Integrating Nursing and Pharmacy Practices in Early Detection of Silent Cardiac Diseases Using Artificial Intelligence and ECG Analysis

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Abstract

Silent cardiac diseases present a significant yet overlooked public health challenge due to their asymptomatic nature. Artificial intelligence combined with electrocardiogram analysis provides a promising strategy for early detection. This initiative identifies specific interprofessional roles for nursing and pharmacy in the early screening, triage, and referral of cases that warrant further investigation. An integrated approach is applied with real ECG evidence and data-driven physician decision support. Pilot studies assess feasibility and clinical performance.

Silent cardiac diseases—especially arrhythmias and ischaemia—affect millions worldwide and contribute to thousands of avoidable deaths every year. Despite this burden, there is an absence of dedicated screening programs. Rapid telephone screening by nursing staff, combined with electrocardiogram analyses of ECG data—especially those provided by patients via mobile phones—could enable early detection. This role aligns with the traditional goal of reducing health inequalities, as nursing and pharmacy staff are often the most accessible health-care professionals. Although automatic AI-based decision support is available, clinical adoption remains limited due in part to understandable fears of injury associated with incorrect displays. The integration of nursing and pharmacy staff enables safe access to unregulated analysis and rapid exploration of adverse pharmacotherapy.

keywords:

Silent cardiac diseases—specifically coronary artery disease (CAD) and ischemic heart disease (IHD)—constitute a burgeoning public health crisis. Within the early-stage disease cohort, the macroscopic ECG reflects an intricate physiological basis yet remains invariant. Capturing a stabilized ECG during this dormant period is essential for training AI models. The absence of symptoms often leads to neglected follow-up visits—an ideal window exists for enhancing early detection of arrhythmias and ischemia via macroscopic ECG analysis throughout this period (Tang et al., 2023). Attention to the graphic alerting dimensions of ECG data can also yield early-stage diagnoses for accompanying comorbidities, amplifying the opportunity for timely involvement of nursing and pharmacy stakeholders.

AI-enabled ECG analysis constitutes a promising modality not only for detection but also for disease management. The proposed strategy targets the burgeoning issues of silent CAD and premature IHD-related demise by providing supplementary ECG-generated intelligence to nursing and pharmacy professionals. Arrhythmia detection and related annotations augment an active AI-enabled road map already under clinical deployment, facilitating the introduction of educational content and medication management (Lu et al., 2024). The approach is further complemented by a dedicated macro-style ECG-analysis engine aimed explicitly at ischemia detection (E Almansouri et al., 2024).

1. Introduction and Rationale

Silent cardiac diseases such as ischemia and arrhythmias represent global health threats, causing over 30% of annual deaths worldwide (Tang et al., 2023). The lack of early symptoms leads to a reliance on widespread screening but traditional methods hinder adoption. Artificial intelligence (AI) combined with electrocardiograms (ECGs) shows promise for scalable automated detection. Nurse- and pharmacist-led screening within community settings could address this need; regulatory changes facilitate broader delivery of ECG—AI solutions and related interprofessional-complementary care (Lu et al., 2024).

ECGs serve as fundamental, concise, and non-invasive hardware-agnostic methods for monitoring cardiac health and represent the primary option for patients seeking remote electrocardiographic evaluation. Residential patients can conduct recordings, and trained non-physicians can provide triage and result referral.

1.1. Background on Silent Cardiac Diseases

Silent cardiac diseases rank among the leading causes of global morbidity and mortality. According to the World Health Organization, 17.9 million people died from cardiovascular diseases in 2019. Cardiovascular illnesses, such as coronary artery disease, often do not exhibit any symptoms prior to the onset of an acute cardiac event. Consequently, these conditions remain undetected until the onset of an acute cardiac episode, such as a myocardial infarction or sudden cardiac arrest, resulting in 50% of the patient pool not reaching the hospital in time (Lu et al., 2024). Since the 1960s, public health campaigns in Western nations have targeted the detection of silent cardiac diseases through education and screening (Ivanov, 2020). The Canadian Hypertension Education Program emphasizes the importance of screening blood pressure at age 18, while pharmacotherapy initiation is advised for hypertension screening with a high-risk score. Occupational Health and Safety regulations strive to identify health risk factors before a health crisis arises. Specifically, silent cardiac disease screening is advocated for individuals at risk of impairing vital functions due to occupational cardiac disease.

1.2. Role of Nursing and Pharmacy in Early Detection

Silent cardiac diseases remain underrecognized in practice, despite large-scale epidemiological studies demonstrating a high prevalence of arrhythmia and ischemia globally (Tang et al., 2023).

Interdisciplinary collaboration is essential to close this detection gap. While electrocardiogram (ECG) analysis by artificial intelligence (AI) is a key enabler, the success of early screening hinges on timely patient engagement, which is highly effective within existing care pathways in pharmacy and nursing (Bridge et al., 2022) ; (Lu et al., 2024). Implementation of AI-supported screening from these disciplines enhances early diagnosis of undetected cardiac issues within low-acuity primary care, before the onset of symptomatic or catastrophic events.

Early identification of such diseases depends on comprehensive triage, educational materials, and dedicated digital channels—roles that pharmacy and nursing personnel are already positioned to fulfil. The provision of general screening and educational support, coupled with equitable medication access, enables early cardiac disease screening from the pharmacy discipline.

1.3. AI and ECG: An Overview

The early detection of silent cardiac diseases is critical for improving patient outcomes. Artificial intelligence (AI) and electrocardiogram (ECG) analysis can facilitate early detection by identifying arrhythmia and ischemia risk from ECG data, but a large-scale screening program requires a triage system to prevent overload. Two professional disciplines play prominent roles in such a system: nursing is often the first point of contact for patients, and pharmacists can directly provide ECG access without a physician visit. Prioritizing these disciplines can broaden reach while enhancing function or clarity. Screened data will inform the design of dedicated care pathways.

AI refers to computational systems that learn from experience to enhance performance (Boulif et al., 2023). Under artificial neural networks, deep learning has become the dominant AI methodology, learning from vast amounts of raw, unstructured data. Such systems often remain opaque, raising concerns about explainability, trust, and safety—issues explicitly considered in the proposed interprofessional approach. ECG captures the heart's electrical activity over time and has become standard for cardiac assessment. It is typically acquired from 12 leads, sampled at 500–1000 Hz, and archived as a 12-channel time series. Annotations indicate normalcy, rhythm classes, and arrhythmia events (Lu et al., 2024).

AI and ECG present unique challenges for early cardiac detection. AI models require extensive, high-quality, representative, and well-annotated data, yet publicly available ECG datasets are limited (Bridge et al., 2022). Such restrictions, coupled with high demand, necessitate a multifaceted data-governance framework controlling acquisition, access, sharing, and protection across multiple disciplines (Ivanov, 2023).(coordination) Coordination across disciplines extends beyond data governance; the framework for team-based care links AI and ECG detection advancements to integrated workflows involving nursing, pharmacy, and monitoring input.

2. Theoretical Framework and Interdisciplinary Collaboration

Healthcare paradigms have shifted towards patient-centered strategies that incorporate interprofessional frameworks and guarantee seamless information flow. Within this context, the role of professional teams in delivering quality care is being increasingly acknowledged. The World Health Organization defines interprofessional education as "students from two or more professions learning about, from and with each other" with the aim of producing collaborative practitioners. Interprofessional education is increasingly prioritized in health professions curricula, emphasizing teamwork to effectively address today's complex health issues. Building on the interprofessional education framework, conceptual models of team-based care have emerged. These models focus on clarifying the distribution of decision-making and communication channels, thereby facilitating the development of desirable systems that promote successful collaboration.

A conceptual model that supports interprofessional education emphasizes three key concepts: team-formation processes, communication channels, and governance mechanisms. Team-formation processes outline the selection of professionals, the configuration of the team, the definition of the problem, and the distribution of responsibilities. Communication channels between team members can take various forms, with models distinguishing between direct communication among decision-makers, a communication hub, one-way information sharing, and communication limited to channels external to the team. Finally, governance mechanisms delineate processes for reconfiguring the team, modifying the problem definition, changing communication patterns, and adjusting access rights to team records. Team-based frameworks can enhance collaboration across nursing and pharmacy disciplines at three levels: workflow integration, information sharing through common dashboards, and notification of relevant events via alerts, channels, or triggers. These aspects, which are closely integrated with the identification of screening and monitoring roles, must be addressed to support effective multi-team teamwork.

2.1. Conceptual Models for Interprofessional Care

Numerous healthcare frameworks describe models, processes, and conditions that underpin interprofessional collaboration, along with the structures and modes through which disciplines communicate. These frameworks help characterize aspects of the nursing-pharmacy-AI-ECG cooperation among healthcare providers, administrators, and technology developers. Such distinctions illuminate communication channels and governance practices that operate in parallel with integrated-clinical-workflows and discipline-specific regulatory environments.

Team-Based Care Models for Interprofessional Collaboration

The proposed team-based-care framework identifies five components—team, reach, task, purpose, and structure—that are central to interprofessional collaboration. The model specifies a variety of team types (e.g., interdisciplinary, multidisciplinary, transdisciplinary) and clarifies the geographies (e.g., physical, virtual) that delineate the reach of collaborative activities. The framework also addresses the optimal and minimum combinations of complementary roles to incorporate in a team undertaking a particular set of tasks toward a specific purpose.

The interaction among disciplines prompted by these dimensions influences the formal and informal communication channels and mechanisms that evolve within and across teams. Communication practices are further shaped by the relative scope of practice and decision-making authority afforded by different regulatory regimes and by the specific capabilities of, and expectations governing, technical systems incorporated into the care delivery ecosystem.

2.2. Workflow Integration Across Disciplines

Collaborative models in health and social care are crucial to meeting the growing expectations on emergency triage (Ponomariov et al., 2017). Primary care, community pharmacy, and emergency medical services share the common goal of improving access to urgent clinical assessment (B. Elvas et al., 2023). AI-ECG screening enables positive re-direction from high-demand services while supporting the assessment of patients whose clinical history or vital signs merit a wider safety net. Between nursing and pharmacy, various handoffs occur along workflows, all of which can be actively supported.

Pharmacy teams can establish a triage and screening service for diabetes and other cardiometabolic risk factors (Lu et al., 2024) while ensuring equitable access to AI-ECG services and actively responding to alerts. This reinforces the team-based nature of nursing and pharmacy practices, with nursing-led, pharmacy-led, and joint pathways all possible. Handoff protocols, shared dashboard interactions, and selective decision-support triggers facilitate flexible collaboration, enabling each discipline to engage at the point of greatest impact and accommodate evolving priority needs as implementation progresses. Operating across health care settings, these frameworks are equally applicable to nursing, pharmacy, and AI-based ECG analysis conducted in the community, during hospitalisation, or post-discharge.

Shared dashboards, whether maintained by clinics, teams, or individual practitioners, allow oversight of comprehensive records, outstanding tasks, and open communications with team members and patients. A decision-support flowchart guides further actions based on earlier screening results, patient profile and history, safety concerns raised by an AI-DTS system, alerts from drug-monitoring systems, and other factors.

3. ECG Data and AI Methodologies

AI techniques will enable automatic detection of silent cardiac diseases, principally arrhythmia and ischemia. These are particularly suitable for clinical settings in which a large volume of data might accrue—ECGs from mobile devices, for instance—but screening is limited by workforce. Other cardiac problems that AI can help detect, but are less silent, include infarction and ventricular hypertrophy. The required datasets are large enough for conventional training, testing, and validation of models.

Four ECG data sources are relevant to this project: the AHA/ACCF/ASE/HRS/IEEE Standard for ECG Device Data Access; the MIT-BIH Arrhythmia Database; the PTB Diagnostic ECG Database; and Shimmer devices with integrated sensors. Procedures for acquiring and quality-controlling these data must be specific about the documentation, parameters, environmental conditions, and patient states during scanning.

3.1. Data Acquisition and Quality Assurance

According to Baker (2021), silent cardiac conditions with no symptoms or prior warning account for the largest percentage of cardiovascular deaths in the United States. Despite decades of efforts focused on education and treatment of risk factors, cardiovascular disease remains the leading cause of death worldwide. Only 30%–40% of the world's adult population is monitored for these serious conditions, while between 0.7% and 12.5% of detected clinical arrhythmia in the population receive proper attention. With 60% of Singaporean adults diving straight into work after receiving an ECG, commitment to early detection and screening remains disturbingly low.

Cardiac diseases with no significant warning signs create a pressing need for timely early detection and screening in high-risk patients using artificial intelligence.

Artificial intelligence (AI) approaches using electrocardiography (ECG) data to detect the presence of arrhythmia and myocardial ischaemia represent emerging and significantly untapped possibilities to provide such early detection and screening services. AI-ECG systems provide detection and screening that takes only seconds from ECG acquisition and even support multiple simultaneous arrhythmia detection types, which strongly align with the compelling clinical and workflow needs associated with arrhythmia and ischaemia.

3.2. AI Techniques for Arrhythmia and Ischemia Detection

Artificial intelligence (AI) promises to expand detection capabilities for silent cardiac diseases from symptoms to premonitory signals. Electrocardiogram (ECG) data convey knowledge about heart function through voltage variations over time. Deep learning is an AI technique particularly well-suited for ECG signals, identifying changes around electrical activity. Models can accordingly be trained to detect arrhythmias or myocardial ischemia that may precede a cardiac event. Automated ECG screening combined with nurse-led triage or pharmacy access can substantially increase the likelihood of timely input from specialized clinicians if a premonitory signal is detected.

AI techniques for ECG-based arrhythmia detection can be grouped into five categories: signal processing for feature extraction; sequence models; classification through patch analysis; direct ECG-to-label prediction; and hybrid approaches (Vasu Kalmady et al., 2024). A model capable of identifying atrial fibrillation from a 12-lead ECG during sinus rhythm has been developed; additional model-agnostic experiments demonstrated the correlation of several features with the probability of paroxysmal atrial fibrilation (Baek et al., 2021). A fast, cost-effective method for spotting abnormal ECG Waveform—derived from a scanned strip rather than the raw digital trace—also exists (Bridge et al., 2022).

3.3. Explainability, Trust, and Safety in AI

Artificial intelligence (AI) has the potential to assist clinicians in the early identification of silent cardiac arrhythmias and ischemia when electrocardiogram (ECG) data is analyzed—including raw waveforms and computed metrics, signals acquired from wearables and portable devices, and archived data from electronic health records. All healthcare professionals, including nurses and pharmacists, can play vital multi-disciplinary roles in early screening and triage when specific ECG data is analyzed in conjunction with AI models. Silent diseases with large population incidence and incomplete detection often lead to hospitalization or morbidity. AI model predictions allow professionals to refine the triage decision enabling detection while often accumulating additional clinical data, thus avoiding innumerable precious hours of wait and health deterioration.

AI and ECG techniques, outperforming traditional algorithms and clinical heuristics, can be integrated into generalized AI applications deployed within mobile and local environments (Wagner et al., 2023). Cross-population or global AI models exhibit poorer generalization—worsening time until the event, leading to potentially serious undue secondary effects and amplification of drifts on unguarded data. Required inputs include original video or images, digital signals in uncompressed or open formats, or query generation—supporting text-document modeling, graphical data, and even categorical generation (Meyer Lauritsen et al., 2020). Enabling early screening, setting a candidate population and acquiring targeted ECG data input, permits subsequent AI model deployment—even when pre-recorded ECG already exists. This approach offers a better chance to reach monthly or unforeseen care needs or population cross-activity.

4. Nursing Practices in Screening and Triage

Silent cardiac diseases rank among the top three silent killers and are among the leading causes of death in the world. Screening people with silent cardiac diseases enables timely service design and implementation, improved patient outcomes, and reduced healthcare costs (Tang et al., 2023). Silent cardiac diseases are defined as cardiac illness without any reported or perceived symptoms. The top two silent cardiac diseases are asymptomatic coronary artery disease (CAD) and silent cardiac arrhythmia. Coronary artery disease (CAD) occurs due to coronary arteries stiffening as a result of plaque accumulation or blood clots. This condition leads to a poor quality of life and increased medical costs, especially in diabetic patients. Only a doctor can detect CAD through costly and time-consuming processes, including coronary angiography, computed tomography angiography, and coronary artery calciumenhanced computer tomography—screening techniques for CAD either have a low penetration rate or high risk. The second silent cardiac disease—arrhythmia—describes abnormal heartbeats. A patient typically realizes the service requirement only after a health crisis occurs. A screening call before normal medication ensures safety and prevents delays.

Artificial intelligence (AI) and electrocardiography (ECG) design a screening service for silent cardiac diseases. Nursing and pharmacy roles are identified to enhance the screening function further. The roles of nursing and pharmacy contributions impact timely service delivery, leading to the involvement of the two professions in the screening service. Addressing and securing the roles of the two disciplines lead to the establishment of a broadly accepted interprofessional-artificial-intelligence screen. Screening through telephone calls, education, and triaging provides patients with more chances to access timely service. The analysis prioritizes highlighting the nursing roles to increase the chance of obtaining further support from the interprofessional team.

The connection between ECGs and AI has been explained through data collection, quality assurance, and two core AI methodologies for different cardiac diseases: arrhythmia and CAD. The specification of acquisition devices, preparation styles, and preprocessing methods ensures the potential applicability, and the training procedures are specified for each disease for implementation. ECG screening also provides the foundation for the pharmacy role, aggregation of evidence for a broad population, and education to increase service acceptance. Monitoring of medication safety during screening captures the side effect directly related to the heart. Recognizing the role and involvement of the team is crucial in establishing a widely recognized screening service.

4.1. Screening Protocols and Patient Education

Research indicates a high prevalence of silent cardiac diseases—including ischaemia, arrhythmia, valvular disorders, and former COVID-19 symptoms—in those without traditional risk factors (Vasu Kalmady et al., 2024). For broader reach, low-cost, non-invasive screening approaches using artificial intelligence (AI)–electrocardiogram (ECG) technologies inform the choice of ECG analysis. ECG is one of the most commonly performed clinical investigations and provides critical diagnostic information (Vindeløv Bjerkén et al., 2023). Nurses consult patients earlier than family doctors in approximately 88% of cases. Following a service closure, re-engagement via educational contact increases the likelihood of patients returning to preventive services. The dual role of nurses in triage and instruction, therefore, permits consideration of ECG data and analysis performed by AI-ECG technologies (Lu et al., 2024).

Early detection of silent cardiac diseases through screening in pharmacy or medical practices would facilitate timely patient re-engagement. Pharmacists are ideally positioned to realise this opportunity during dispensing or collecting medication, as well as when patients receive new treatment; receipt of a first prescription prompts the highest level of engagement for adherence considerations. Detecting previously undiagnosed silent cardiac disease and addressing medication-related problems are thus high-priority pharmacy intervention areas. Pharmacists can enhance detection of silent cardiac disease, and ensure safe, effective medication use. Pharmacists identify and document medication therapy problems, including adverse drug reactions, drug interactions, and lack of monitoring; collating this information enables AI analysis of ECG data and simultaneously flags pharmacotherapy-related concerns.

4.2. Vital Signs, Risk Stratification, and Referral Pathways

Vital signs and risk stratification are essential in evaluating patients' health status and guiding referral pathways. Widespread blood pressure monitoring, for example, has improved hypertension detection (Lu et al., 2024). Although cardiac disease screening typically requires electrocardiography (ECG), obtaining an ECG is often difficult and time-consuming. Artificial intelligence (AI) analysis of ECG data can enhance rapid screening—particularly when combined with readily available data on vital signs and other characteristics. An initial monitoring focus should be on heart rate, oxygen saturation, and atrial fibrillation; combined risk scores from the National Early Warning Score and ECG- and age-based arrhythmia models can guide subsequent healthcare options (Tsai et al., 2023).

4.3. Nursing Decision Support Tools in AI-Driven Care

Artificial Intelligence (AI) has a long-standing reputation for impact on clinical analysis. In cardiology, AI plays an important role in clinical assessment and decision making through the wider adoption of Artificial Intelligence-based Clinical Decision Support Systems (AI-CDSS) helping analysis for better prediction and classification. In Cardiovascular Science, Artificial Intelligence is a key element to improve early detection through a wider adoption of solutions that mitigate false positives and precision of electrocardiogram (ECG)-based screening. AI-based solutions generally show low trust level by clinical experts as no clinical context is taken into account during the examination. The main characteristics of ECG analysis are presented together with the main methodologies available for screening.

AI-CDSS refers to any system that utilizes artificial intelligence to enhance health care. AI-CDSS can serve a diverse range of functions across health care and assist clinical practitioners through patients' management in control, detect adverse reaction or equipment malfunction, facilitate data analysis and treatment adherence. AI-CDSS can also target a specific phase of patient treatment by either reducing sedentary behaviours or motivation activation. Early stage screening systems do exist and can only be examined in conjunction with other methodologies that acceptable and trusted within the health care community.

5. Pharmacy Roles in Medication Management and Detection

Pharmacists can enhance early detection of silent cardiac diseases and promote safe pharmacotherapy for patients to whom insights have been shared through artificial intelligence (AI)-enabled electrocardiogram (ECG) analysis. Since pharmacists are more accessible than other healthcare professionals, they can monitor signals of cognitive decline or medication-related problems requiring further professional follow-up (Teresa Climent et al., 2018). Pharmacovigilance extends to gathering information on suspected adverse drug reactions and ensuring that safe and effective pharmacotherapy remains available for all patients in equitable and efficient ways (Edrees et al., 2022). A working knowledge of medications linked to ECG modifications, including those capable of QT-interval prolongation, along with routine monitoring in accordance with local policies where pertinent, allows pharmacists to foster pharmacological safety even as early detection occurs (Del Rio-Bermudez et al., 2020). Finally, the AI-enabled ECG-output data can inform reminders about adherence strategies for a patient's scheduled doses of, for instance, prominently used agents such as beta blockers, or for which missed doses generally necessitate direct reconciliation, including currently popular antimicrobials used to treat tuberculosis.

5.1. Pharmacovigilance and Access to Diagnostic Tools

Drug safety remains a major concern in post-marketing settings, relying heavily on spontaneous reporting, which can introduce biases. Artificial intelligence has great potential to improve pharmacovigilance efficiency and effectiveness. AI techniques like NLP and deep learning can process documented adverse drug effects from various data sources, especially electronic health records. AI can also collect new information to measure actual adverse drug event rates and enable automated targeted follow-up of high-risk patients. Such datasets help develop clinical decision-support tools to prevent or mitigate medication-related adverse effects and optimize treatment outcomes. AI and wearable technologies in telemedicine support pharmacovigilance through real-time data monitoring, minimizing patient harm and improving outcomes (Edrees et al., 2022).

Pharmacists play a vital role in monitoring medicine safety, detecting both obvious and subtle adverse signals. They cannot, however, act on a signal until it is perceived. AI can significantly strengthen pharmacovigilance by increasing the number of signals previously unnoticed, providing an opportunity for pharmacists to act (Quartieri et al., 2022). ECGs constitute an essential tool for monitoring medicines that induce cardiac arrhythmia at risk of serious consequences such as sudden cardiac death. Patients disposed to ischaemia or high arrhythmia risk may also benefit from following-up after medicines that could affect the condition. An easy-to-access device capable of performing ECG on a large population would promote early detection and, as a result, patients' safety.

5.2. Drug-ECG Interaction Awareness and Safety

The potential of Artificial Intelligence (AI) applied to Electrocardiography (ECG) analysis to complement early cardiac detection has been increasingly recognized. ECGs offer a unique opportunity for screening silent cardiac disturbances since individual medical histories, symptoms, and vital signs do not readily indicate a cardiac phenomenon (Lu et al., 2024). These disturbances account for up to 90% of all cardiac events (Vasu Kalmady et al., 2024) , yet screening is often overlooked due to lengthy wait times or the absence of in-person consultations following requests. Team-based screening is therefore suggested to facilitate timely detection with minimal resource demands, leveraging the broad access, extended availability, and high functionality of devices like the single-lead, handheld, pocket ECG. To succeed, the screening procedure, trained personnel, and supporting artificial intelligence (AI) analysis must be defined. The previously formatted protocol-based screening outline, nursing AI-selection techniques, and pharmacy-led analysis-feedback service address the selection iteration, while clarifying candidates, medications, and criteria for further advancement; thorough capture of each care step, activity, and collaboration also remains essential.

Almost all cardiac drugs impact the ECG; hence, awareness alone may suffice to initiate careful monitoring. Prolongation of the QT interval—indicative of potential Torsades de pointes and thus life-threatening—is among the most widespread of such effects (Liu et al., 2019). Detailed preselected QRS-T nomenclatures and associated monitoring guidelines can be set up upon the AI completion stage, yet these considerations require integrating pharmacovigilance with ECG-analysis capacities to avoid the burden of extensive pre-screening technicalities.

5.3. Pharmacy-Driven Adherence Interventions with AI Feedback

Artificial intelligence (AI) offers remarkable opportunities to harness automated feedback for patients on antipsychotic medication. Algorithms can indicate needs and trigger automated reminders; decision-support alerts can suggest further actions for healthcare workers. Using algorithms to initiate needs-based interventions for people on antipsychotic medication involves AI systems like AI^2, which uses machine learning on prescription and benefits data to detect medication discontinuation or missed health checks. A personal nudging model sends text messages to patients when alerts are detected. In a clinical decision-support model, alerts are presented as flags to mental health professionals. Implementation protocols and evaluation plans aim to address pragmatic issues and improve application, supporting further integration into personal and clinical practice (Oakey-Neate et al., 2020).

AI feedback also enhances adherence interventions for cardiovascular patients with echocardiography-based apps. Pharmacists oversee these monitors and assist patients by facilitating barrier identification, providing education, and suggesting treatment adjustments. Through early detection of cardiovascular disease risk and assessment of pharmaceutical safety, pharmacists enhance monitoring and collaboration. AI-output uncertainty profiles accompany

ECG-discussion illustrations to communicate limited endorsement of arrhythmia-free status, thereby supporting well-informed decision-making.

6. Clinical Workflows and Ecosystem Design

Early detection of silent cardiac diseases occurs when the patient is not aware of any symptoms concerning their cardiac health. The integrated approach increases the chance of early detection of silent cardiac diseases by collaborating with nurses in screening and pharmacy professionals supporting medication-monitoring. ECG signals are acquired and AI processing is performed to detect arrhythmia and ischaemic events. Outreach education targets high-risk groups to promote health-seeking behaviour for screening ECG acquisition in the health care system.

Silent cardiac diseases remain an underappreciated and widespread issue but constitute a leading cause of death. Arrhythmias and ischaemic changes can be detected passively by obtaining ECG signals and processing them with AI algorithms. Yet the barriers to acquire the ECG signal are still significant. The role of pharmacy professionals enables early integration of the ECG signal into the decision-making process and encourages the safe use of medications that may impact cardiac health.

The integrated approach recognizes and leverages the different enabling positions that these two health care professionals have on early detection of silent cardiac diseases. Prior to seeking an ECG signal, patients must be sufficiently motivated to undergo screening. Nurses are well-positioned to create this health concern either through direct outreach or information requests. Awareness of accessing pharmacy services is also a cue that enforces both license holders to complete a broader healthcare delivery circle—a 360-degree cycle from nursing to pharmacy, back to nursing, and returning to pharmacy again.

6.1. Integrated Care Pathways for Early Cardiac Detection

Silent cardiac diseases are often undiagnosed for years because they are asymptomatic in the early stages. When they are finally identified, the patient is sometimes already critically ill or dead. To address this situation, an interdisciplinary group devised a reliable integrated approach for early detection of silent cardiac diseases based on artificial intelligence (AI) and ECG analysis (Tang et al., 2023). Such an integrated approach palpably improves the chances of early detection and, subsequently, better prognoses. ECG analysis needs to be conducted in combination with automated AI-based appraisal of the ECG signal and clinical interpretation. Therefore, the focus turns to outlining how the relevant procedures, under the nursing-focus umbrella, shape the integrated approach and the corresponding arrangements in early cardiac-disease detection. The nursing approach includes the matching of verbal initial-symptom screening conducted by nursing professionals with ECG recordings acquired from any source followed by further ECG recording in the wake of specific initial symptoms.

6.2. Data Governance, Privacy, and Security

Data governance, privacy, and security are paramount in developing artificial intelligence (AI) applications for the early detection of cardiovascular diseases. AI technologies, while holding the promise of better health outcomes, also raise issues regarding the confidentiality of sensitive information such as electrocardiogram (ECG) and patient medical records (Murdoch, 2021). These concerns are exacerbated when continuous ECGs are sought and documents associated with medication lists are added to the dataset, explicitly requiring administrative consultation and individual-level data control (Agrawal et al., 2024). Although large annotated multi-centre datasets can be assembled, extensive screening and multiple annotation levels may still fall short of the completion needed to foster data-sharing partnerships across institutions, thus reinforcing the necessity of integrated protocols (Lu et al., 2024).

Fairness, equity, and transparency in AI decision-making are also critical for ensuring safe and beneficial intervention. A growing volume of warnings and recommendations pertaining to model interpretations has emerged in numerous disciplines, underlining the scientific community's increasing emphasis on these attributes; guidance documents have even started to advocate for clearer definitions of AI functionalities and limitations in submitted research.

6.3. Patient-Centric Communication and Shared Decision-Making

Clinicians are responsible for interpreting test results, understanding the implications, and, in collaboration with patients, making shared decisions about further steps. Maintaining patient-centeredness at every stage of AI-assisted screening for silent cardiac disease is critical to its ethical, effective, and equitable implementation. A patient-centric communication protocol—detailing how results are conveyed and documented with patient input—guides all integration efforts. Initially, an interactive laptop-based system connects with the patient through verbal and written input; subsequently, a web-based platform facilitates centralized documentation across settings, captures patient follow-ups, and enables prospective workflow sustainability.

Communication is prioritized at every point along the integrated care pathway: during initial screening and triage calls, at the AI-analysis stage, and following auxiliary connections with the pharmacy, cardiology, or other involved teams. Each transition features the systematic use of patient-friendly questions, which facilitates identification of additional needs or reasons for non-action, guides the choice of supplementary content within the software tool, and ensures that awareness is preserved before, during, and after transitions. By following a dedicated protocol for reinforced communication, the comprehensive screening-and-detection opportunity is preserved and no barriers to pharmacy access, medication adjustment, adherence intervention or other pathways are inadvertently introduced.

7. Implementation and Evaluation

Artificial intelligence–electrocardiogram (AI-ECG) analysis has the potential to transform early detection of silent cardiac diseases through interprofessional engagement with nursing and pharmacy. These fields enhance access to ECGs and education about silent cardiopathy, which more than half of patients cannot report symptoms before myocardial infarction (Tang et al., 2023). AI-ECG interpretation lacks formal integration but aligns with complementary roles in screening, medication management, and pharmacovigilance. Team-based conceptual models clarify integration paths and communication across disciplines.

Pilots in diverse settings will confirm operational feasibility of interdisciplinary workflows, performance dependence on ECG acquisition and patient characteristics, and longitudinal impacts on screening, triage, and pharmacotherapy. Primary measures—sensitivity, specificity, and clinical prioritization—accompany subgroup analyses for age, gender, location, acquisition device, and screen- ECG combination. Economic assessments weigh costs against existing cardiology demand and staffing resources to project comprehensive incorporation into community practices.

Interprofessional scrutiny will address risks to equity, transparency, consent, and interdisciplinary accountability associated with training data and algorithmic outputs (Ranjha et al., 2023). Insights on access disparities, decision-making frameworks, data ownership, and professional responsibilities will inform decisions about governance, oversight, and redistribution. Expanding screening and triage to settings with unmonitored access to adjustment and monitoring recommendations ensures equitable benefit from AI-ECG advances.

7.1. Pilot Studies and Feasibility

Pilot studies and feasibility evaluations are crucial in developing AI-based ECG solutions using wearable devices. One study demonstrated the development of a multiplatform system for rapid deployment of AI ECG interpretation using devices like the Apple Watch and KardiaMobile. The ECG data from these devices is channeled to a centralized data lake for real-time analysis without substantial differences in data acquisition across platforms. Such findings indicate that AI-driven ECG interpretation can be efficiently implemented across devices, enabling widespread clinical impact through rapid deployment.

Nurse-led home-based ultrasound detection of cardiac dysfunction provides a relevant precedent. Novice nurses with limited training performed home-based echocardiographic examinations to identify patients with reduced left ventricular ejection fraction or increased left atrial volume index with accuracy comparable to trained senior physicians. Deep learning algorithms exhibited good agreement with expert measurements, facilitating interpretable assessments in 80% of patients. Home-based AI-enabled point-of-care ultrasound ultrasound was preferred over conventional clinic-based echocardiography, underscoring the potential of remotely monitored, nurse-led, AI-supported examinations (Tromp et al., 2023).

7.2. Metrics: Sensitivity, Specificity, and Clinical Impact

Early Detection of Silent Cardiac Diseases using AI-ECG: Sensitivity, Specificity, and Clinical Impact

Artificial intelligence (AI) techniques can enhance the early detection of silent cardiac diseases with non-invasive electrocardiogram (ECG) data. Applying such technology within a regulatory framework that safeguards patient equity, safety, and privacy, nurses and pharmacists can accelerate identification and treatment, thereby reducing morbidity and mortality in a cost-effective manner. The highly automated nature of the AI-ECG algorithm and the straightforward deployment of ECG devices through community pharmacies allow flexible adaptation to diverse healthcare settings.

These two disciplines can also collaboratively develop principled governance structures ensuring secure patient data management and appropriate care access. Such frameworks facilitate guided triage and education during nurse-led screening via community pharmacy channels.

Sensitivity, specificity, and clinical impact constitute the primary evaluation metrics (Tang et al., 2023). AI-ECG intervention aims to enhance screening by 1) increasing sensitivity and specificity, as measured by ECG signals at uptake points, and 2) influencing clinical guidance through real-world pharmacy and physician pathways, thereby addressing the earlier stages of screening care. Subgroup analyses will further investigate variations across polypharmacy statuses, ECG signal types, annotation modalities, and clinic settings (Vasu Kalmady et al., 2024).

Inter-profession collaboration offers a promising approach for addressing silent cardiac diseases in more communities and countries. Further attention to equity concerns during AI-ECG integration holds the potential to democratize healthcare access according to patient needs, contextual factors, and other barriers, ultimately targeting remote or resource-strapped locations (Lu et al., 2024).

7.3. Economic and Resource Implications

Silent cardiac diseases, which account for approximately 65% of all cardiovascular fatalities globally, often go undetected during early stages of the disease. Major obstacles to early detection of silent cardiac disease revolve around elevated access barriers for electrocardiogram (ECG) screening in the general population and challenges in scaling widespread ECG monitoring without cumbersome user interfaces. The implementation of Artificial Intelligence (AI) methods capable of analyzing ECG signals on consumer devices could address these challenges. The scheme relies heavily on the ECG signal's temporal characteristics to ensure the analysis works even without access to specialized medical devices. Based on the ECG signals obtained from smart devices, an integrated decision-support tool combines triage, medication management, and adherence calculation to offer timely intervention recommendations. AI-based ECG screening can be seamlessly integrated into existing nursing triage and medication management practices. The programme consequently facilitates early detection of cardiac conditions and consequently enables prompt treatment.

8. Ethical, Legal, and Social Implications

For cardiac diseases, screening and early detection are crucial, especially for silent but potentially severe diseases like cardiac hypertrophy, atherosclerosis, arrhythmia, and ischemia. Artificial intelligence augmented electrocardiograms (AI-ECG) hold promise for improved early detection. The integrated approach leverages nursing and pharmacy roles in screening, triage, education, and safe pharmacotherapy, complemented by support from AI-ECG methods. EMS prehospital electrocardiograms (ECGs) also represent a valuable opportunity to enhance cardiac disease screening. Assessing the feasibility of implementing AI-ECG and cross-sector integration between nursing, pharmacy, and AI in the detection of silent cardiac diseases can significantly advance early screening and detection efforts.

AI-augmented ECG analysis for silent cardiac disease detection offers the potential to improve early screening where screening is minimal. Although critical for public health, screening for cardiac disease remains insufficient, particularly for prevalent yet silent forms. Expanding ECG interpretation capacity through automated ECG analysis while maintaining access equity could greatly alleviate this problem. Thus, an integrated approach to screening, education, safe pharmacotherapy, and prevention would represent a substantial advance towards a more equitable healthcare environment for silent cardiac disease, addressing an important public health challenge (Lu et al., 2024).

8.1. Bias, Equity, and Access

Uncontrolled growth of AI and ECG technologies may generate significant harms. Training and operational data must be equitable, accessible, and devoid of bias to ensure universal benefits (Vasu Kalmady et al., 2024). Large language models exemplify how entrenched biases may elude even conscientious governance. Such risks are exacerbated in developed regions, suggesting settings with greater data control and societal oversight. Founded on the supremacy of human well-being and safety, AI ECG value propositions, standards, and safeguarding paradigms must evolve. Solutions must address balance, avoidance, formulation, transfer, and transition of long-term, predictable, aggregated, and ecosystem-wide risks associated with active AI adoption and use. Gaps often center on interdisciplinary goal-oriented AI adaptation; further scoping is warranted.

8.2. Informed Consent and Data Ownership

ECG data require careful management to ensure patient confidentiality, regulatory compliance, and sustainable governance (Murdoch, 2021). Logs will track access rights, anonymization, and transfers. Access will be limited to team members whose direct roles the AI analysis supports, preventing misuse of unrelated data; periodic review will confirm continued necessity. Appropriate governance models must balance risk sharing—essential given the diverse, wide-reaching nature of electronic health records (EHRs)—with accountability, public acceptability, and transparency, preserving stakeholder trust (Vasisht Shankar et al., 2023).

Consent mechanisms for ECG-data collection, sharing, and model training will comply with local regulations and health authorities. Screening conversations will inform candidates about the analysis, its potential benefits, the AI's interpretative role alongside clinician validation, and the option to withdraw. Documented consent will specify data types, sharing conditions, and project scope; a standardized template will ensure consistency and satisfy regulatory requirements.

9. Future Directions and Policy Implications

Silent cardiac diseases can be detected earlier through an interdisciplinary, AI-ECG approach that integrates pharmacy and nursing roles. Silent cardiac conditions, including arrhythmias and ischemia, carry high morbidity and mortality risks. Nursing, with its broad access to the general population, can facilitate early screening, education, and triage. Pharmacists additionally contribute to the detection of these undiagnosed, potentially severe conditions through access to medications and follow-up services.

A wider implementation of AI-ECG for silent cardiac disease screening will require further steps on multiple fronts: establishing corresponding standards around data acquisition, training, and technical competency; generating curricular content and training plans; and exploring avenues for sustainable workforce development and support. Integrating additional educational elements on AIEC, such as adverse effects of targeted medications, monitoring protocols for drugs causing QTc prolongation, and specific pharmacist-increasing ECG analysis capabilities, may further strengthen pharmacy involvement in this team-based effort. The collaborative nature of this AI-

ECG framework presents a unique opportunity for refining and enhancing one discipline in interdisciplinary screening without compromising interprofessional contribution.

9.1. Scalability and Standards

Artificial intelligence (AI) has become an important tool for transforming ECG diagnostics in silent cardiac disease detection. The potential of AI-ECG does not only facilitate advanced early detection of silent cardiac diseases through electronic triaging and screening but also provides an expanded opportunity for team-based collaborative interprofessional early screening that combines the disciplines of nursing and pharmacy. In the proposed framework, AI-ECG systems cover missing electrocardiogram (ECG) testing equipment in health facilities, allow examination of innumerable ECGs, and perform frontline comprehensive ECG screening with feasible measures to tackle existing inefficiencies.

Nurses represent the largest group of health professionals and are accessible in almost all outpatient and primary care resulting in preferred entry points for screening (Thomas Chew et al., 2021). Nurse-led, telephone-based screening dialogues concerning suspected silent cardiac diseases are conducted to inform patients on the significance of silent cardiac disease screening and enhance screening voluntary participation. Community pharmacists are often the most easily approachable health professionals, even in the absence of medical prescriptions, and are also available for consultative help on medication and arrhythmia queries every day. Pharmacists are often one of the first few health professionals that patients initiate contact especially when experiencing drug adverse effects and are responsible to identify any early signs of silent cardiac disease.

9.2. Training, Education, and Workforce Development

Silent cardiac diseases represent a medicine-wide epidemiological problem, particularly in low- and middle-income countries such as India. The unique aspect of silent cardiac diseases is their capacity to progress unnoticed by individuals for years and even decades. Patients do not show any of the classical warning symptoms or signs of cardiac misbehavior. Consequently, these individuals remain undetected and untreated, leading to damage and deterioration of cardiac functions. In many cases, the first manifestation occurs through sudden cardiac arrest (SCA). SCA becomes the cause of death for these individuals who are otherwise apparently healthy. Large-scale, low-cost, early-detection systems that are unaffected by individual awareness and that can reach the vast majority of the general population are urgently needed.

On the other hand, Artificial Intelligence (AI) has gained widespread attention in the medical field over the last few years due to the superior performance of AI in detecting diseases from medical signals and helping individuals to manage health. Heart signals, which can be conveniently and broadly acquired through Electrocardiograms (ECGs), represent a key signal for monitoring heart conditions, providing helpful information to both professionals and individuals. AI then integrates with heart signals to provide silent cardiac-disease detection through medical signals. One of the challenges in such a system is data governance, as AI requires a sufficient amount of data to train a well-performing model, and sensitive health data is strictly regulated. However, ECGs are not confidential under national policies, especially when compared to other health signals such as

Magnetic Resonance Imaging (MRI) pictures. Consequently, ECGs and heart signals become an ideal entry point for silent cardiac-disease detection.

10. Conclusion

While silent cardiac diseases are increasingly prevalent, timely detection remains challenging despite clear evidence for systematic screening. This interprofessional initiative targets early detection of arrhythmia and ischemia by integrating artificial intelligence and electrocardiography within the nursing and pharmacy disciplines. A systematic review identified relevant electrocardiographic data, artificial intelligence methodologies, and screening approaches. These insights inform a non-exhaustive research programme aimed at orchestrating multidisciplinary workflows governed by coordinating teams. Such collaborative, team-based care can enhance patient equity and safety, optimise data-sharing governance, and potentially improve health outcomes across diverse, resource-constrained contexts. Automating electrocardiogram analysis and triaging allows nurses to detect anomalies and inform pharmacists. Pharmacists can further identify and verify electrocardiogram findings, leveraging artificial intelligence at the point of care to augment patient data and decision-making, streamline adherence interventions, and strengthen pharmacovigilance.

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