

Systematic Review of Foundation Models for Electrocardiogram Diagnosis: Technical Designs, Performance, and Reproducibility

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REVIEW TITLE AND BASIC DETAILS

Review title

Systematic Review of Foundation Models for Electrocardiogram Diagnosis: Technical Designs, Performance, and Reproducibility

Condition or domain being studied

Electrocardiogram; Artificial intelligence; Machine learning; Cardiovascular disease; Atrial Fibrillation; Heart Failure; Clinical Support; Cardiac Arrhythmia

Rationale for the review

Electrocardiogram (ECG) is a non-invasive, low-cost, and widely used diagnostic tool for assessing cardiovascular conditions. In recent years, the rise of foundation models—pre-trained models capable of generalization and transfer learning—has gained attention in the field of medical artificial intelligence. Several studies have proposed foundation models trained on large ECG datasets using self-supervised or supervised pretraining, with varying architectural designs and downstream performance. However, no comprehensive review currently exists to synthesize their methodologies, performance, and reproducibility. This systematic review aims to fill that gap by providing an overview of the techniques, model architectures, evaluation approaches, and transparency practices adopted in current ECG foundation models, offering insights into best practices and limitations to inform future research.

Review objectives

- (1) What training strategies and model architectures are employed in ECG foundation models?
- (2) How effective are these models on downstream tasks?
- (3) How many models are publicly released and to what extent are they reproducible?

Keywords

Electrocardiogram; Foundation models; Deep learning; Artificial intelligence; Pre-trained model; Cardiovascular disease

Country

Sweden

ELIGIBILITY CRITERIA

Population

Included

Studies using ECG data collected from human subjects, including patients diagnosed with various cardiovascular or systemic conditions (e.g., heart failure, arrhythmia, myocardial infarction, diabetes), as well as general population samples.

Intervention(s) or exposure(s)

Included

The intervention of interest in this review is the development of ECG foundation models, which involves a two-stage training paradigm: (1) a pretraining stage in which large-scale ECG datasets are used to initialize model parameters; and (2) a fine-tuning stage in which the pretrained models are adapted to specific downstream diagnostic tasks.

Comparator(s) or control(s)

This review does not have any comparators

Study design

Only nonrandomized study types will be included.

Included

This review includes model development studies that focus on foundation models for ECG data. Therefore, the review does not apply restrictions based on traditional clinical study designs.

Context

Included studies are drawn from peer-reviewed journals and top-ranked computer science conferences, as well as selected model repositories, to capture both methodological rigor and recent developments. Only studies published between 2018 and 2025 are considered.

SIMILAR REVIEWS

Check for similar records already in PROSPERO

PROSPERO identified a number of existing PROSPERO records that were similar to this one (last check made on 20 July 2025). These are shown below along with the reasons given by that the review team for the reviews being different and/or proceeding.

- Performance of predictive models for progression of chronic kidney disease: systematic review and meta-analysis [published 2 August 2016] [CRD42016044025]. **The authors did not check this review**
- Effectiveness of Artificial Intelligence Foundation Models for Disease Detection using Oculomics [published 17 December 2024] [CRD42024623548]. **The authors did not check this review**
- A systematic review of models of service that care for adults experiencing serious mental illness in secure rehabilitation facilities. [published 10 October 2021] [CRD42021269127]. **The authors did not check this review**

TIMELINE OF THE REVIEW

Date of first submission to PROSPERO

This record has not been submitted.

Review timeline

Start date: 20 July 2025. End date: 31 January 2026.

Date of registration in PROSPERO

This record has not been published.

AVAILABILITY OF FULL PROTOCOL

Availability of full protocol

A full protocol has not been written.

SEARCHING AND SCREENING

Search for unpublished studies

Both published and unpublished studies will be sought.

Main bibliographic databases that will be searched

None of the major databases will be searched but other important databases will be, as described below.

Other important or specialist databases that will be searched

Web of science, DBLP, Hugging Face, and Zenodo.

Search language restrictions

The review will only include studies published in English.

Search date restrictions

Databases will be searched for articles published from 1 January 2018 and before by 18 July 2025.

Other methods of identifying studies

No other methods will be used.

Link to search strategy

A full search strategy is not available.

Selection process

Studies will be screened independently by at least two people (or person/machine combination) with a process to resolve differences.

Other relevant information about searching and screening

None

DATA COLLECTION PROCESS

Data extraction from published articles and reports

Data will be extracted by one person (or a machine) and checked by at least one other person (or machine).

Authors will not be contacted for further information.

Study risk of bias or quality assessment

Risk of bias will be assessed using:

To be determined.

Data will be assessed by one person (or a machine) and checked by at least one other person (or machine).

Additional information will be sought from study investigators if required information is unclear or unavailable in the study publications/reports.

Reporting bias assessment

Risk of bias due to missing results will be assessed

Certainty assessment

Certainty of findings will not be assessed

OUTCOMES TO BE ANALYSED

Main outcomes

Model architectures and training strategies used in ECG foundation models; model performance on downstream tasks, typically measured by metrics such as AUROC or F1 score at the evaluation stage; and reproducibility assessed by availability of open-source checkpoints.

Additional outcomes

There are no additional outcomes.

PLANNED DATA SYNTHESIS

Strategy for data synthesis

This review will synthesize included studies by categorizing them according to the model architectures and training strategies employed in ECG foundation models. Key variables such as model type, pretraining approaches, and pretraining dataset will be extracted and compared across studies. Model reproducibility will be assessed based on the availability of open-source checkpoints.

CURRENT REVIEW STAGE

Stage of the review at this submission

Review stage	Started	Completed
Pilot work	✓	
Formal searching/study identification		
Screening search results against inclusion criteria		
Data extraction or receipt of IPD		
Risk of bias/quality assessment		
Data synthesis		

Review status

The review is currently planned or ongoing.

Publication of review results

Results of the review will be published.

REVIEW AFFILIATION, FUNDING AND PEER REVIEW

Review team members

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No conflict of interest decision selected yet.

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No conflict of interest declared.

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No conflict of interest declared.

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No conflict of interest declared.

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Review affiliation

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Funding source

No preview available

ADDITIONAL INFORMATION

Review conflict of interest

No preview available

Medical Subject Headings

No preview available

PROSPERO version history

No preview available

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