware components in an attempt to alleviate this, and have enacted solutions such as expanding the range of analyzable heart rates[27] or adding additional ECG leads to their handheld devices.[28] In addition, advancements in artificial intelligence research and its adoption in ECG analysis allow us to tap into additional information that is not available when using conventional algorithms, such as identifying a patient with underlying paroxysmal AF from analysis of a segment of their ECG displaying normal sinus rhythm.[29] Additional research shows that a neural network can even detect the ratio of AF to normal sinus rhythm recordings done using an AliveCor Kardia device, a correlate to the patient AF burden.[30] Although this technology requires further prospective validation, the use of artificial intelligence on data acquired using wearables might have the ability to augment HPC decisions and allow a more personalized risk stratification. Two additional challenges nearly half of practitioners cited are the additional time and effort required for data interpretation and the potential need for additional confirmatory testing. Appropriate patient selection may increase diagnostic relevance and yield.

Most responders endorsed the need for scientific society recommendations regarding the use of digital AF detection, though this observation may likely be owing to the fact that all participants in the present study are professional society members. Interestingly, 2 additional specific steps respondents deemed key to their decision to recommend devices for AF detection, each with over a quarter of responses, were patient reimbursement for these devices and physician compensation for data interpretation. Although by no means

universal, several health insurance companies in the United States and Europe offer plans that reimburse or offer rewards for the purchase or use of wearable devices capable of AF detection,[31,32] yet the large majority of practitioners were not aware of their existence. This finding is unsurprising, as the proportion of insurance carriers offering reimbursement for device costs is still relatively low, and thus this is not an available option to patients in many states or countries. Similarly, only a small percentage of respondents were aware that specific billing codes can be used for reimbursement of interpreting device-obtained ECGs.[33] This lack of awareness likely at least partially explains respondents who cited these as necessary next steps, and also highlights the need for more systematic dissemination of this information to clinicians.

Integration of digital devices into AF care

The use of digital devices has been catalyzed by the COVID-19 pandemic. A joint statement from the HRS, the American College of Cardiology, and the American Heart Association has emphasized the importance of converting to telemedicine visits for patients with nonurgent clinical needs, and goes even further to recommend "obtaining vital signs and ECG tracings using digital wearables where available."[34] This is significant advancement toward recognition of the potential of digital technologies in streamlining heart rhythm care, and there have already been efforts to adapt and integrate these technologies to facilitate AF screening. The TeleCheck-AF project is an epidemic response involving 36 hospitals in 13 countries (as of May 2020, and still increasing) leveraging the FibriCheck smartphone application to maintain AF management for patients remotely, and the research team has developed a suite of tools, including operating procedures and patient materials, to facilitate the adoption of the process by other hospitals.[35,36]

With the increasing number of virtual clinical encounters in the COVID-19 pandemic, integration of commercial digital devices may increase the value of the virtual visit by providing HCPs access to heart rhythm information outside of conventional clinical settings. Notably, this survey was administered before the full impact of the pandemic was apparent, and practitioner perspectives regarding digital health technologies may have further shifted. More research is needed to explore the impact of integrating digital technologies into ambulatory heart rhythm care on critical patient-reported and clinical outcomes, including quality of life and stroke.

Strengths and limitations

Our study has numerous strengths. The survey instrument used in this study was developed collaboratively with US experts in cardiac electrophysiology, digital medicine, and implementation science from the United States, Europe, Asia, and Latin America. The survey was distributed globally and electronically by prominent professional societies to a large and contemporary cohort of HCPs, which provides diversity in responses to obtain nuanced insights from different

survey response profiles. However, a major limitation to our study is the potential for selection bias. The survey was targeted toward members of professional societies focused on heart rhythm care and a large portion of survey respondents were cardiac rhythm specialists from the United States, which may not be generalizable to non–heart rhythm specialists or other healthcare professionals who treat AF patients, such as those in internal medicine or family practice. We also did not include questions in the survey to ascertain the types of follow-up testing that were prescribed to validate findings from digital health technologies, and this remains an important area for future research. Additionally, although general practice demographics of HCPs were collected, more granular location information beyond country, as well as personal demographics such as age, sex, and race, were not ascertained in this survey.

Conclusions

In the largest study to ascertain HCP opinions about consumer digital technologies for AF detection conducted to date, most survey respondents reported having integrated digital technologies into their clinical practice. We observed significant differences by practitioner type, suggesting that familiarity with digital technology is expanding from specialists to more general practitioners. Device accuracy, uncertainty as to the clinical meaning of device-detected AF, and incomplete integration of digital heart rhythm data into the electronic health record were identified by respondents as barriers to greater digital device adoption for AF detection and care. HCPs have a positive outlook regarding digital technologies for AF detection but indicate a desire for further study and input from professional societies on the appropriate use of digital and mobile devices for AF care.

Funding Sources

Disclosures

The authors have no conflicts of interest to disclose.

Appendix
Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.cvdhj.2020.06.002.

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