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REVIEW

Experiences of health professionals towards using mobile electrocardiogram (ECG) technology: A qualitative systematic review

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Abstract

Objectives: To identify and explore the experiences of health professionals towards using mobile electrocardiogram (ECG) technology.

Introduction: Mobile technology is increasingly being incorporated into healthcare systems, and when implemented well, has the potential to revolutionise the way in which care is delivered. The uptake of mobile ECG technology enables health professionals to record and transmit ECGs electronically, at the point of care. It is important to explore both the impact of this technology and staff experiences to help understand how readily it is accepted and how effectively it is used in practice. There is a paucity of knowledge and understanding from primary healthcare providers and a lack of qualitative evidence offering insight into the monitoring and use of mobile ECG technology. Therefore, this review adds to the available body of knowledge by giving insight from the perspectives of health professionals on its use.

Methods: TRIP, CINAHL, MEDLINE, Scopus and sources of grey literature were searched for eligible studies. Databases were searched from their inception dates, with a restriction on studies written in English. The results of the search are presented in a PRISMA flow diagram. Two reviewers independently screened studies and assessed methodological quality in accordance with JBI methodology for systematic reviews of qualitative evidence. Data were extracted from the included studies and meta-aggregation methodology adopted to identify categories and create synthesised findings related to the healthcare professionals' experiences.

Results: A total of six studies were included, which resulted in 18 findings and five categories. Three synthesised findings were generated: Quick, easy and feasible in both urban and remote settings; Increased accessibility of AF screening opportunities for all; Enhanced support in staff resources, time and technology are required. The

level of confidence of synthesised findings varied from low to moderate according to ConQual.

Conclusions: This systematic review synthesised the experiences of healthcare professionals using mobile ECG technology. The methodological quality of the included studies was high, and findings indicated healthcare professionals (HCPs) generally found mobile ECG technology simple, quick, easy to use and non-invasive. Enablers regarding mobile ECG technology were time, workload, and remuneration for improved interoperability with current systems and sustainability for screening long term. Data on the experiences of HCPs came from studies capturing mainly proactive, lower-risk patients; therefore, this review was unable to demonstrate if there are any differences between the experiences of HCPs working in primary care settings, such as GP practices/pharmacies, and those working remotely in the community. This highlights a gap in provision for those patients requiring HCPs to record an ECG in their own home.

Relevance to Clinical Practice:

- The experiences of HCPs towards using Mobile ECG technology in practice is quick, easy and feasible in both urban and remote settings.
- HCPs and organisations should consider identifying key staff as "change champions" and use change/leadership models to support the integration (with current workflows), transformation, and evaluation of mobile ECG technology in their practice setting.
- HCPs and providers using mobile ECG technology should ensure it prioritises at-risk individuals and includes the "housebound" population.

KEYWORDS
atrial fibrillation, community, ECG, electrocardiogram, experiences, healthcare professionals, mobile applications, mobile technology, qualitative research

1 | INTRODUCTION

Given the rise in aging populations and their use of health services, facilitating healthcare providers to deliver cost-effective healthcare for both staff and service users is crucial (Cheung et al., 2018). Technology is continually evolving and giving rise to new possibilities including the potential to enhance primary and secondary disease prevention and deliver interventions that are personalised, adaptive, and sustainable. Mobile technology use is also increasing and appears to be impacting positively on healthcare research, healthcare delivery and health outcomes (Hamilton et al., 2018). The uptake of proven, affordable innovations in digital technology, including digitalising community services and deploying technology to support healthcare staff, is specifically highlighted in current and future UK policy and strategy such as the NHS Long Term Plan (NHS Long Term Plan, 2019).

Positive trends in using and deploying mobile technology across various environmental settings and populations are making it increasingly feasible for healthcare professionals, throughout the world, to better manage the care of people with long-term conditions (The Queens Nursing Institute, 2018). This includes an increase in the demand for services providing remote care, such as wireless technology and digital health, enabling care to be more person-centered when and where it is needed, which improves coordination of care and effective exchange of information (NHS Long Term Plan, 2019).

Electrocardiography is the process of producing an ECG, a recording of the heart's electrical activity. Conventional 12-lead ECG machines have practical limitations to use in community and remote geographical settings due to their bulky size and lack of portability (Walker & Muhlestein, 2018). Mobile ECG technology consists of a device and application enabling the recording and review of ECGs anywhere, anytime, having a positive impact on accessibility at the point of care. Registered health professionals from a variety of disciplines are increasingly using mobile ECG technology, the greatest benefits being demonstrated in contexts where time efficiency and clinical decision making are crucial (Wong et al., 2021).

Following literature searches, it became evident there is a growing body of evidence related to the use of mobile technology for the detection of cardiac arrhythmias, in particular Atrial Fibrillation (AF). AF is the most common heart rhythm disturbance, it causes an irregular, fast heart rate, is commonly asymptomatic

and can also be paroxysmal, which can make detection a challenge (NICE, 2021). It has a significant impact on morbidity and mortality and is a major cause of stroke (ESC, 2020). While a considerable amount of literature has been established on the importance of AF detection and the risk of AF-related strokes (ESC, 2020; NICE, 2021), evidence including the experiences of HCPs using mobile ECG technology in all settings to help inform future innovation spread and research is limited.

There may be comfort and familiarity of staff using existing non-mobile ECG technology within hospital settings, however, the simplicity of mobile ECG technologies has been shown to increase health professionals' motivation, comprehension, and self-efficacy in relation to AF screening (Wong et al., 2021). Importance was placed on the availability of staff, training, motivation, support tools integrated with current practice software systems to inform the doctor/prescriber of the ECG result and provide best practice AF management recommendations. The provision of health services outside of hospitals, using wireless technologies, is occurring and has the potential to reduce the workloads of healthcare providers (Farahani et al., 2018). However, the wider adoption of mobile technology does not necessarily reflect user uptake of such innovations. In terms of user readiness for technological developments, understanding health professionals' views on the impact of technology on the future of healthcare systems is vital. Further evidence suggests enablers for the use of mobile ECG technology include confidence, independence, ease of training and an understanding of the relevance of screening for disorders such as AF (Mehta et al., 2015). Studies such as this, indicate the experiences and attitudes of staff towards new technologies influence how readily they are accepted and how effectively they are used in practice.

There are a variety of wearables, devices and applications marketed directly at detecting AF, however, the role, management, and experiences from the perspective of the HCP are not defined. A preliminary search of the literature for the study protocol revealed 1068 studies, this informed the full search strategy which revealed 2912 studies that potentially explored experiences of using mobile technology within a variety of settings. The evidence identifies a diverse range of mobile ECG technologies and provides useful qualitative data; however, it is important to synthesise these and explore gaps in knowledge to inform education and training for health professionals currently, or potentially utilising mobile ECG technology in the future.

1.1 | Objective

To identify and explore the experiences of health professionals towards using mobile electrocardiogram (ECG) technology.

2 | METHODS

To provide a comprehensive, unbiased synthesis of the existing knowledge, this systematic review was conducted in accordance with JBI methodology for systematic reviews of qualitative evidence (Munn et al., 2019). The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) checklist (Appendix S1) was used to plan, undertake and report this systematic review and it was registered with the International Prospective Register of Systematic Reviews (PROSPERO 2019 CRD42021243038).

2.1 | Inclusion and exclusion criteria

When devising the inclusion and exclusion criteria presented in Table 1, the PICo mnemonic for qualitative research was used to support and structure the question. The core elements of PICo are outlined below and include; P *participants*; I *phenomenon of Interest*, and Co indicates the *context* (Aromataris & Munn, 2020).

2.2 | Participants

This review considered studies including the experiences and attitudes of health professionals that operate in a patient facing capacity and are registered with a regulatory body. These include doctors, nurses, pharmacists, midwives, paramedics, electrophysiologists and technical officers.

2.3 | Phenomenon of interest

Studies were considered for inclusion if they focused on the experiences of HCPs towards the use of mobile ECG technology. The term “Mobile ECG technology" refers to wireless ambulatory electrocardiography with recording devices using wireless technology such as

TABLE 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• English Language • Studies conducted in any location, in any healthcare setting, internationally • Experiences of health professionals operating in a patient facing capacity • Studies including mobile ECG technology use • Qualitative and mixed-methods studies	• Quantitative Studies • Focus of study not on experiences of health professionals • Not published in English language • Not focused on mobile ECG technology

applications utilising smartphones, laptops, tablets and other mobile, portable devices to record ECGs at the point of care.

2.4 | Context

This review considered studies conducted in any cultural or geographical context, involving healthcare settings from any location, internationally, to reduce bias. However, any differences in HCPs experiences of using mobile ECG technology specifically related to the healthcare setting (i.e. hospital or community based) were noted and explored where appropriate.

2.5 | Types of studies

The focus of this review is on qualitative research; however, mixed-methods research were included, broadening the search to capture all relevant reviews (Aromataris & Munn, 2020). These studies were included only where qualitative results were reported separately; the quantitative findings from these studies were not included. Due to limited resources, studies published in languages other than English were unable to be translated and included in this review.

2.6 | Search strategy

Studies published from database inception dates to the present were included, as no clear date limit applies to the research question. All potential studies underwent a screening process based on the inclusion, exclusion criteria and PICo (Aromataris & Munn, 2020). This maintains focus, preventing bias from selection of studies as the criteria are defined before the literature search, and before including/excluding studies (Hornberger & Rangu, 2020). The search strategy used a combination of text words and subject headings combined with Boolean operators, an example of this is outlined in Table 2.

The search strategy aimed to find both published and unpublished studies and a three-step search strategy was utilised in this review (Aromataris & Munn, 2020). An initial search of MEDLINE was undertaken followed by analysis of the text words contained in the title, abstract, and of the index terms used to describe an article. A second search using all identified keywords and index terms was undertaken across all included databases, with a qualified librarian specialised in systematic reviews. The librarian matched the keywords, search terms and results to the review objective. This approach provides a systematic way of searching each database, minimising the impact of the researcher on the outcome of the search and enhances trustworthiness of the review findings. Third, the reference lists of all studies selected for critical appraisal were screened for additional studies.

TABLE 2 Search strategy

Search string; Medline (Ovid)
1. (ECG).ti,ab
2. (electrocardiograph* OR electrocardiogram*).ti,ab
3. exp ELECTROCARDIOGRAPHY/
4. (1 OR 2 OR 3)
5. (mobile*).ti,ab
6. (app OR apps).ti,ab
7. (smartphone* OR "i-phone*" OR "cellular phone*" OR cellphone* OR "cell phone*" OR android).ti,ab
8. "MOBILE APPLICATIONS"/ OR exp "COMPUTERS, PORTABLE"/ exp
9. exp "CELLULAR PHONE"/
10. (handheld OR "hand held").ti,ab
11. (portable).ti,ab
12. "HOME DIAGNOSTIC TESTS"/
13. (5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12)
14. (4 AND 13)
15. ("health professional*" OR "healthcare professional*" OR "health care professional*").ti,ab
16. ("healthcare provider*" OR "health care provider*").ti,ab
17. (clinician* OR doctor* OR physician*).ti,ab
18. ("general practitioner*").ti,ab
19. (nurse*).ti,ab
20. (pharmacist*).ti,ab
21. (technician* OR electrophysiologist* OR "cardiac scientist*" OR cardiologist*).ti,ab
22. ("medical assistant*" OR "healthcare assistant*" OR "health care assistant*" OR "assistant practitioner*").ti,ab
23. ("allied health professional*" OR therapist* OR midwife OR midwives OR paramedic*).ti,ab
24. exp "HEALTH PERSONNEL"/
25. (15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24)
26. (4 AND 13 AND 25)

2.7 | Information sources

The following databases were searched in July 2021: TRIP, CINAHL (via EBSCO), EMCARE (via ELSEVIER), MEDLINE (via OVID), Scopus (via ELSEVIER), PsychINFO (via EBSCO) and EMBASE (via ELSEVIER). These academic databases were considered sufficiently comprehensive to address the topic and discipline for this review. Sources searched for unpublished studies and grey literature included EthOS, OpenGrey, ProQuest (dissertations and theses), websites (Google Scholar, Web of Science NICE, NHS England), published conference proceedings, briefings and government reports.

2.8 | Study selection

Following the search, all identified citations were collated and uploaded into Rayyan (Qatar Computing Research Institute, Doha, Qatar) and duplicates removed. Titles and abstracts were screened by two reviewers independently for assessment against the inclusion criteria for the review. Potentially relevant studies were retrieved in full and imported into the Joanna Briggs Institute (JBI) System for the

Unified Management, Assessment and Review of Information (Munn et al., 2019). Full-text studies that did not meet the inclusion criteria were excluded; reasons for their exclusion are provided in Figure 1, Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) flow diagram (Page et al., 2021).

2.9 | Assessment of methodological quality

Eligible studies were critically appraised for methodological quality by two reviewers independently using the standard JBI Critical Appraisal Checklist for Qualitative Research (Lockwood et al., 2015). Authors of papers were contacted to request missing or additional data for clarification if required. All studies, regardless of the results of their methodological quality, were included for data extraction and synthesis. The critical appraisal focused mainly on the following aspects: study methodology and method; data collection and analysis; and possible influence of the researcher on the study, ethics, participants' voices and conclusion.

2.10 | Data extraction

Qualitative data were extracted from studies included in the review by two reviewers using the standardised JBI data extraction tool (Lockwood et al., 2015). Data extracted included specific details such as the methodology, method for data collection and analysis, phenomena of interest (i.e. use of mobile ECG technology), research setting, geographical and cultural context, data on participants, and authors study conclusions. Data extraction was performed by one reviewer and checked by a second.

2.11 | Data synthesis

Qualitative research findings were aggregated using the meta-aggregation methodology of JBI (Aromataris & Munn, 2020; Lockwood et al., 2015) to identify categories and amalgamate existing qualitative findings on the HCPs experiences of using mobile ECG technology. This involved a comprehensive, exhaustive search and independent critical appraisal including standardised data extraction (Aromataris & Munn, 2020). The extracted findings were then rated according to their level of credibility, that is, unequivocal, credible, not supported (Munn et al., 2014). Unequivocal (U) relates to evidence beyond reasonable doubt, which may include findings that are matter of fact, directly reported/observed, and not open to challenge. Credible (C) findings are plausible in light of data and theoretical framework, although they are derived from the authors' interpretations. They can be logically inferred from the data, however, because the findings are interpretive, they can

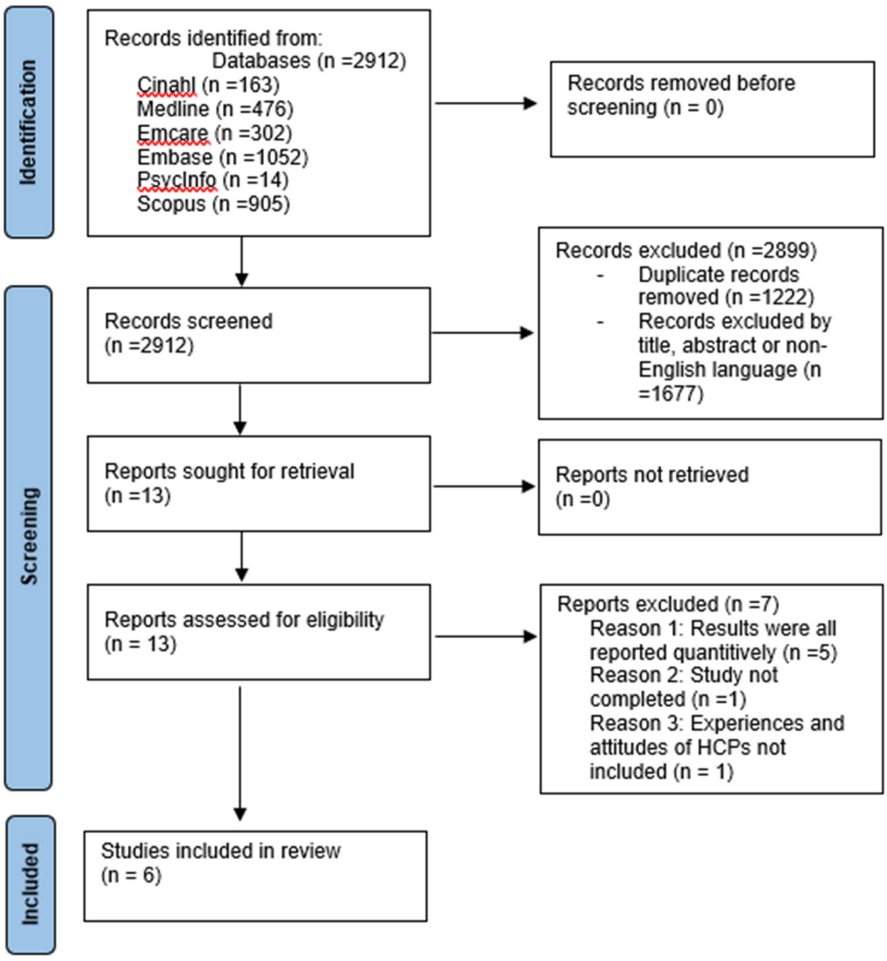

FIGURE 1 Preferred reporting items for systematic reviews and meta-analysis (PRISMA) flow diagram

be challenged. Not supported (NS) relates to findings unsupported by the data, where there is no congruity between the research methodology and the research question, objectives or methods used (Munn et al., 2014). The rated findings were categorised based on similarity in meaning of ideas or concepts. Two reviewers performed the data synthesis and each reviewer individually read the initial 20 findings to determine their credibility compared to the verbatim illustrations. The reviewers subsequently discussed the credibility of the findings and based on the discussion; the reviewers reached a consensus for each finding, then grouped the unequivocal and credible findings into categories. These categories were then subject to a meta-aggregation to produce a single comprehensive set of synthesised findings that form recommendations to guide HCPs and policy makers (Aromataris & Munn, 2020).

2.12 | Assessing confidence in the findings

The final synthesised findings were appraised and graded according to the ConQual approach (Munn et al., 2014) using the scores generated from the JBI Critical Appraisal Checklist for Qualitative Research (Lockwood et al., 2015), and assigned a level of credibility and dependability. The ConQual Summary of Findings includes the major elements of the review and details how the ConQual score was developed. Each synthesised finding from the review is presented, along with the type of research informing it, scores for dependability and credibility, and the overall ConQual score. Credibility evaluates whether there is congruency between the author's interpretation and the original source data. Dependability is related to the consistency of findings and is established if the research process is logical (i.e. the methods are suitable to answer the research question and are in line with the chosen methodology), traceable and clearly documented (Moher et al., 2009). The level of confidence provides the assessment of evidence produced from qualitative systematic reviews.

3 | RESULTS

3.1 | Study Inclusion

The results of the search are presented in Figure 1 in a Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) flow diagram (Page et al., 2021). The results of the database searches were imported to Rayyan for title and abstract screening, then studies were retrieved for full-text review. A total of 2912 papers were identified through electronic databases. After 1222 duplicates were removed and 1677 studies excluded, 13 full-text studies were included for eligibility assessment based on the inclusion criteria (e.g. participants, context, phenomena of interest, type of studies). After study selection and critical appraisal, six were included, four were qualitative studies (Lowres et al., 2015; Orchard et al., 2014; Orchard et al., 2016; Savickas et al., 2020) and two were mixed methods, (Gibson et al., 2017; Macniven et al., 2019), with qualitative results reported separately allowing for inclusion. As the phenomenon of interest was on the HCPs' perspective, only primary sources with HCPs voices adequately represented were selected.

3.2 | Methodological Quality

The included studies were assessed and found to be of low to high methodological quality with scores of 9/10 and 6/10 based on the ten questions of the JBI critical appraisal tool (Munn et al., 2014) and can be seen in Table 3. The aims, objectives and data collection method were congruent with a qualitative study design; thus, the reviewers could infer the qualitative nature of the design and respond affirmatively to Q1, Q2, Q3, Q4 and Q5. Aside from Q6 concerning the researcher's cultural or theoretical background and Q7 concerning the influence of the researcher on the research, and vice-versa, the authors of the included studies responded adequately to the remaining questions. Further information was requested from one study (Gibson et al., 2017) to gain clarity on questions 9 and 10; however, this was not available at the time of collating the results. All the included studies responded to Q8 concerning the illustration of the participant's voice, which was an eliminatory question.

3.3 | Characteristics of Included Studies

The majority of the studies were undertaken within healthcare settings such as General Practitioner (GP) practices and pharmacies; however, one study included some experiences of HCPs working in urban, regional and remote areas (Macniven et al., 2019). The participants were adult healthcare professionals in all studies, with the inclusion of out-patients aged over 65 years in two of the studies;

TABLE 3 Critical appraisal results for included studies using the JBI-qualitative critical appraisal checklist (Munn et al., 2014)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Gibson et al. (2017)	Y	Y	Y	Y	Y	N	N	Y	U	U
Lowres et al. (2015)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Macniven et al. (2019)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Orchard et al. (2014)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Orchard et al. (2016)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Savickas et al. (2020)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y

Abbreviations: N, no; U, unclear; Y, yes;

however, for the purposes of this review, the HCP experience is the focus; the patient experience would require further research. The most represented country in this review was Australia (Lowres et al., 2015; Macniven et al., 2019; Orchard et al., 2014; Orchard et al., 2016); the remaining two studies were undertaken in the UK (Gibson et al., 2017; Savickas et al., 2020). The characteristics of the six included studies are outlined in Table 4.

3.4 | Review Findings

Only one study included some experiences of HCPs working in urban, regional and remote areas (Macniven et al., 2019) so the transferability of the findings to HCPs working in either acute hospital settings or remote areas may be limited. From the six qualitative primary research studies included in the review, 20 findings were extracted, with an equal amount of these findings graded as "unequivocal" ($n = 9$) and "credible" ($n = 9$). Two were graded as "not supported"; therefore, these were not included in the meta-aggregation because these findings were unsupported by the data. The "not supported" findings were as follows: "pharmacists had faith in the device and felt it more reliable than pulse palpation" p. 6 (Savickas et al., 2020) and "combined AF screening with other pharmacist health checks increased time efficiency and customer satisfaction"p. 1117 (Lowres et al., 2015). Once retained, the 18 findings were grouped into categories based on their similarity in meaning, ideas or concepts of the findings generated by the healthcare professionals' illustrations.

3.5 | Categories and Synthesised Findings

The findings were grouped into five categories, they include "potential for developing future use with an increase in staff understanding", "positive experiences of using the technology in practice", "not enough time or resources", "prioritising people at highest risk of having AF" and "negative experiences of poor internet connections". These five categories were then aggregated to produce three synthesised findings. To constitute a synthesised finding, categories had to have similar meaning or illustrate a similar concept or idea (Aromataris & Munn, 2020). The three synthesised findings are as follows: "enhanced support in staff time, resources and technology are required", "quick, easy and feasible in both urban and remote settings", and "increased accessibility of AF screening opportunities for all". A summary of the five categories with an example illustration for each rated finding is presented in Table 5.

The full Meta-Aggregative Flowchart is outlined in Figure 2 (Part 1 and 2).

Synthesised Finding 1: Enhanced support in staff time, resources and technology are required to make future use and spread a success.

This synthesised finding was derived from 11 findings, merged into three categories. These findings and categories were similar in the ways the HCP described the facilitating and inhibiting factors to the use of mobile ECG technology. HCPs experiences related to the use of the mobile ECG technology varied to some extent according to the setting; however, all recognised the importance of time for planning and integration with current workflow.

"Workflow can be improved in future by automatic importation of the ECG recording and the rhythm diagnosis into the patient's electronic medical file." p. 317 (Orchard et al., 2014).

Another facilitator to long-term sustainability suggested by HCPs was to integrate AF screening routinely with other standard adult health checks such as cardiovascular disease reviews.

"We really liked this because we can make this part of their adult health check, I can include the iECG in the regular routine with Blood Pressure ect." p. 4 (Macniven et al., 2019).

To support this, remuneration for additional resources to maximise uptake and sustainability of the technology was mentioned as key to future success.

"Screening could be added to the list of professional services that we'd be paid for, possibly, if the government wanted to help people prevent strokes. And I think there's a large push from the general population for the government to invest in that". p. 1116 (Lowres et al., 2015).

The differences between the barriers for a GP practice setting and rural/remote community were mainly related to variable internet connections and follow-up times for abnormal readings. An abnormal reading needs to be sent from the mobile device to a secure server to then be uploaded and integrated into the patients' health record for review. This can be problematic if the HCP is working remotely.

"Internet coverage is very slow for us, staff don't always have email, we shouldn't have to be faced with this stuff. I could personally see that if the ECG was ok but if I couldn't upload it to Dr in town I would have to have a back up plan." p. 4 (Macniven et al., 2019).

Healthcare organisations are complex adaptive systems responding to ever changing environments, when responding to change, having someone within a team to inspire, motivate and influence others was highlighted as an enabler.

"…it was key to have someone (either a GP or practice manager) at the practice to 'champion' the screening programme." p. 18 (Orchard et al., 2016).

Synthesised Finding 2: Quick, easy and feasible in both urban and remote settings.

This synthesised finding was derived from five findings, merged into one category. These findings and categories were similar in the ways the HCP described their experiences of using mobile ECG technology, in general, they expressed confidence and ease with the technology.

"It worked very well, it was quick, results immediately, just so simplified and when you're in outreach and there's only 2 nurses, this sort of technology is good for us, especially when time management is difficult." p. 4 (Macniven et al., 2019).

TABLE 4 Characteristics of included studies

Study reference and year	Type of research	Participants	Phenomenon of interest	Method
Gibson et al. (2017)	Mixed methods	Purposive Sample of 15	Evaluating the uptake and acceptability of introducing opportunistic AF detection using the handheld ECG device "MyDiagnostick" into routine practice in primary care.	Semi-structured interviews with nurses, healthcare assistants, primary care physicians and practice managers from five UK general practices.
Lowres et al. (2015)	Qualitative	Purposive sample of 9	Exploring the experience of implementing an AF screening service in pharmacies using "Alivecor" heart monitor mobile ECG tech. From the pharmacist's perspective.	Semi-structured interviews with pharmacists (from the 10 pharmacies involved with the SEARCH-AF study in Australia).
Macniven et al. (2019)	Mixed Methods	Purposive sample of 18	Screening for AF with a single Lead ECG attached to a smartphone in Aboriginal adults (in both clinic & community setting)	Semi-structured interviews with staff from the urban, regional & remote communities in three Australian states/territories
Orchard et al. (2014)	Qualitative	Purposive sample of 14	iPhone ECG screening using "Alivecor" heart monitor by practice nurses, GPs & receptionists	14 semi-structured interviews with GPs, nurses, receptionists & patients in general practices in Australia.
Orchard et al. (2016)	Qualitative	Convenience sample of 17	Exploring views of handheld smartphone ECG screening using "Alivecor" heart monitor to identify unknown AF	17 Semi-structured interviews with practice nurses, practice managers and GPs at 5 general practices in urban Australia
Savickas et al. (2020)	Qualitative	Convenience Sample of 38	Exploring the perspectives of three stakeholder groups to pharmacist-led AF screening with mobile single lead ECG technology	Six focus groups with general practice staff, clinical pharmacists and patients from four general practices in the UK

In addition, HCPs valued and appreciated the time saving and efficiency of the technology compared with standard practice.

"A very good tool for me as it was a fast way of diagnosis. It sped up the diagnosis procedure and sped up the treatment pathway" (Urban RN) "…Wherever we did it they were happy and it didn't take up too much time." p. 4 (Macniven et al., 2019).

Others noted an initial period of familiarisation to be beneficial and increased the HCP's confidence using the technology with patients and can also therefore be seen as an enabler.

"I found the first few that I did took me a bit longer. Making sure just that I've done the correct thing, that I've set it properly…I was a bit nervous but then after that it became easier. p. 1116 (Lowres et al., 2015).

Synthesised Finding 3: Increased accessibility of AF screening opportunities for all.

This synthesised finding was derived from two findings, merged into one category. These findings and categories were similar in the ways the HCP highlighted the importance of being able to offer accessible AF screening for everyone. Specifically noting the exclusion of those unable to easily access the general practice or pharmacy, or those not readily engaging with routine opportunities for reviews such as flu vaccines.

"Obviously, you're missing all the housebound patients as well because we don't go to search in care homes, there's going to be actually quite a few in care homes." p. 7 (Savickas et al., 2020).

"People who don't attend the flu vaccine are probably ones who are more at risk because they're not looking after their health". p. 5 (Savickas et al., 2020).

The confidence of the synthesised findings was low to moderate based on the ConQual approach (Munn et al., 2014). Despite a low to moderate ConQual grade, as presented in Table 6, the findings of this qualitative systematic review included studies of high-to-moderate methodological quality.

4 | DISCUSSION

A scoping review had been undertaken (Marston et al., 2019) to explore trends of mobile ECG technology and acknowledge its growing popularity. The included studies focused on the varying rationales for and cost effectiveness of using mobile ECG technology. Limitations of this work include a paucity of knowledge and insight from primary care providers and a lack of qualitative material. Furthermore, this review acknowledged the need for further reviews to provide

TABLE 5 Summary of the five categories with example findings and illustrations

Category	Potential for developing future use with an increase in staff understanding	Summary: Having an influence on how technology could support patients and service users.
Finding	Enhances opportunities for health promotion, particularly in rural & remote settings (U). (Macniven et al., 2019)	
Illustration	"Opening that dialogue around heart health, whether it was having that conversation if they had a pre-existing condition, asking about what medication they are on. It was a good engagement tool for people who would otherwise not be engaged in that kind of conversation." p. 4 (Regional AHW/ RN)	
Category	Positive experiences of using the technology in practice.	Summary: HCPs experience, attitude, knowledge and confidence using mobile ECG technology are influencing factors in its uptake.
Finding	Quick, and easy to use, especially if familiar with "smart phone" technology (U). (Lowres et al., 2015)	
Illustration	"It was so non-invasive", "it's not like they had to put an electrode on or get dressed in any way." p. 1116	
Category	Not enough time or resources	Summary: Health services require investment, funding and integration with current workflow systems if future AF screening models are to be effective and sustainable
Finding	Additional time and resources are required (Orchard et al., 2016)	
Illustration	"…an unexpected abnormal result put them [nurses] under substantial time pressure, as additional time was not allocated for screening during the flu-vaccination consultation. Nurses from practices that had established protocols for dealing with abnormal results found this process much easier." p. 18	
Category	Prioritising people at highest risk of having AF	Summary: Offering AF screening to include those at higher risk and unable to attend practice settings and clinics.
Finding	Lack of a formal AF screening programme, prioritising at-risk individuals26 (U). (Savickas et al., 2020)	
Illustration	"Obviously, you're missing all the housebound patients as well because we don't go to search in care homes, there's going to be actually quite a few in care homes" (GPS6). p. 7	
Category	Negative experiences of poor internet connections	Summary: Contingency needed for sending mobile ECGs remotely if not integrated within a secure health service site.
Finding	Poor internet connectivity affects follow up assessment times (especially in remote areas. (U). (Macniven et al., 2019)	
Illustration	"Internet coverage is very slow for us, staff don't always have email, we shouldn't have to be faced with this stuff. I could personally see that if the ECG was ok but if I couldn't upload it to Dr in town, I would have to have a back up plan" (Remote AHW/RN) p .4	

greater insight into the benefits of mobile ECG technology from the viewpoint of both the health professional and provider. There are a number of other studies focusing on mobile ECG technology for the detection and monitoring of health conditions, and rationale for their use (Stern et al., 2014). However, there is a lack of synthesised evidence related to the monitoring and use of mobile ECG technology from the perspective of the health professional. The need to better understand the experiences and use of mobile ECG technology from an international perspective should also be acknowledged.

This review examined the available evidence on the use of mobile ECG technology from the perspective of the HCP. Their experiences towards mobile ECG technology were, in general, that it is simple, quick, easy to use and non-invasive. Rich data on the enablers to mobile ECG technology introduction were time, workload and remuneration for improved interoperability with current systems and sustainability for screening long term. Another reported experience was the importance of identifying key staff to move new innovations such as this through the phases of initiation, development and implementation. HCPs and organisations could therefore consider identifying key staff as "change champions" and use change/leadership models to support the integration (with current workflows), transformation and evaluation of mobile ECG technology in their practice setting. This has been well supported in the literature by many change models, theories (Hiatt, 2006; Kotter, 1996) and NHS leadership models (NHS England, 2018). By utilising a change model when introducing technology such as mobile ECG, staff can evaluate, plan and implement strategies to ensure the benefits and relevance for both them and their patients are realised. The main barrier, in relation to the operational use of the technology, was unreliable and variable internet connection and the ability to connect remotely with the server. Some of the included studies capturing AF screening were potentially biased as they included mainly proactive, lower-risk patients so the reported experiences of HCPs using the mobile ECG technology were often with the lower-risk cohorts. The data were unable to demonstrate if there are any differences between the experiences of HCPs working in primary care settings such GP practices/pharmacies and those working remotely in the community. Therefore, the experiences of those HCPs assessing patients in the community, unable to access health services easily are more limited. Moreover, further

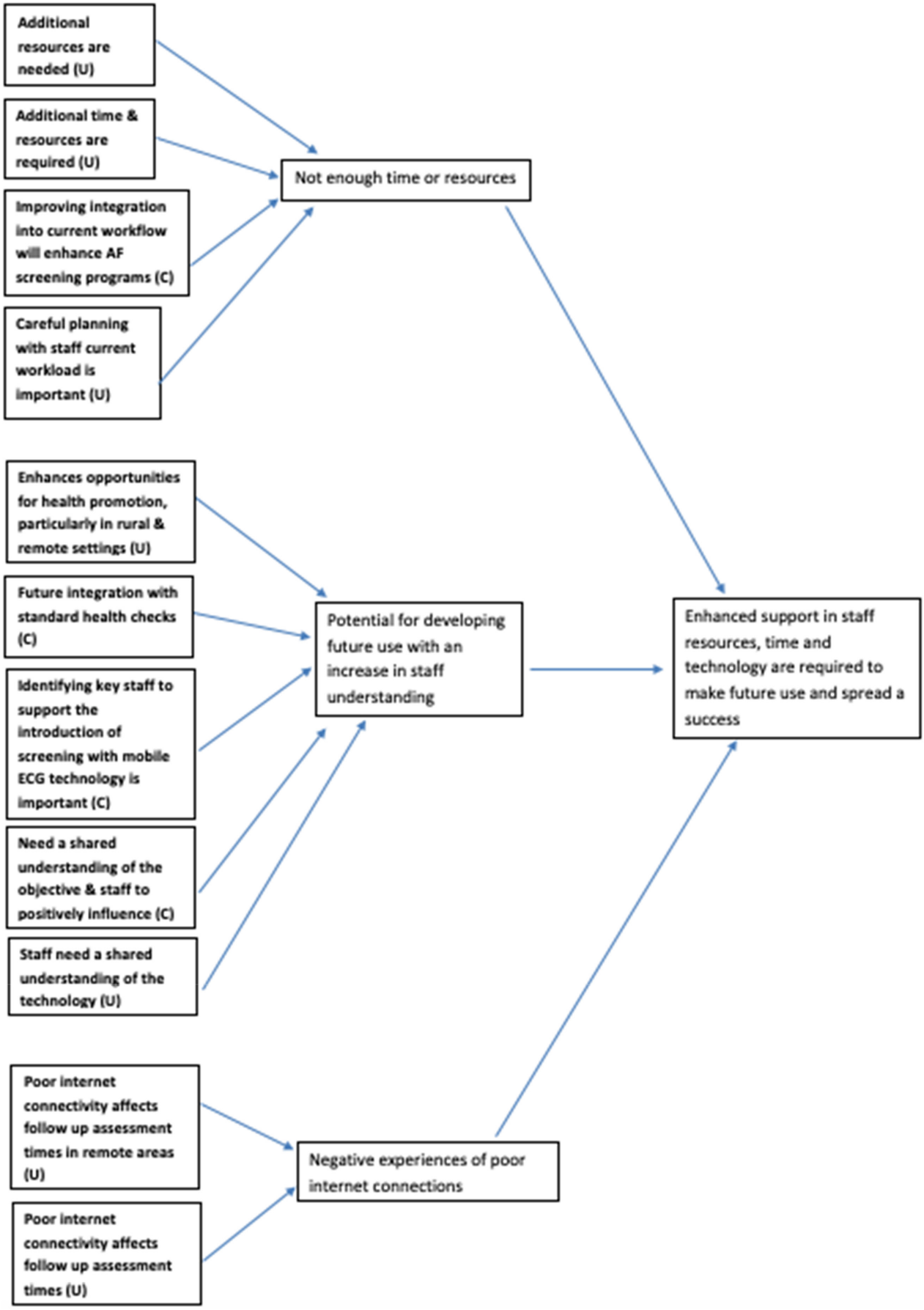

FIGURE 2 (Continued)

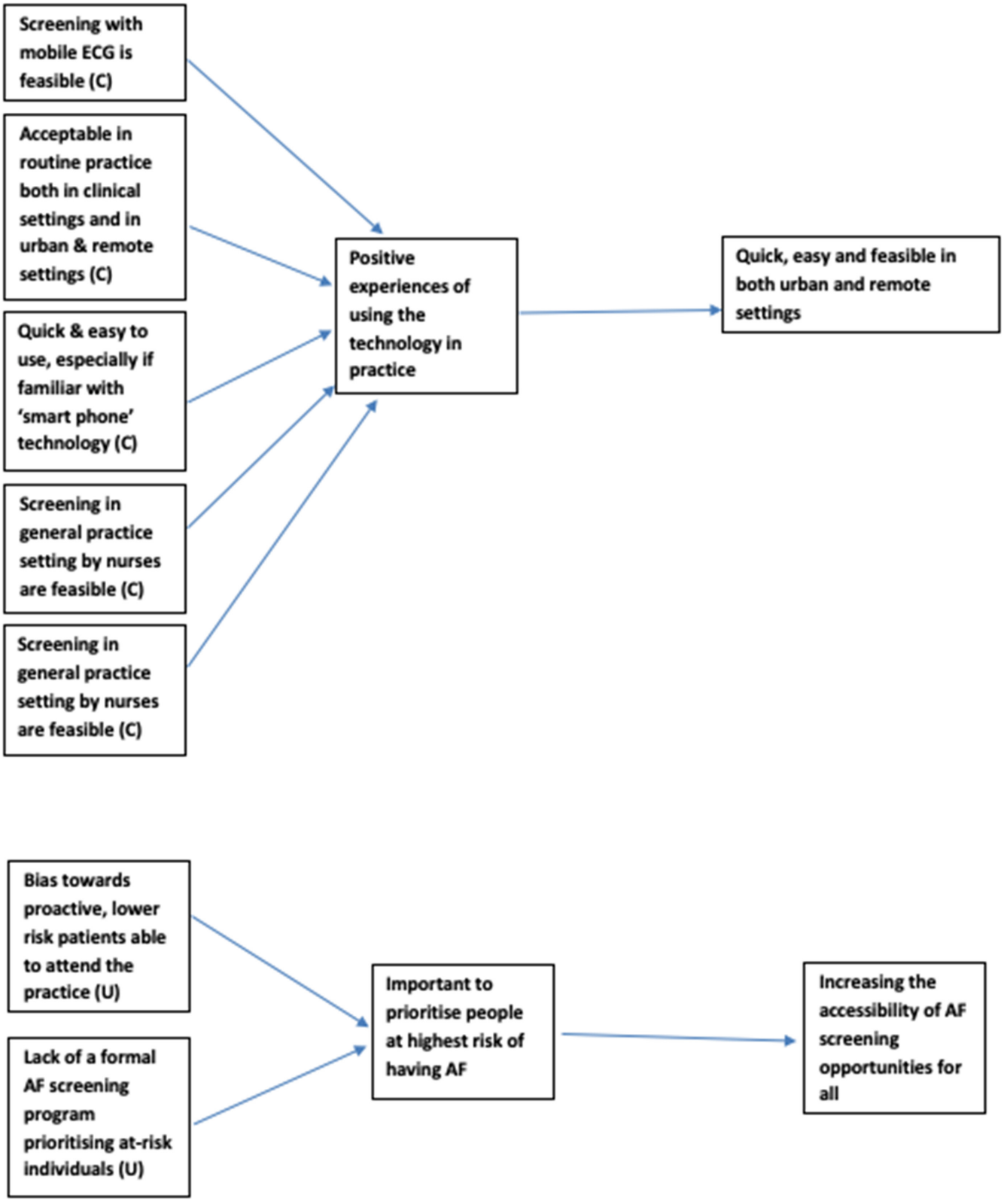

FIGURE 2 Meta-aggregative flowchart (part 1)

studies are required to explore the experiences of HCPs using mobile ECG technology to screen higher-risk patients who are unable to access healthcare services in the community setting, as their experiences may differ.

5 | STRENGTHS AND LIMITATIONS

This systematic literature review provides an overview of the experiences of HCPs using mobile ECG technology to record ECGs.

TABLE 6 ConQual summary of findings

Synthesised finding	Type of research	Dependability	Credibility	ConQual score	Comments
Experiences of health professionals using mobile ECG technology					
Enhanced support in staff resources, time and technology are required to make future use and spread a success.	Qualitative	Downgraded 1 level	Downgraded 1 level	Low	Downgraded 1 level due to no statement locating the researcher culturally or theoretically in any of the included studies. Downgraded 1 level due to a mix of unequivocal and credible findings
Quick, easy and feasible in both urban and remote settings	Qualitative	Downgraded 1 level	Downgraded 1 level	Low	Downgraded 1 level due to no statement locating the researcher culturally or theoretically in any of the included studies. Downgraded 1 level due to a mix of unequivocal and credible findings.
Increased accessibility of AF screening opportunities for all	Qualitative	Downgraded 1 level	Remains the same	Moderate	Downgraded 1 level due to no statement locating the researcher culturally or theoretically in any of the included studies. Credibility: all findings unequivocal so remains the same

Based on the JBI critical appraisal tool, the methodological quality of the included studies was high, and the studies were all published within the last 6 years. A limitation is that all the included studies were conducted in English-speaking countries; the majority of which were Australia. The healthcare systems and context of the included countries, as well as technological innovations, may differ from other countries and would therefore require further exploration.

6 | CONCLUSION

The findings of this qualitative systematic review highlight HCPs' unique experiences and perspectives regarding the use of mobile ECG technology, which are well accepted, simple to use and non-invasive. The findings are also in line with and support the aspirations of the National Health Service Long Term Plan (NHS Long Term Plan, 2019) regarding digital transformation. This specifically includes enabling clinicians by promoting research and promoting service transformation to improve the detection and treatment of high-risk conditions such as AF. The National Institute for Health and Care Excellence (NICE) AF guidelines (NICE, 2021) note the gold-standard for AF confirmation is 12-Lead ECG; however, key recommendations for research are around the use and accuracy of mobile ECG technology, stating the mobile ECG devices are accurate and showed promise. However, the equipment needed to record a standard 12-Lead ECG is not readily available for traditionally hard-to-reach populations such as those people who are, through ill health or poor mobility, unable to leave their home, particularly if living in rural or deprived locations (Bell & Heitz, 2020). Therefore, there remains a gap in provision for those patients requiring HCPs to record an ECG in their own home. This gap applies regardless of whether the recording is needed because the patients are symptomatic or if recording an ECG becomes part of a routine health check, to identify the many patients that have asymptomatic AF (Freedman & Lowres, 2015).

7 | RELEVANCE TO CLINICAL PRACTICE

The accounts of the participants and the findings of the six included studies give indications for some recommendations; these have all been graded "B" in alignment with the moderate to low level ConQual grade of synthesised findings (Munn et al., 2014).

- Mobile ECG technology in practice is quick, easy and feasible in both urban and remote settings.
- HCPs and organisations should consider identifying key staff as 'change champions' and use change/leadership models to support the integration (with current workflows), transformation, and evaluation of mobile ECG technology in their practice setting.
- HCPs and providers using mobile ECG technology should ensure it prioritises at-risk individuals and includes the 'housebound' population.

All the findings of this qualitative systematic review are derived from English-speaking studies; thus, the transferability of the results might be limited in countries with different healthcare policies and systems. The gap in knowledge highlighted by this systematic review relates to the experiences of HCPs using mobile ECG technology working in the community in patient's homes and nursing/residential settings. HCPs working in these settings work with higher-risk patients with multi-comorbidities (Stafford et al., 2018; The Queens Nursing Institute, 2018); therefore, their experiences of using mobile technology may differ from those working in GP practices and pharmacies. Additional exploratory qualitative studies and mixed-method studies combining interviews with the main healthcare stakeholders (i.e. patients, healthcare professionals, and the general public) specifically within different settings would help gain a local and European view of the implications and preferences on the use of mobile technology to record ECGs.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

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

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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