

Digital health tools for patient-centered lifestyle and risk factor modification in atrial fibrillation management

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ABSTRACT

Structured lifestyle risk factor modification (LRFM) is an evidence-based core pillar for atrial fibrillation management. Despite consistent endorsement by international guidelines, real-world implementation of LRFM remains limited because of fragmented care delivery, logistical challenges, and lack of reimbursement models. Digital health technologies including mobile applications, wearable and non-wearable sensors, remote monitoring, and virtual coaching offer an innovative pathway to scale and personalize LRFM delivery.

This scientific statement synthesizes current evidence supporting digital LRFM interventions and outlines essential components of LRFM programs. It also highlights opportunities for patients, clinicians, and health systems by illustrating how digital health tools can facilitate and expand the implementation of LRFM. The document further addresses health system, policy, and regulatory considerations, emphasizing the need for data transparency, inter-operability, and sustainable reimbursement frameworks to enable broad adoption. Finally, it identifies key research and policy priorities to ensure equitable, effective, and scalable integration of digital health-enabled LRFM in routine AF care.

KEYWORDS Atrial fibrillation; Lifestyle risk factor modification; Digital health

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Introduction

Preamble

The Heart Rhythm Society (HRS) has developed scientific and clinical documents guiding the management of cardiac arrhythmias since 1996. This HRS statement discusses the use of digital health tools to support patient-centered risk factor modification in the management of atrial fibrillation (AF).

Editorial independence

The statement is sponsored by the HRS and was developed without commercial support. All writing committee members and peer reviewers volunteered their time to the writing and reviewing efforts.

Organization of the writing committee

HRS has rigorous policies and methods to ensure that documents are developed without bias or improper influence. The HRS policy on relationships with industry and other entities can be found in Appendix C of the Heart Rhythm Society Code of Ethics & Professionalism and in the HRS Scientific Documents Methodology Manual. [Appendix 1](#) is a comprehensive list of relationships with industry and other entities disclosed by the writing committee members. [Appendix 2](#) is a comprehensive list of relationships with industry and other entities disclosed by peer reviewers.

Document review and approval

This statement was approved by the writing committee and underwent internal review by the HRS Scientific Documents Committee.

Document updates

The HRS Scientific Documents Committee reviews each scientific document for currency every 2–5 years after publication.

Document scope and rationale

Atrial fibrillation (AF) is closely associated with modifiable risk factors such as obesity, hypertension, diabetes mellitus, physical inactivity, and harmful lifestyle behaviors, such as smoking and alcohol intake, each contributing significantly to AF onset and progression.¹ Effective management of these risk factors through structured lifestyle interventions, commonly referred to as lifestyle and risk factor modification (LRFM), is recognized globally as a cornerstone of comprehensive AF care. These interventions can substantially improve clinical outcomes such as symptom burden, arrhythmia recurrence, and associated complications including stroke and heart failure.² This recognition is reflected in guidelines worldwide. United States (US) guidelines now designate LRFM as a Class I recommendation, whereas Canadian guidelines have recommended LRFM with specific treatment targets since 2020 to reduce major cardiovascular events, prevent recurrence of the arrhythmia, and decrease symptom burden.^{3,4} Similarly, European guidelines have elevated weight loss, tailored exercise, and alcohol avoidance to Class I indications, and Asia Pacific guidelines recommend lifestyle modification to prevent new-onset AF and AF-related complications.^{5,6} Additionally, the recent HRS AF Centers of Excellence document positions LRFM prominently within the AF management framework, highlighting its critical role in AF care.⁷

Despite robust evidence supporting the efficacy of structured LRFM programs, significant implementation gaps persist across health care systems worldwide.^{2,8} In the US,

for example, widespread adoption of structured LRFM is constrained by current care delivery and reimbursement frameworks, such as the exclusion of AF as a qualifying diagnosis for cardiac rehabilitation services.

Emerging digital health technologies present a transformative opportunity to address these implementation gaps by offering scalable, accessible, and patient-centered approaches to LRFM. Digital platforms using mobile health applications, wearable and non-wearable smart devices, remote patient monitoring (RPM), and telehealth interfaces are increasingly used in chronic disease management, demonstrating considerable potential to facilitate real-time personalized interventions, enhance patient self-management, and improve clinical outcomes across diverse patient populations, including those with AF.⁹

Digital health-enabled programs as a pathway to implement guideline-recommended lifestyle and risk factor modification

Current digital health-enabled risk factor modification programs are generally consumer-focused and are not specifically designed for patients with AF. These programs tend to be costly, with access limited to those whose insurance plans or health systems offer coverage.^{10–12} Other programs are marketed directly to health systems, employers, or payors, offering digital coaching and RPM services for various chronic disease management.^{13,14} However, none of these platforms are tailored specifically to the unique needs of patients with AF, who face distinct challenges in adopting behavior change because of symptom variability and fear of exercise-induced AF episodes. This limitation highlights a clear need for digital health programs to be designed and evaluated specifically for this population.

In recent years, AF-specific virtual LRFM programs have been developed and studied (Table 1^{15–29}). Most studies on digital health-enabled LRFM in AF have been published since 2020, likely reflecting the accelerated adoption of remote care models during and after the COVID-19 pandemic, and growing recognition of the importance of LRFM in AF management.

A common feature of virtual LRFM programs is their multi-component design (Table 1^{15–29}). Interventions combine smartphone applications, connected health devices for rhythm and health metric monitoring, and some form of human interaction, including coaching. This multicomponent nature reflects the complexity of behavior change, particularly when multiple risk factors should be addressed through education, goal setting, tracking, and feedback. Importantly, studies suggest that digital health programs lacking human accountability, such as those relying solely on smartphone apps, fail to effectively engage patients. For example, in the MOTIVATE-AF study, patients randomized to app-based reminders had lower engagement than those who received telephone follow-up, highlighting the value of human interaction.²⁸ This complexity presents a challenge in evaluating new interven-

tions, as it becomes difficult to isolate which aspects of the intervention drive the positive or negative outcome. The ongoing mTECH-AFib 2 study aims to compare the effects of health metric tracking with smartwatch only vs a multi-component program, including a smartphone app, a smartwatch, a scale, a blood pressure cuff, and coaching on AF recurrence following catheter ablation.³⁰ Although this design may not fully disentangle the effect of each component of the intervention, it is expected to provide insight into the relative value of self-monitoring alone vs enhanced self-monitoring combined with coaching, which will further shed light on the importance of personalized coaching in virtual programs.

There is increasing interest in determining whether artificial intelligence (AI) can replicate or supplement the human role for coaching to enhance scalability and offset cost of these virtual programs. In the Coordinating Health Care With Artificial Intelligence–Supported Technology for Patients With Atrial Fibrillation (CHAT-AF) trial, patients receiving fully automated AI-driven phone calls reported engagement and perceived self-management support and also acknowledged the need for better dialogue flexibility and personalization of content.³¹ Furthermore, a patient-centered relational agent was found to be useful, trustworthy, and informative by patients.^{15,20}

The scope of AF digital programs varies in focus, intensity, and timing. Some programs address all pillars of AF management, incorporating but not emphasizing LRFM, whereas others are more targeted toward LRFM with some overlap with other aspects of AF care (Table 1^{15–29}). Most studies have used quality of life as the primary outcome and have reported improvements across interventions. AF-HEART, which leverages a smartphone app, has focused specifically on LRFM and has reported significant weight loss in modest size samples.^{24,26,27} The large-scale mAFA program, which addressed holistic AF management, demonstrated an improved composite outcome of ischemic stroke/systemic thromboembolism, death, and rehospitalization with the virtual program.^{21,22} Adherence to interventions was generally high across studies.

Finally, the timing of the LRFM in relation to rhythm control intervention is heterogeneous among studies, with some studies focusing on enrolling patients before catheter ablation and others after rhythm control interventions.^{24–27}

Having described the current landscape of AF-specific interventions to support LRFM, we next outline the minimal requirement for implementing these programs in clinical practice.

Components of LRFM programs, timing of LRFM implementation, and patient selection

The 2023 US AF guideline recognizes AF as progressive disease and outlines stages of disease from at risk for AF (stage 1), pre-AF (stage 2), AF (stage 3), and permanent AF (stage 4).⁴ Treatment of modifiable risk factors is recommended across all stages of AF.⁴ Although electrophysiologists may

Table 1 Studies evaluating digital health technology for risk factor modification among patients with atrial fibrillation

Study name	Publication year	Study type	Sample size (n)	Components of intervention	AF risk factors targeted	Outcomes	Relationship with ablation	Duration of intervention and follow-up	Results
The Atrial Fibrillation Health Literacy Information Technology System: Pilot Assessment ¹⁵	2017	Observational	31	Computer-animated agent providing coaching specific to AF and AliveCor Kardia monitor	Unspecified	QoL (measured by AFEQT score) ¹⁶ ; medication adherence (measured by MMAS score ^{17,18}); patient activation (PAM) ¹⁹ ; and intervention adherence	Unspecified	30 days and 30 days	Improved QoL and marginal improvement in medication adherence. No difference in patient activation. The intervention was acceptable.
The Atrial Fibrillation Health Literacy Information Technology Trial: Pilot Trial of a Mobile Health App for Atrial Fibrillation ²⁰	2020	Pilot randomized controlled trial (digital health-enabled program vs usual care)	120	Computer-animated agent providing coaching specific to AF and AliveCor Kardia monitor	Unspecified	Primary outcome of QoL (measured by AFEQT); other outcomes including anticoagulation adherence and participant's use and acceptability of intervention	Unspecified	30 days and 30 days	Higher improvement in QoL in intervention group and better adherence to anti coagulation therapy. Intervention was acceptable; 70% in the intervention group completed medication adherence module, and 79% completed AF education module.

Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial ²¹	2017	Pilot cluster randomized trial	113	The mAFA platform, consisting of patient- and clinician-facing versions of the mAFA app, including clinical decision support tools, patient education material, and self-monitoring via PPG-based rhythm monitoring	Unspecified	Patient's knowledge; QoL; drug adherence; anticoagulation satisfaction; intervention acceptability	Unspecified	3 months and 3 months	QoL and medication adherence was higher in the intervention group compared with control group. mAF use was acceptable (90% of users).
Mobile Health Technology to Improve Care for Patients With Atrial Fibrillation ²²	2020	Cluster randomized trial	3324	The mAFA platform, consisting of patient- and clinician-facing versions of the mAFA app, including clinical decision support tools, patient education material, and self-monitoring via PPG-based rhythm monitoring	Blood pressure; alcohol intake	Composite outcome of ischemic stroke/ systemic thromboembolism, death, and rehospitalization	Unspecified	6 months and 277 days (mean)	Composite outcome was lower in the intervention group.
A Nurse-led Approach to Improving Cardiac Lifestyle Modification in an Atrial Fibrillation Population ²³	2019	Observational	53	"ACTION" intervention including nurse-led coaching (30-minute weekly sessions over 6 months) via telehealth and My AFib symptom tracker via the My AFib Experience web-based resource	Life's Simple 7 components	Effect on risk factor modification; intervention acceptability	Unspecified	6 months and 6 months	Intervention was acceptable; patients achieved improvement in AF risk factors and had improvement in Life's Simple 7 score

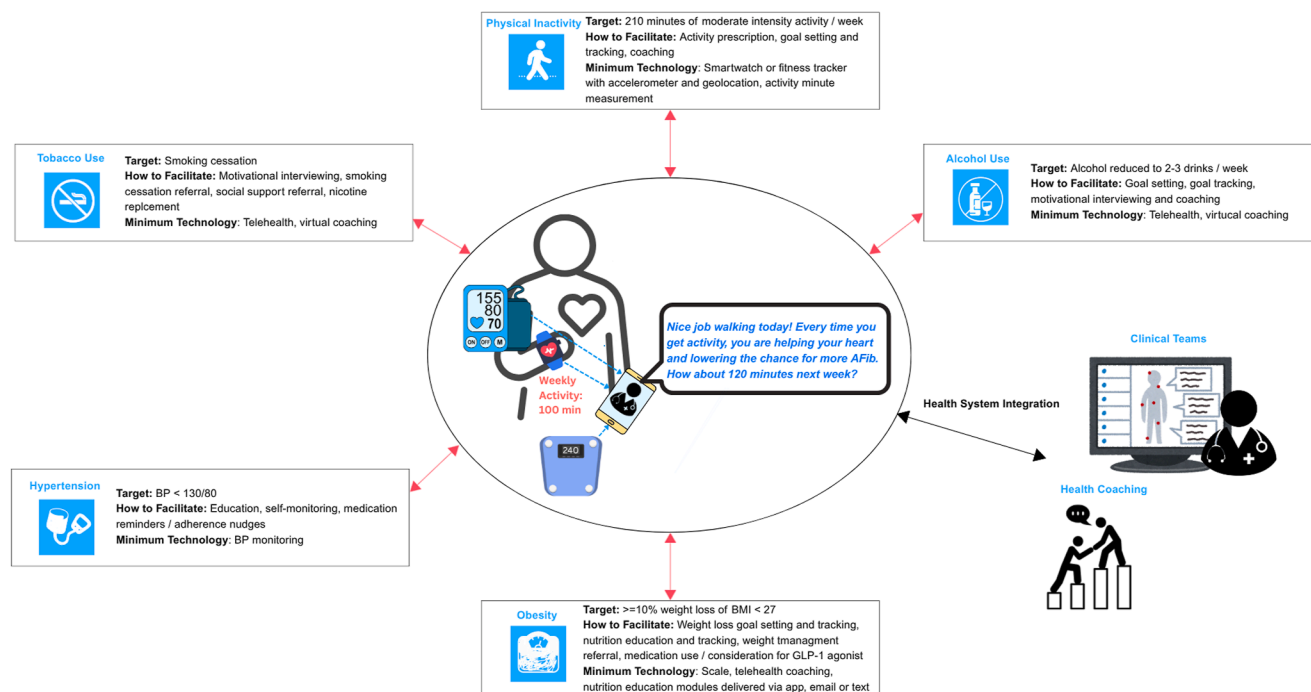
(continued)

Table 1 Continued

Study name	Publication year	Study type	Sample size (n)	Components of intervention	AF risk factors targeted	Outcomes	Relationship with ablation	Duration of intervention and follow-up	Results
Risk Factor Management of Atrial Fibrillation Using mHealth: The Atrial Fibrillation – Helping Address Care with Remote Technology (AF-HEART) Pilot Study ²⁴	2022	Randomized (virtual intervention vs usual care)	20	Rhythm monitoring via smart device (AliveCor KardiaBand connected to Apple Watch or KardiaMobile device); weight; blood pressure tracking via smart devices; telehealth visits with dietitian (biweekly for 6 months for 30-minute sessions); sleep apnea and hypertension treatment through referrals when needed	Weight; sleep apnea; alcohol use	Feasibility for heart rhythm tracking; risk factor modification and AF symptom reduction; QoL	Post-rhythm control (AAD, DCCV, or ablation)	6 months and 6 months	Patients achieved weight loss and had improved QoL
The Usability and Effect of an mHealth Disease Management Platform on the Quality of Life of Patients with Paroxysmal Atrial Fibrillation - The emPOWERD-AF Study ²⁵	2022	Randomized (app-based intervention vs usual care)	80	myAlgos: Physician-oriented platform and patient-oriented smartphone app (patient education, messaging within the app, medication reminders, and heart rate log)	Unspecified	Primary outcome of QoL; other outcome of platform usability	Pre-ablation	6 months and 6 months	Improved QoL was observed, and platform and app were easy to use.
Impact of Digital Monitoring on Compliance and Outcome of Lifestyle-Change Measures in Patients with Coexistent Atrial Fibrillation and Obesity ²⁶	2022	Observational	105 (20 received intervention and 85 usual care)	Smartphone app (LRFmx) with goal setting, tracking, and reminders; scale; blood pressure monitor; health coaching with 12-week program through telehealth and text-based communications	Exercise; weight	Weight loss; adherence to lifestyle recommendations	Pre-ablation	6 months and 6 months	Diet and exercise recommendation compliance was higher, and weight loss was more prevalent among patients who received intervention. There was no significant difference in arrhythmia recurrence.

Outcomes of a Remote Cardiac Rehabilitation Program for Patients Undergoing Atrial Fibrillation Ablation: Pilot Study ²⁷	2023	Observational	12	Asynchronous, remotely supervised exercise after an in-person evaluation (weekly phone calls with exercise physiologist); scale; blood pressure cuff; Kardia Mobile 6L + KardiaPro for ECG review and storage; EHR portal with patient-generated data flowsheet	Physical activity; weight; blood pressure	Primary outcome of program completion; other outcomes including change in self-tracking adherence, weight, 6-minute walk test, waist circumference, AF symptom score, and program satisfaction	Post-ablation	12 weeks and 12 weeks	The vast majority of participants completed the program. Adherence was fair; patients achieved reduction in weight and waist circumference and had improved 6-minute walk test. Patients were satisfied with the intervention.
Randomized Trial of Applied Motivational Support for Patients with AF to Promote Weight Loss (MOTIVATE-AF) ²⁸	2024	Randomized (smartphone-based follow-up vs nurse-led telephone follow-up biweekly)	64	Smartphone app (AVATR)–based patient education platform receiving biweekly reminder messages to track weight and activity	Weight; physical activity	Primary outcome of weight loss; other outcome of QoL	Unspecified	6 months and 6 months	No difference in weight loss was seen between phone follow-up and app groups. Patients were more engaged in telephone follow-up group. Follow-up questionnaire completion in the app group was low, limiting further analysis.
Patient-Centered mobile Health TECHNOlogy Enabled Atrial Fibrillation Management (mTECH-Afib): A Pilot Randomized Controlled Trial ²⁹	2025	Randomized pilot	61	Smartphone app; weekly virtual coaching for 12 weeks; Apple Watch for exercise, heart rhythm, and heart rate tracking; clinician dashboard	Blood pressure; weight; physical activity; sleep apnea; alcohol intake; smoking	Feasibility (participant recruitment, engagement, and satisfaction)	Unspecified	12 weeks and 12 weeks	High recruitment, engagement, and satisfaction rates were observed.

Aad = antiarrhythmic drugs; AF = atrial fibrillation; AFEQT = AF Effect on Quality-of-Life questionnaire; DCCV = direct current cardioversion; ECG = electrocardiogram; EHR = electronic health record; MMAS = Morisky Medication Adherence Scale; PAM = Patient Activation Measure; PPG = photoplethysmography; QoL = quality of life.

**Figure 1**

Lifestyle and risk factor modification delivery via digital health programs. Patient-, clinician-, and health care-facing opportunities for scalable and successful virtual risk factor modification among patients with atrial fibrillation. Afib = atrial fibrillation; BP = blood pressure.

not encounter patients until AF is diagnosed, educating primary care clinicians and cardiologists is important to begin early implementation of LRFM to prevent development and progression of AF.

Virtual LRFM programs should have components to allow tailored modification for each AF risk factor (Figure 1). Programs should track progress toward achieving guideline-recommended targets for LRFM: weight loss of at least 10%, physical activity reaching 210 minutes of moderate exertion per week, alcohol reduction to <2–3 drinks/week or abstinence, smoking cessation, and optimal hypertension control. These metrics are recommended by national AF management guideline.⁴ However, these programs should be adjusted and personalized based on individual patient needs. For example, some patients with AF are not able to participate in exercise, as they have disabling symptoms from AF. This may limit the exercise component of LRFM, but other components can be implemented. Although it may be reasonable to include sleep apnea screening and treatment interventions, the benefits of screening and treating sleep apnea on maintaining sinus rhythm are not clear at this time.⁴ Additionally, education regarding other pillars of AF, stroke prevention and symptom management, should be included for a holistic approach and patient empowerment.

Although there are no data on required testing prior to implementing risk factor modification, some of the exercise-heavy trials (eg, ACTIVE AF trial) assessed patients using a stress test prior to the exercise program initiation.³² At this time, physician discretion for assessing safety of exercise is recommended and the need for ordering formal exercise

stress testing should be determined according to standard guidelines.³³

Opportunities provided to patients and clinicians

Patient-facing opportunities

Empowering self-management and engagement

Digital health offers a transformative opportunity to shift AF care from disease control to person-centric health promotion based on real-time, personalized support.³⁴ Although tools ranging from mobile apps to wearables are increasingly used for chronic disease self-management,³⁵ the challenge lies in identifying which strategies most effectively engage individuals with AF.

Many successful digital interventions are grounded in behavior change techniques.^{36–38} Self-monitoring, prompts and cues, action planning, graded tasks, and the use of credible sources have been shown to be particularly effective in improving cardiovascular outcomes.^{39,40} These techniques align well with the needs of individuals managing AF, who often benefit from structured guidance and real-time feedback.

Qualitative research highlights key facilitators of behavior change, including awareness of AF risks and having a clear action plan, confidence in the ability to change, and social support.⁴¹ Conversely, barriers such as symptom-related distress, medication side effects, and lack of symptom monitoring awareness can hinder engagement. These insights underscore the need to tailor digital tools to address both the emotional and the practical challenges faced by patients

and justify the complexity or multicomponent nature of LRFM programs outlined previously.

The “smart health ecosystem” concept integrates physiological, behavioral, and environmental data to deliver personalized interventions across multiple channels (apps, text messaging, e-mail).⁴² These ecosystems can support the full spectrum of self-care, as described in Riegel’s middle-range theory: maintenance (risk reduction), monitoring (detecting symptomatic and asymptomatic AF episodes, symptom changes), and management (responding to changes in rhythm and symptoms).⁴³ Interventions that encompass all 3 components have been shown to improve patient-reported outcomes, clinical metrics, and health care utilization for individuals with AF.⁴⁴

Patients increasingly expect clinicians to guide app selection, incorporate wearable data into care decisions, and demonstrate digital literacy, particularly younger patients who anticipate AI-proficient care.⁴⁵ However, patients also experience anxiety from information overload and inconsistent online messaging, preferring that information comes from trusted sources and is delivered in a format that suits their individual needs, whether paper based or digital.⁴⁶ Patient portals and patient-facing electronic health record (EHR)-integrated dashboards can offer scalable solutions to meet these needs.

Expanding access beyond traditional care settings

Digital health technologies significantly enhance accessibility by dismantling traditional barriers to care. For individuals residing in geographically isolated or medically underserved regions, digital platforms offer a lifeline to specialized cardiology expertise and health education resources that would otherwise be unavailable.^{47,48} These telehealth consultations allow patients to connect with health coaches, cardiologists, dietitians, or exercise physiologists regardless of their physical location, circumventing the need for arduous travel and associated costs.⁴⁸ The continuous data flow from smartphones, smartwatches, or other smart devices facilitates proactive interventions and timely adjustments to treatment plans, ensuring that geographical distance no longer dictates the quality or availability of essential risk factor management.^{49,50} Furthermore, the inherent convenience and flexibility of digital health are invaluable for patients with demanding work schedules, mobility limitations, or caregiving responsibilities, for whom traditional in-person appointments are often impractical. The ability to access educational modules on cell phones or online, participate in virtual coaching sessions, or communicate asynchronously with clinicians at their convenience significantly improves adherence to complex LRFM regimens.⁵¹ Limitations of access to technology and internet are discussed later on in this document.

Promoting health equity

Beyond mere access, digital health technologies may actively promote health equity by addressing disparities rooted in

socio-economic status, health literacy, and cultural background. Generative AI, for instance, possesses the capability to tailor health information and educational content to a patient’s specific health literacy level, preferred language, and cultural context, making complex medical concepts related to AF and its risk factors more understandable and relatable.⁵² Such personalized communication can significantly enhance patient understanding and engagement, particularly for minority groups or those with limited English proficiency who have historically faced barriers to equitable health information.⁵² Moreover, by empowering patients with real-time data from their wearables or apps, digital tools foster a sense of ownership and agency over their health. This active participation in self-management, coupled with personalized feedback and reminders, translates into improved adherence to lifestyle changes and medication schedules, ultimately leading to better health outcomes and a reduction in health disparities.⁵¹

Clinician-facing opportunities: Implementation of risk factor modification without increased burden on clinicians

Automated digital checklists and prompts

Digital prompting within EHR systems can enable delivery of evidence-based, comprehensive care, including LRFM. CardioConsult AF, guideline-based clinical decision support software for AF management, has been shown to improve quality of life and adherence to guidelines and even reduce mortality.^{53–55} Such tools offer a scalable approach to identify patients with modifiable risk factors and prompt appropriate interventions without increasing clinician burden. Automated clinical decision support within EHRs can also flag patients for targeted risk factor modification. For example, a study using a best practice advisory alert improved anticoagulation prescribing for patients with AF, demonstrating that automated prompts can change clinician behavior.⁵⁶ Similar strategies could identify patients with elevated body mass index, uncontrolled hypertension, or untreated sleep apnea and direct them toward structured management programs. The ongoing Integrated Care in Patients with Atrial Fibrillation: A Randomized Controlled Trial (iCARE-AF) study is evaluating how digital checklists can optimize the implementation of LRFM within routine AF care.⁵⁷

Optimizing clinician time and workflow integration

Digital health tools can track progress in LRFM and visualize it in clinician-facing dashboards. These dashboards, especially when integrated into or accessible from the EHR, can summarize trends in patient weight, blood pressure, glucose levels, and physical activity. Instead of relying on infrequent office visits, clinicians can monitor patients’ progress remotely and use these data during routine encounters to guide care.

A key consideration is minimizing disruption to workflow. Seamless integration (single sign-on, in-workflow dashboards, minimal clicks) is essential to avoid adding burden.

When implemented well, digital tracking could save clinician time by enabling data-driven discussions (eg, “Your weight trend is down 5% since your last visit, which is great progress in trying to reduce your AF burden”) and by reducing unnecessary in-person visits through remote monitoring of risk factor control.

Team-based care with health coaches

Trained health coaches and/or AI-based digital coaches can offload much of the work of behavior change from physicians. Health coaches, including nurses, dietitians, and lifestyle counselors, can monitor data from digital platforms and provide targeted outreach when patients are not meeting goals. In the MOTIVATE-AF trial, patients with AF and obesity received weight loss support via either automated text reminders or nurse-led phone calls. Both groups achieved modest weight loss, but engagement was higher with nurse support.²⁸ This suggests that while digital interventions can be effective, human interaction may enhance adherence.

AI-based coaches are rapidly evolving. Outside the AF literature, a study involving individuals with cancer, an AI-driven voice assistant (MyCoach) delivering lifestyle coaching led to a significant increase in daily step count compared with control.⁵⁸ These tools can scale easily and operate continuously, offering low-cost, personalized support.

Implementation considerations

Modern platforms can integrate patient-generated data (such as weight, blood pressure, and physical activity) from devices and apps directly into the EHR. Platforms like Validic and Human API enable aggregation of data from wearables, home monitors, and smartphone apps.⁵⁹ This allows EHR systems to automatically monitor trends and notify care teams when targets are not being met, supporting early intervention.

Hybrid models combining AI with human coaching may offer the best of both worlds. In the mAFA-II trial, an app-guided, holistic AF program (including stroke prevention, symptom tracking, and risk factor management) paired with virtual coaching reduced the composite end point of stroke, death, and hospitalization by ~60% compared with usual care.²² Patient adherence to the digital tools was high, with over 80% maintaining app usage.

Health system and policy considerations

Scalable risk factor modification

Digital health tools are an important step forward to increased accessibility and scalability of LRFM implementation; however, the format and style of the digital health platform most suitable for a particular patient may be different. These tools allow individuals who are unable to or who prefer not to attend traditional in-person clinics to receive evidence-based care. A digital approach will also avoid overwhelming the limited number of in-person AF clinics offering in-person LRFM. Virtual programs can be integrated in AF Centers of

Excellence and offered to patients across all stages of AF, including those “at risk” for AF.⁷ An important next step to achieve scalability is to establish sustainable reimbursement models that will need to be tailored to the needs of different regions globally.

Financial benefits of digital health tools in value-based care

Smart devices, such as Bluetooth-enabled blood pressure cuffs and scales and smartwatches equipped with electrocardiogram (ECG) or PPG (short for photoplethysmography) sensors, can capture a wealth of real-time health data and have been supported by payors. In addition, RPM enables clinicians to track patient health status between appointments and intervene proactively when needed. By improving care coordination, promoting preventive care, and demonstrating positive health outcomes, smart devices can help clinicians meet the quality and cost-effectiveness requirements of value-based care models. It is well-established that LRFM reduces AF progression, and when this is successfully implemented, clinicians will meet the quality and cost-effectiveness requirements of value-based care models. Furthermore, early detection of AF in specific patient populations, which leads to earlier intervention, will likely reduce downstream costs related to prevention of AF-related comorbidities, for example, congestive heart failure and stroke.

Data transparency, inter-operability, and regulatory considerations

Digital health technologies, while heralding a new era for AF management and risk factor modification, simultaneously introduce a complex framework of issues pertaining to data transparency, inter-operability, and regulatory considerations that demand meticulous attention for their safe, equitable, and effective integration into clinical workflows and practice.^{60,61}

Transparency

The ecosystem of mobile applications, wearable devices, and remote monitoring platforms generates unprecedented volumes of patient-generated health data; however, the clinical utility and trustworthiness of this information are critically dependent on robust data transparency and protection.⁶² A paramount concern lies in the inherent opacity of AI algorithms, which increasingly influence AF diagnosis, risk stratification, and personalized treatment recommendations. It is important to note that 18%–26% of tracings from wearable devices label ECGs as “inconclusive” and sensitivity and specificity for AF detection ranges from 58% to 85% and 69% to 79%, respectively.⁶³ This “black box” problem, where the intricate decision-making logic of these algorithms remains obscure, may unnecessarily erode clinician trust and hinder their ability to adopt and use AI-enabled digital technologies if they do not fully comprehend or justify AI-derived insights, which may impede informed clinical judgment.^{52,64}

Patients also possess a fundamental right to understand how their sensitive health data is collected, processed,

analyzed, and shared, especially when it directly affects their therapeutic pathways and outcomes.^{62,65} Beyond algorithmic clarity, transparency must extend to the provenance and quality of the data itself; inconsistencies in sensor accuracy across various devices, variations in user adherence to data input protocols, and the inherent potential for biased data collection can compromise the reliability and validity of the information, leading to erroneous clinical conclusions or inappropriate interventions for AF risk factors.^{60,66} Without stringent validation against established clinical standards and clear documentation of data collection methodologies, the utility of this “real-world data” in guiding AF management remains questionable, potentially exacerbating existing health disparities, particularly if biases in data collection or algorithmic design are not identified and mitigated.⁶⁷

Inter-operability

Digital health technologies for AF frequently operate in isolated silos, meaning data generated by a patient’s smartwatch or home blood pressure monitor may not seamlessly integrate with their EHR system, or information from a remote cardiac rhythm monitor might not be easily accessible to different specialists involved in the patient’s AF management journey.⁶⁸ This pervasive lack of seamless data exchange results in several detrimental consequences: clinicians may struggle to compile a holistic view of a patient’s health, potentially missing critical trends in AF symptom burden or the progression of associated risk factors; health care staff often resort to time-consuming and error-prone manual data entry, diverting valuable resources from direct patient care; delays in accessing real-time or comprehensive data can hinder interventions for AF risk factor modification, such as timely medication adjustments or the initiation of lifestyle counseling; and fragmented data significantly impedes large-scale research efforts necessary for advancing AF epidemiology, assessing treatment effectiveness, and developing truly personalized medicine approaches.^{51,69} Achieving true inter-operability necessitates the development and widespread adoption of standardized data formats, common data models, and open application programming interfaces to facilitate secure and efficient information exchange across diverse platforms and health care systems.^{60,61}

Regulatory

Regulatory considerations represent a critical and rapidly evolving domain that struggles to keep pace with the swift advancements in digital health technologies for AF. Regulatory bodies, such as the Food and Drug Administration in the US and the European Medicines Agency, classify certain digital health tools as “Software as a Medical Device” if they are intended for ≥ 1 medical purposes without being part of medical device hardware.^{70,71} This classification imposes rigorous requirements for pre-market review, robust quality management systems, and continuous post-market surveillance to ensure safety and effectiveness. However, the

distinction between a “wellness app” that merely tracks activity and a “medical device” that provides diagnostic insights for AF can be ambiguous, leading to inconsistencies in regulatory oversight and potential gaps in patient protection.^{20,27} The unique characteristics of AI/machine learning-driven algorithms, particularly their capacity for continuous learning and adaptation post-deployment, pose unprecedented challenges for traditional regulatory approval pathways, as their behavior and performance may evolve over time, necessitating new approaches to validation and monitoring.⁶⁵

Cybersecurity and data privacy

Ensuring the cybersecurity and data privacy of sensitive patient information transmitted and stored by digital health tools is a paramount regulatory concern, requiring strict adherence to established frameworks like Health Insurance Portability and Accountability Act in the US and General Data Protection Regulation in Europe, alongside the implementation of advanced cybersecurity measures to protect against breaches and misuse.⁶² Ultimately, regulators demand robust clinical evidence demonstrating that digital health tools for AF not only perform technically well but also genuinely improve clinical outcomes, or effectively facilitate risk factor modification in real-world settings, a level of validation that can be complex and resource-intensive.⁷² Harmonization of these diverse regulatory approaches across international jurisdictions is also crucial to foster innovation while maintaining patient safety on a global scale.⁷³ Addressing these multifaceted issues of data transparency, inter-operability, and regulatory oversight is not merely a technical or legal exercise, but a fundamental imperative to build trust, ensure equitable access, and realize the full, transformative potential of digital health in improving outcomes for patients with AF.

Call for future research and policy advancements

Despite the promise outlined in the preceding sections, significant evidence gaps and implementation barriers must be addressed before digital health tools can meaningfully impact LRFM in AF. Later, and in Table 2, we outline priority research and policy development, organized by domain.

Clinical evidence gaps

The mAFA study demonstrated the benefit of a comprehensive digital health intervention, including LRFM, to reduce a clinically important outcome (composite of stroke, thromboembolism, all-cause death, and rehospitalization) in patients with AF.²² However, most LRFM focused studies to date remain small or feasibility-focused, highlighting the need for large-scale studies focused on LRFM powered for health outcomes in patients with existing AF, such as the mTECH-Afib 2.³⁰ A variety of components have been included in the digital interventions developed and tested to date. Future large-scale studies should include pragmatic comparative effectiveness assessments of these components to

Table 2 Research and policy priorities for digital health enabled lifestyle and risk factor modification in atrial fibrillation

Domain	Specific research and policy needs
Clinical evidence gaps	• Long-term outcomes (atrial fibrillation recurrence, atrial fibrillation burden, stroke, hospitalizations, and mortality) • Atrial fibrillation incidence and delay of onset • Comparative effectiveness of components
Implementation science priorities	• Program duration and maintenance • Evaluation of advanced artificial intelligence tools for health coaching • Determining intensity (titration) of human vs digital intervention required for specific patients • Co-design with patients and clinicians • Workflow at level of health system and role of primary care, cardiology, or electrophysiology
Technology and data infrastructure needs	• Ingestion of patient-generated health data into clinical workflows • Optimal data presentation formats for both patients and clinicians • Artificial intelligence and machine learning development for surfacing clinically actionable data
Addressing health equity	• Bridging technology and health literacy gaps • Technology access programs for underserved populations • Culturally adapted interventions and engaging local communities • Trust-building and privacy protection
Policy and reimbursement research	• Important health outcome-focused and cost-effectiveness studies • Advocacy for payor reimbursement of digital lifestyle and risk factor modification interventions • Policy support for patient financial assistance to obtain monitoring technologies • International and regional adaptation strategies

determine which components provide the most impact for which patients. These components must also be tested against proven in-person approaches when possible. Major hurdles would be to demonstrate that these digital interven-

tions provide effective LRFM and favorable AF outcomes similar to those seen with in-person programs and are acceptable to both patients and clinicians facilitating implementation of guideline recommendations to practice.

Finally, many ambulatory care patients without AF have conditions that place them at risk of AF (ie, hypertension, diabetes, sleep apnea, obesity) that are also frequently monitored with digital devices. Given the increasing number of patients who may possess digital tools to both manage their chronic risk factors and monitor their rhythm, it may also be feasible to perform large-scale pragmatic studies to determine whether aggressive LRFM can either reduce the incidence or delay onset of AF.

Implementation science priorities

An important area of heterogeneity across studies is the duration of intervention. Currently, the duration of intervention across published studies ranges from 30 days to 6 months, with follow-up typically limited to duration of intervention (Table 1^{15–29}). Evidence-based models used in cardiac rehabilitation for coronary artery disease and heart failure, which share many risk factors with AF, leverage 12-week RFM programs.⁷⁴ Based on this evidence, perhaps a 12-week program duration with some form of maintenance engagement is the most optimal approach for the active phase of the intervention. This should be tested in future studies with longer-term follow-up included to determine if gains observed during the intervention are maintained over time.

Several studies to date have demonstrated the benefit of health coaching. Given the growing burden of AF, it may be difficult for any intervention to sustain health coaching at scale. Studies have assessed conversational agents to support self-management but have struggled to dynamically personalize content to individual needs.³¹ As large language models improve, they may provide that increased personalization. Conversational agents driven by advanced large language models must be tested and compared with human coaching.⁷⁵ It is likely that there will be variation in how much human support a particular patient requires. Therefore, future studies also need to test hybrid models that titrate human support based on need, allowing for less frequent but strategically timed, personalized human interaction.

Additionally, program design itself appears to influence engagement, especially when guided by patients and clinicians. For example, the mTECH-Afib program was developed by input from patients through a human-centered design process where patients, their caregivers, and clinicians informed the content of the program.⁷⁶ Future interventions should continue to be co-designed with patients to promote relevance and sustainable engagement. Finally, co-design also extends to including care teams from other disciplines, as emphasized in the most recent European guidelines that illustrate the multidisciplinary nature of integrated AF care.⁶ Digital workflows must reflect this multidisciplinary care and be integrated into workflows across those disciplines if possible.

Technology and data infrastructure needs

As described previously, LRFM requires comprehensive programs, ideally integrating smart devices and apps, clinician dashboard, and health coaching. Data on dynamic (ie, alcohol use, smoking, physical inactivity, obesity) and static (hypertension, sleep apnea) AF risk factors guiding LRFM can be tracked by various smartphone apps and smart devices that generate their own summaries and have no means for EHR integration other than patient-submitted summaries of data. It will be important to evaluate methods to ingest that patient-generated health data and incorporate it into clinical workflows.⁷⁷

Once made available to clinical systems, there is therefore a pressing need to study and validate comprehensive programs that can provide summaries or dashboards that can combine data from multiple types of digital monitoring devices and apps and integrate it into the EHR, either through home-grown mechanisms or third-party software. These programs can be integrated into comprehensive AF management clinics where data are presented via clinician dashboards. Patient-facing dashboards that allow them to receive tailored education, communicate shared goals with their clinical team, and track their own progress require development and testing. Once available to health systems, AI and machine learning that surface clinically actionable data and support clinical care must be developed and tested to determine if these models affect outcomes.

Addressing health equity

The promise of digital health for health equity and accessibility hinges on diligently addressing the persistent digital divide. Disparities in access to reliable internet, affordable smartphones or devices, and foundational digital literacy skills can inadvertently exacerbate existing health inequities.⁷⁸ In addition, AF demographics are well known, and AF risk increases with age.⁴ Some studies show that older individuals are less likely to use technology and have poor technology literacy, which can limit technology use.^{79,80} In contrast, other studies demonstrate successful use of technology among elderly individuals.^{81,82} This discrepancy is likely because of patient selection. It is indeed challenging for some older patients to adopt technology, which contributes to the digital divide.

When deploying digital health tools, systems must study methods to ensure high-fidelity uptake regardless of the baseline digital literacy possessed by a patient. To minimize the impact of technology access and literacy at the program design and clinical trial stage, researchers should provide technology and technology onboarding based on an individual's technology literacy level. Programs should also offer accessible "tech" support throughout the program and make data plans available for reliable internet access. These programs should be designed together with patients and other key parties (eg, clinicians and health partners) to incor-

porate preferences of individuals from diverse backgrounds and individual needs into account and design intuitive and accessible interfaces. Concerted efforts by governments, professional societies, insurance companies, community partners, and health systems are also required to support access to technologies and internet for low-income populations.⁷⁸ The efforts should be tested pragmatically to ensure equitable deployment of digital health tools to support AF care.

Crucially, building and maintaining patient trust in these technologies, especially concerning data privacy and security, is paramount, as distrust can disproportionately affect vulnerable populations and undermine the effectiveness of digital interventions.^{62,65,83} By proactively tackling these challenges, digital health technologies can fulfill their potential as powerful means for equitable and accessible AF risk factor modification.^{83,84}

Policy and reimbursement research

Demonstrating the positive outcome on health outcomes and cost-effectiveness of digital health interventions to support LRFM in AF care will provide critical data to support policy change and reimbursement. Capitated payment schemes have been suggested to support digital health adoption in longitudinal cardiovascular care.⁸⁵ Future trials must show that the digital interventions provide a balance of cost and clinical efficacy that are comparable to in-person delivery of services if in-person LRFM programs are available. If no in-person equivalent exists (which is true for many geographic areas), the outcomes studies proposed in Section 6.1 could be pivotal in supporting efforts for reimbursement.

Important health outcome-focused and cost-effectiveness trials should be supported by professional societies and digital technology companies, as results could justify reimbursement for digital health technologies. Once proven, to facilitate uptake of digital health tools, advocacy from professional societies and patient groups will be necessary for payors to reimburse for digital LRFM and potentially provide patient financial support to obtain monitoring technologies. Relevant billing modalities already exist (eg, for RPM or cardiac rehabilitation), but a concerted effort will be necessary to broaden their use to the management of AF.

In addition, patients with stage 1 or 2 AF who have a high burden of modifiable risk factors now have multiple consumer pre-diagnostics that can identify AF.⁸⁶ However, no studies have yet demonstrated a reduction in AF-related morbidity or mortality because of AF pre-diagnoses, and demonstrating such an effect would be critical in redefining policy and reimbursement efforts around AF screening and prevention.

Finally, as interventions are developed, researchers should consider how policy differences between nations or regions within a nation may affect implementation of those interventions and consider international studies of those interventions to support generalizability.

Conclusion

LRFM is an established pillar in AF management, but its implementation in practice is limited. Digital health tools offer a transformative pathway to bridge this gap. Mobile apps and smart wearable and non-wearable devices, along with virtual coaching, are enabling personalized and scalable LRFM strategies that can empower patients to engage in sustained behavior changes. Progress is already underway, with several AF-specific digital health interventions demonstrating feasibility and impact and ongoing randomized trials further evaluating their effectiveness and scalability.

The future of LRFM implementation lies in continuing to build and research digital ecosystems that are dynamic, inclusive, equitable, and patient-centered. In parallel, addressing inter-operability, EHR integration, and reimbursement will be critical to ensure that digital health-enabled LRFM becomes a standard and sustainable component of comprehensive AF care.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT and Claude in order to support grammar and clarity during the drafting of this manuscript. All substantive content, analysis, and conclusions were generated and verified by the authors.

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Appendix Supplementary data

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Appendix 1 Writing committee member disclosure of relationships with industry and other entities

Writing committee member	Employment	Honoraria/speaking/ consulting	Speakers' bureau	Research*	Fellowship support*	Ownership/ partnership/ principal/ majority stockholder	Stock or stock options	Intellectual property/ royalties	Other
Nino Isakadze, MD, MHS (Chair)	None	Boston Scientific	None	Apple, Inc; Corrie Health; PhRMA Foundation; Zoll/ Itamar Medical	None	None	None	None	None
Matt Kalscheur, MD (Vice Chair)	None	None	None	GE Healthcare	None	None	None	None	None
Jason G. Andrade, MD, FHRS	None	None	None	None	None	None	None	None	None
Antonis A. Armoundas, PhD, FHRS ¹	None	None	None	None	None	None	None	None	American Heart Association, Institute of Precision Medicine, RICBAC Foundation, National Institutes of Health
Tina Baykaner, MD, MPH	None	Abbott Medical; Biotronik; Boston Scientific; Johnson & Johnson; Medtronic, Inc.; PaceMate; Volta Medical	None	National Institutes of Health, Jannsen	None	None	None	None	None
Michael Cutler, DO, PhD, FHRS	None	Boston Scientific; Johnson & Johnson	None	None	None	None	None	None	None
Peem Lorvidhaya, MD, FHRS	None	None	None	None	None	None	None	None	None
Peter A. Noseworthy, MD, FHRS	None	Optum	None	National Institutes of Health; National Institute on Aging; Agency for Healthcare Research and Quality; U.S. Food & Drug Administration; American Heart Association, Medtronic, inc.	None	None	None	AliveCor, Anumana	None
Rod Passman, MD, FHRS	None	Abbott Medical; Boston Scientific; CoreMap; Johnson & Johnson; Medtronic, Inc.	None	American Heart Association; National Institutes of Health	None	None	None	UpToDate	None

Krishna Pundi, MD, FHRs	None	Evidently; iRhythm Technologies	None	American College of Cardiology; American Heart Association	None	None	None	None	None
Prashanthan Sanders, MBBS, PhD, FHRS	None	Metronic, Inc.; Abbott Medical, Boston Scientific, Pacemate, CathRX	None	Medtronic, Inc.; Abbott Medical; Boston Scientific, Becton Dickinson	None	None	None	None	National Health and Medical Research Council or Australia

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Appendix 2 Reviewer disclosure of relationships with industry and other entities

Peer Reviewer	Employment	Honoraria/ speaking/ consulting	Speakers' bureau	Research*	Fellowship support*	Ownership/ partnership/ principal/ majority stockholder	Stock or stock options	Intellectual property/ royalties	Other
Natalia A. Trayonova, PhD, FHRS	None	Catheter Precision; Mediasphere Medical; Medical Device Business Services; Medtronic, Inc.; Volta Medical	None	National Institutes of Health	None	None	None	None	None

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