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Artificial intelligence capabilities in identifying atrial fibrillation using baseline sinus rhythm electrocardiography: Protocol for a systematic review

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 13 March 2025 and was last updated on 13 March 2025.

INTRODUCTION

Review question / Objective Review question:
What is the effectiveness of AI algorithms in detecting AF using baseline (i.e., before ECG confirmation of AF) surface SR-ECG, and what factors influence their performance considering methodologies, limitations, and ethical considerations?

Aims and objectives:
Aims:
1. To evaluate the performance of AI algorithms in detecting AF using baseline surface SR-ECG.
Objectives:
a) Systematic review: Conduct a systematic literature review to evaluate existing AI algorithms utilized for diagnosing AF from SR-ECG.
b) Critical appraisal – Reliability analysis: Critically evaluate the methodology and performance of AI algorithms and investigate their reliability in identifying AF while on SR.
2. To understand the potential factors influencing the performance of algorithms recognizing AF during SR.
Objectives:
a) Reproducibility: Explore the reproducibility of AI-assisted methods in both inpatient and outpatient settings.
b) Comparative analysis and ECG processing evaluation: Investigate which AI methodology and analytical approach performs superiorly in detecting AF using SR-ECG.
3. To inform future research on AI algorithm development and implementation.
Objectives:
a) Knowledge gaps: Summarize current research findings and identify gaps and areas for improvement.
b) Recommendations: Provide evidence-based recommendations for future clinical trials on AI-assisted AF detection.

Rationale Atrial fibrillation (AF) is the most common arrhythmia worldwide, with a rising incidence contributing to significant morbidity and

mortality. It is a major risk factor for stroke and thromboembolic events, and its increasing prevalence underscores the need for improved detection and management strategies. Early identification of AF is crucial to mitigate these risks, yet current diagnostic approaches, reliant on physician-interpreted electrocardiography (ECG), face challenges, particularly in detecting paroxysmal AF due to its intermittent nature.

Despite the recognized need for effective AF screening, a consensus on the optimal strategy remains elusive, even for high-risk populations. Traditional risk scores like CHARGE-AF and C2HEST are either too complex or lack consistent clinical utility. Artificial intelligence (AI) algorithms have emerged as promising tools for AF prediction and diagnosis, with the ability to analyze subtle ECG changes and identify patients at risk. Recent studies have demonstrated the efficacy of AI-driven models using sinus rhythm ECG (SR-ECG) to predict future AF episodes with high sensitivity and specificity. However, these approaches require further validation and integration into clinical practice.

This systematic review aims to synthesize the current evidence on AI algorithms for AF detection using SR-ECG. By evaluating the strengths, limitations, and clinical applicability of these models, the review will provide a comprehensive update to inform future research, clinical trials, and policy decisions. Given the European Society of Cardiology's emphasis on advancing modern ECG assessment techniques, this project addresses a key research gap. Ultimately, the findings could facilitate the adoption of AI-enhanced ECG in large-scale screening, improving early AF detection and reducing AF-related complications and healthcare costs.

Condition being studied Atrial fibrillation.

METHODS

Search strategy Search terms included keywords such as “artificial intelligence”, “machine learning”, “deep learning”, “atrial fibrillation”, and “electrocardiogram” .

Sources:
Databases: PubMed (MEDLINE), EMBASE (via Ovid), Scopus, Web of Science, Google Scholar
Trial registries: ClinicalTrials.gov, European Union Clinical Trials Register, International Clinical Trials Registry Platform.

Participant or population Adult population defined as individuals at least 16 years old but excluding disease-specific populations (i.e. populations consisted only by individuals who have a specific condition, e.g., spetic patients, leukaemia patients).

Intervention The implementation of artificial intelligence algorithms on surface sinus rhythm electrocardiograms to detect atrial fibrillation.

Comparator n/a.

Study designs to be included Randomised controlled trials, or diagnostic studies with cohort or case-control design.

Eligibility criteria Inclusion criteria:
1. Use of baseline (prior to any AF diagnosis) SR-ECGs of human adults (≥16 years old): Focuses on presumably AF-free adults, avoiding the confounding effects of rare paediatric AF, and aims to assess AI's screening potential.(51)
2. Implementation of AI algorithms on surface SR-ECG to detect AF.
3. Randomised trials, or diagnostic studies with cohort or case-control design.
4. Reporting AF diagnostic outcomes [at least one of: accuracy, sensitivity, specificity, precision (or data to calculate these, i.e., a confusion matrix), area under the receiver operating characteristic curve (AUC)].
5. Testing AI model on separate unseen dataset: enhances generalizability.
6. Confirmatory AF diagnosis occurs within a maximum of one year: distinguishes diagnosis and prediction.
7. Published between 2014 and 2024: ensures recency and relevance.
8. Original articles (including grey literature) in English with full-text availability.

Exclusion criteria:
1. AI models combining ECG data with clinical or other parameters: favours simplicity of AF screening strategy.
2. Inclusion of only AF cases or disease-specific populations: enhances generalizability.
3. Input data other than traditional ECG, including vectorcardiography or photoplethysmography (PPG): as ECG is universally accessible.
4. Prediction of direct onset of a paroxysmal AF episode within 24 hours: event prediction falls out of review scope.
5. Not reporting the timeframe in which the confirmatory AF diagnosis occurs.
6. Performing AF risk estimation using AF precursors such as atrial tachycardia or left atrial

enlargement: ascertains that only presumably normal SR-ECGs are included in analyses.
7. Reviews, letters, editorials, other non-original research articles, or abstracts without full-text available.

Information sources
Sources:
Databases: PubMed (MEDLINE), EMBASE (via Ovid), Scopus, Web of Science, Google Scholar (to enhance grey literature search)
Trial registries: ClinicalTrials.gov, European Union Clinical Trials Register, International Clinical Trials Registry Platform.

Main outcome(s) 1. Comprehensive analysis of AI performance in AF detection using SR-ECG through a systematic review: Quantitative analysis of performance metrics (accuracy, sensitivity, specificity, precision, AUC) using median, range, and IQR, with analysis across different AI techniques (CML, DL) and timeframes (31 days, one year) to detect the most effective AI approaches.
2. Improved understanding of AI-enhanced ECG for AF identification during SR: Qualitative analysis of methodological limitations and ethical considerations and quantification of recurring themes.
3. Identification of knowledge gaps and provision of directions for future research:
Recommendations for clinical trial designs for AI algorithm development and implementation to enhance methodological rigor and address ethical considerations.

Quality assessment / Risk of bias analysis Quality assessment of diagnostic accuracy studies (QUADAS)-2 tool.

Strategy of data synthesis The data extracted will be summarised in groups according to AI class and time from AI-enabled ECG to confirmatory AF event capture to answer the review questions. Due to the heterogenous study designs and interventions, a meta-analysis will not be conducted. However, in compliance with the SWiM guidelines and the Cochrane Handbook for Systematic Reviews, the outcome measures (performance metrics – see Table 1) will be summarized quantitatively using median, range, and interquartile range (IQR) to estimate the range and distribution of the effect. Analyses will be conducted using SPSS Statistics 29.0 (IBM, New York, USA).

Subgroup analysis Analyses by AI class (machine learning vs deep learning) and time from AI-enabled ECG to confirmatory AF event capture (up to 31 days vs 31 days up to a year).

Sensitivity analysis n/a - meta-analysis not to be performed.

Country(ies) involved United Kingdom.

Keywords atrial fibrillation; artificial intelligence; deep learning; electrocardiography.

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