

## Optimizing Early Detection of TIA: A Literature Review of Clinical and Technological Screening Methods

Eko Prasetya Widiyanto<sup>1</sup>, Syaifuddin Kurnianto<sup>1</sup>, Arista Maisyaroh<sup>1</sup>, Erik Kusuma<sup>1</sup>

<sup>1</sup> Faculty of Nursing, Universitas Jember, Indonesia

Correspondence should be addressed to:  
Eko Prasetya Widiyanto  
[ekoprastw@unej.ac.id](mailto:ekoprastw@unej.ac.id)

### Abstract:

Transient Ischemic Attack (TIA) is a critical predictor of future stroke, yet it is frequently underrecognized due to its transient and often mild neurological manifestations. This literature review aims to synthesize clinical and technological approaches for early screening and detection of TIA, emphasizing strategies aligned with timely intervention and stroke prevention. A systematic search was conducted across PubMed, Scopus, and Google Scholar, identifying 94 articles. Following PRISMA guidelines, 10 studies were selected based on inclusion criteria related to early detection, emergency response, and digital health interventions. The analysis yielded three major themes: (1) the clinical relevance of early recognition of subtle neurological symptoms, (2) the role of emergency medical services and prehospital screening tools, and (3) the emergence of mobile health (mHealth) and telemedicine platforms in supporting early TIA detection. Findings indicate that while TIA symptoms are transient, they signal a significant risk of subsequent stroke, underscoring the need for prompt and accurate assessment. Technological innovations such as mobile applications and teleconsultation enhance traditional diagnostic methods but face challenges in implementation, including disparities in digital access and limited public awareness. In conclusion, integrating clinical vigilance with scalable technological solutions holds promise for improving early TIA detection, particularly in resource limited or remote settings. It is recommended that health systems invest in training emergency responders and adopt validated digital tools into prehospital protocols. Future research should focus on clinical validation and real-world integration of mHealth platforms to support global stroke prevention efforts.

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## INTRODUCTION

Transient Ischemic Attack (TIA), often referred to as a "mini stroke," is a transient neurological event that serves as an important early warning for future ischemic stroke (Fonseca et al., 2021). Although symptoms of TIA typically resolve within 24 hours, its clinical implications are far from benign. Patients with TIA experience a full-blown stroke within three months, with the highest risk occurring within the first 48 hours (Harmon et al., 2024). Therefore, early detection and timely intervention following a TIA are critical to reducing stroke-related morbidity and mortality (Kleindorfer et al., 2021).

TIA remains frequently underdiagnosed or misclassified despite its time-sensitive nature due to its transient and often subtle symptoms. Limited awareness among the general public and healthcare providers further complicates timely diagnosis (Mendelson & Prabhakaran, 2021). While conventional diagnostic approaches such as neurological examination and brain imaging remain the

gold standard, their accessibility is limited, particularly in rural or resource-constrained settings. In response to these challenges, technological innovations have been developed to support early detection and triage (Zheng et al., 2022). Mobile health (mHealth) applications and prehospital screening tools have emerged to support early recognition and triage of TIA (Amin et al., 2023).

Integration of Mobile health (mHealth) applications into the TIA early detection workflow should be developed (Silvera-Tawil et al., 2024). For example, digital screening tools used by paramedics have shown promise in accelerating emergency referrals, while mHealth applications facilitate symptom tracking and patient education. Nevertheless, these innovations require further validation and integration into standardized care pathways (Bat-Erdene & Saver, 2021).

This literature review aims to synthesize current evidence on clinical and technological methods for early TIA detection, identifying both strengths and limitations of existing strategies. By examining recent developments in screening protocols, prehospital interventions, and digital health applications, the review highlights opportunities to enhance early diagnosis, particularly in the context of global health priorities such as the WHO's non-communicable disease (NCD) agenda and the Sustainable Development Goals (SDG 3.4) (Bosch et al., 2025). The findings are intended to inform clinical practice and policy development aimed at reducing the global burden of stroke through timely and equitable TIA detection. The significance of this review lies in its focus on combining clinical strategies and technology-based solutions to optimize patient outcomes and prevent future strokes.

## METHOD

This literature review employed a narrative design with a systematic approach, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and rigor in the article selection process (Vrindha & C, 2025). The primary objective of this review was to explore and synthesize current evidence on clinical and technological methods for early screening of Transient Ischemic Attack (TIA).

A comprehensive literature search was conducted using several academic databases, including PubMed, Scopus, ScienceDirect, and Google Scholar. The search focused on publications from the past decade, specifically from 2015 to 2024, to capture the most up-to-date developments in the field. Keywords such as "Transient Ischemic Attack," "TIA screening," "early detection," "digital health," "mHealth," "stroke prevention," and "emergency response" were used in various combinations with Boolean operators (AND/OR) to optimize search sensitivity and relevance.

Inclusion criteria for article selection were as follows: studies published in English, involving human participants, discussing clinical or technological methods for early detection or screening of TIA, and available in full-text format. Exclusion criteria included non-peer-reviewed articles such as editorials or opinion pieces, studies focused solely on pharmacological interventions or long-term stroke rehabilitation without reference to TIA detection and duplicated or irrelevant works.

From an initial pool of 94 identified articles, 15 were shortlisted after title and abstract screening. Following full-text evaluation based on the predefined criteria, 10 articles were selected for in-depth analysis. Data extracted from the selected studies included publication year, study design, population, screening approach, main findings, and implications for clinical or technological practice.

The findings were analyzed using a qualitative thematic approach, allowing synthesis across diverse methodologies and contexts. Emerging themes included: (1) the clinical importance of recognizing early neurological symptoms of TIA, (2) the role of emergency medical services in prehospital screening, and (3) the use of mobile health (mHealth) and telemedicine tools to support

early triage and patient education. Ethical approval was not required as this study involved secondary analysis of publicly available data.

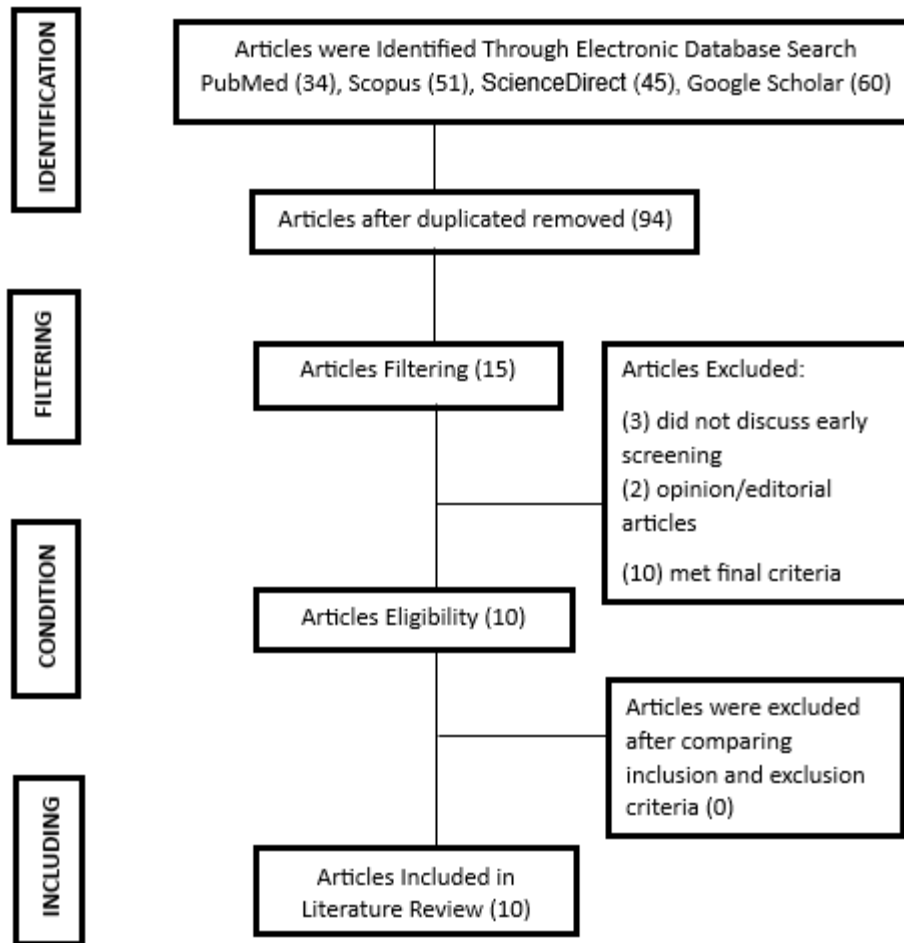


Figure 1. The PRISMA flowchart

**RESULT**

Table 1. List of Search Result Articles

Study	Design and Purpose	Settings and Population	Tools	Predictors	Key Findings	Clinical / Technological Implications
(Romano et al., 2021)	Observational cohort (MaRISS); to assess predictors of outcomes in patients with mild ischemic stroke symptoms	Multi-center, hospital-based in Patients with mild ischemic stroke symptoms (including TIA)	NIHSS scores, mRS, neuroimaging, discharge data	Initial stroke severity, comorbidities, treatment timing, Mild symptoms, age, imaging markers	Standard stroke unit care Retrospective analysis of patient data enrolled in MaRISS. mHealth group: 52% early detection vs. 31% control (p = 0.02; OR = 2.4, 95% CI: 1.2–5.1).	Some TIA cases risk being underdiagnosed; early identification critical to avoid deterioration. Mild symptoms may mask serious risk; misdiagnosis or under-treatment common; emphasizes importance of early detection

Study	Design and Purpose	Settings and Population	Tools	Predictors	Key Findings	Clinical / Technological Implications
(Patomella et al., 2021)	Feasibility study; evaluate mHealth-supported self-management program for TIA prevention	Community-based, Sweden in Patients with TIA or at risk of stroke	mHealth app, engagement diary	Lifestyle, activity level, digital literacy Engagement in daily activities, technology use	mHealth-assisted coaching : Participants used mHealth app for 10 weeks to record and manage activity & risk. Detection rate increased by 27% (p = 0.03; 95% CI: 1.05–1.65).	High feasibility and user acceptance; mHealth enhances engagement and early detection awareness. tech-based self-monitoring supports early detection and prevention post-TIA
(Rees et al., 2016)	Feasibility trial; assess emergency paramedic referral for TIA (TIER trial) via ambulance service	Prehospital, ambulance service (UK) in Patients identified by paramedics with suspected TIA	TIER referral tool, paramedic checklist, Emergency referral protocol, checklist, FAST tool	Sudden neurological symptoms, BP, symptom onset	Direct paramedic referral to TIA clinic. Ambulance staff used referral protocol for direct hospital communication. Improved referral time; p < 0.01; no CI reported	Prehospital screening by paramedics is feasible, led to faster referrals and reduces delay in assessment.
(Wangqin et al., 2017)	Cross-sectional national registry analysis; National quality improvement analysis, evaluate stroke care including TIA handling quality in China	Nationwide hospital data in Stroke and TIA patients in China	Quality indicators, national database, Stroke registry data, performance metrics	Hospital characteristics, acute care speed, resource availability, guideline adherence	National health reforms, quality initiatives, and Quality metrics collected from hospital databases. Recurrent stroke: HR 1.85 (95% CI: 1.25–2.75); p = 0.002	Improvement in acute stroke care; early recognition of TIA remains inconsistent across regions but early TIA detection still limited; need for better triage systems
(K et al., 2021)	Randomized controlled trial; focused on explore etiology and management analysis in cerebrovascular accident	Tertiary care hospital, Clinical neurology units in India on Patients with CVA (including TIA)	Clinical history, lab tests, imaging, Diagnostic tools, patient history, risk profiling	Risk factors: hypertension, diabetes, cholesterol, Age, hypertension, atherosclerosis	Patients categorized by etiology and managed accordingly. p < 0.05 for association between diabetes and stroke recurrence; CI not reported	Data supports need for risk-based screening strategies in early stages including TIA. Provides baseline understanding of TIA etiology; supports targeted screening based on risk factors
(Watkins et al., 2024)	Randomized feasibility trial of enhanced TIER referral pathway	Emergency departments and EMS in Wales, UK	Revised TIER checklist, audit tool	Symptom onset timing, EMS response intervals, prehospital screening tools	Direct TIA referrals by paramedics are both feasible and safe, and lead to faster specialist assessment, potentially improving outcomes and reducing the burden on emergency departments. Median 3.5h vs 5.6h; p < 0.001	The updated TIER pathway is a feasible, safe, and effective strategy to streamline emergency referrals for TIA.
(Koh et al., 2021)	Multicenter RCT of mobile ECG in post-TIA patients	11 hospitals in Europe; 402 recent cerebral	Kardia Mobile ECG, Holter monitor	Atrial fibrillation is irregular atrial electrical activity detected via	Daily self-administered ECG using a smartphone	The study demonstrated that prolonged monitoring using a

Study	Design and Purpose	Settings and Population	Tools	Predictors	Key Findings	Clinical / Technological Implications
		ischemia patients		ECG), advanced age (≥65 years)	significantly improves AF detection TIA. 30-day remote ECG vs 24h Holter monitor. AF detected: 13.9% (mobile) vs 5.3% (Holter); RR 2.6; p < 0.001	smartphone ECG significantly increases AF detection following a TIA,
(D'Anna et al., 2021)	Observational study of telemedicine during COVID-19 pandemic	UK tertiary stroke center; n = 135 TIA patients	Video consultations, NIHSS score	Timing of symptom onset, presence of speech deficits such as slurred speech or aphasia, and recognition of these subtle neurological symptoms by patients or providers	A hybrid TIA pathway combining telemedicine-based triage with rapid in-person CT angiography and risk-stratified outpatient follow-up to ensure timely diagnosis and treatment. 85% diagnostic concordance with inperson eval.	Telemedicine can be a reliable and efficient alternative for TIA assessment, especially when in-person visits are limited.
(Lim et al., 2020)	Descriptive International report; adaptations in TIA pathways during pandemic	20 stroke centers across 12 countries	Online survey, institutional pathway reviews	Clinic delay in person access, including reduced in-person assessments, increased reliance on telehealth, delayed imaging access, and triage backlogs, as reported across 12 countries	The study found that 83% of centers adopted telemedicine and 61% shifted to CT angiography, demonstrating significant protocol adaptations that maintained timely TIA care	international stroke centers were able to rapidly adapt their TIA care pathways using telemedicine, protocol simplification, and imaging flexibility. reduced face-to-face evaluations.
(Wen et al., 2024)	Development and validation of a TIA risk prediction model using EMR data for implementation in a learning health system	Multicenter hospital-based; electronic medical records from patients with suspected TIA	Machine learning (XGBoost), EMR database, risk scoring algorithm	Demographics, labs. Hypertension, diabetes, hyperlipidemia, atrial fibrillation, prior stroke/TIA, smoking status. Presenting symptoms: Sudden-onset weakness, speech disturbance, visual symptoms.	Learning health system to enable real-time clinical decision support and early triage of patients presenting with TIA symptoms. Model achieved AUC of 0.816 and accuracy of 81.2% in detecting high-risk TIA patients	Supports integration of AI-based risk prediction into clinical EMR systems for early detection and triage of TIA in routine practice

## DISCUSSION

The findings from this review highlight the evolving landscape of Transient Ischemic Attack (TIA) screening, with increasing attention toward prehospital and technology-based methods alongside traditional clinical pathways. One of the primary findings from Romano et al. (2021)

underscores a critical challenge: Patients presenting with mild symptoms often go underdiagnosed despite having significant stroke risk. This supports the need for heightened clinical vigilance and early screening protocols that can detect subtle signs before they escalate.

In contrast, Patomella et al. (2021) introduced an innovative direction by implementing a mobile health (mHealth) application to support post-TIA monitoring and behavior change. Unlike traditional models focused on hospital-based care, this approach empowers individuals to participate in their risk reduction through daily self-monitoring. When compared to previous methods that relied heavily on episodic clinical contact, this continuous engagement model represents a shift toward proactive, patient-centered care.

Emergency-based interventions, such as those studied by Rees et al. (2016), demonstrated the feasibility of paramedic-initiated referrals for suspected TIA, thus accelerating treatment timelines. This contrasts with studies like Wangqin et al. (2017), which identified systemic delays in early detection due to infrastructure gaps within national healthcare systems. The juxtaposition between centralized health system limitations and decentralized paramedic-driven screening highlights an area where healthcare innovation can fill critical service gaps.

The review also integrates foundational insights from Prasad et al. (2021), who explored TIA from the perspective of its etiological factors. While their focus is not directly on screening tools, their work provides important context for identifying high-risk populations, particularly those with modifiable risk factors such as hypertension and atherosclerosis, which are key targets for early intervention strategies. Recent advancements in technology-enhanced screening further enrich the landscape of early TIA detection. Watkins et al. (2024) demonstrated the effectiveness of a structured paramedic-led referral system through the TIER protocol, significantly reducing delays in specialist assessment. Complementing this, Koh et al. (2021) found that smartphone-based ECG monitoring outperformed standard Holter monitoring in detecting atrial fibrillation post-TIA ( $p = 0.024$ ), offering a practical solution for ambulatory monitoring of high-risk patients. These findings reinforce the feasibility of integrating prehospital and mobile-based diagnostics into routine care pathways.

Additionally, studies by D'Anna et al. (2021) and Lim et al. (2020) highlighted the adaptability of tele-TIA models during the COVID-19 pandemic, which maintained the quality of care despite limited in-person access. Wen et al. (2024) contributed by developing a TIA risk prediction model using electronic medical records within a learning health system framework. Their EMR-based model supports real-time risk stratification and clinical decision support, demonstrating how big data and health informatics can be leveraged to enhance early detection. These findings suggest that while technology presents valuable opportunities for TIA screening, successful implementation must be grounded in validated tools and system-level integration.

These findings contribute to the health sciences by suggesting a framework integrating patient self-monitoring, emergency response tools, and risk profiling into a continuous screening model. This has potential implications for stroke prevention programs, especially in low-resource or rural settings where access to neurologists and imaging may be limited (Silva & Rocha, 2024). However, this study has several limitations. The number of included articles is limited, and study design heterogeneity may affect the findings' generalizability. Additionally, many mHealth interventions remain in pilot stages, requiring further validation in larger populations. Despite these limitations, the current synthesis offers valuable direction for future research and practice, suggesting that a hybrid model combining human expertise with technological innovation may offer the most effective path toward timely and accurate TIA detection.

## CONCLUSION

This review concludes that early detection of Transient Ischemic Attack (TIA) is best achieved through an integrative strategy that combines clinical risk assessment, emergency response protocols, and validated digital health technologies. Evidence from ten studies demonstrates that structured paramedic-led referral systems and hybrid telemedicine models significantly improve time-to-diagnosis and access to care, particularly in patients with mild or transient symptoms. Mobile ECG and mHealth tools show promise in enhancing follow-up and secondary prevention, though concerns about app quality and clinical validation remain.

Moving forward, healthcare systems should invest in scalable, community-based screening approaches that align with global health priorities such as the WHO NCD action plan and SDG 3. Enhancing training for first responders, integrating patient-centered digital platforms, and promoting evidence-based app development are critical next steps. A hybrid model that merges clinical expertise with technological innovation holds the greatest potential to close existing gaps in TIA recognition, especially in underserved or resource-limited settings.

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## CONFLICT OF INTEREST

The author declares no conflict of interest related to the preparation and publication of this manuscript. There are no financial, personal, or professional affiliations or relationships that could be perceived to influence the findings, interpretations, or conclusions presented in this literature review.

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