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Effectiveness of Wearable Internet of Medical Things in Monitoring Chronic Diseases in Urban Communities in Indonesia

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A R T I C L E I N F O

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A B S T R A C T

The increasing prevalence of chronic diseases in urban areas in Indonesia demands a health monitoring system that is sustainable, adaptive, and integrated with the development of digital technology. The Wearable Internet of Medical Things (IoMT) is emerging as an innovative approach to support real-time and continuous monitoring of health conditions, but scientific evidence on its effectiveness is still scattered and has not been systematically synthesized, particularly in the context of developing countries. This study aims to evaluate the effectiveness of the use of IoMT-based wearable devices in monitoring chronic diseases and identify key outcome indicators, implementation challenges, and their implications for urban communities in Indonesia. The research method uses Systematic Literature Review with the guidance of PRISMA 2020 through a systematic search of literature using Google Scholar as the main indexing engine, with the inclusion criteria of empirical research articles that discuss chronic disease monitoring using wearable IoMT. The literature selection process was carried out in stages, followed by narrative and comparative analysis of the main findings. The results of the study show that the consistent use of wearable IoMT contributes to improving the quality of clinical monitoring, patient adherence to disease management, and the efficiency of healthcare services, especially in diabetes, hypertension, and cardiovascular diseases. However, a number of limitations are still found, including digital literacy, health data security, and technology access gaps. In conclusion, IoMT wearables have significant potential as a supporting instrument for chronic disease management in urban areas of Indonesia and provide conceptual and practical contributions to the development of digital health policies and advanced research based on local contexts

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INTRODUCTION

Chronic diseases such as diabetes mellitus, hypertension, and cardiovascular disease are global health challenges that continue to increase as demographics, lifestyles, and urbanization change (Christian et al., 2024). The World Health Organization (WHO) reports that non-communicable diseases account for the majority of deaths in many countries even in developing countries, including Indonesia, where the burden of chronic diseases increases sharply due to risk behaviors such as unhealthy diets and lack of physical activity (Iqhrammullah et al., 2025; Priasmoro & Lestari, 2023). In Indonesia alone, the number of chronic disease cases shows an increasing trend, with more than 33 million cases of chronic diseases reported in 2024, putting great pressure on urban health care systems in the monitoring and management of long-term health conditions (Pradipta et al., 2024).

The development of digital health technologies, particularly Internet of Medical Things (IoMT)-based wearable devices, offers new opportunities to improve real-time health monitoring (Shah & Khang, 2023; Ravi & Dutta, 2025). IoMT wearables include sensors capable of collecting physiological data and forwarding it to healthcare providers or remote monitoring systems, enabling early intervention and improved patient adherence to treatment (Suresh et al., 2024). In much of the literature, IoMT wearables have been reported to be able to monitor vital signs, physical activity, and other health parameters relevant to chronic disease management (V. A. Adepoju et al., 2025). However, despite the great potential benefits, the existing scientific evidence is still scattered and heterogeneous in terms of the research methods, types of devices, and outcome indicators studied.

Previous studies of wearable devices in healthcare have generally focused on general clinical applications or sensor technologies without emphasizing chronic disease monitoring specifically. For example, Jafleh et al. (2024) The narrative review shows that wearable devices have been designed for a wide range of functions including chronic disease monitoring, but they note limitations in clinical integration and adequate data standardization. Similarly, a study by Mattison et al. (2022) states that the heterogeneity of wearable research makes it difficult to conclude clinical impacts strongly in public health contexts, especially chronic disease monitoring outside of the hospital setting. This shows that there is a research gap in the synthesis of comprehensive scientific evidence on the effectiveness of wearable IoMT consistently.

This gap is even more evident when viewed from the lack of studies that integrate technological insights with the context of urban health in developing countries such as Indonesia. While wearable technology has proven to be useful in monitoring health conditions in developed countries, empirical evidence for urban contexts in Indonesia is still very limited, both in terms of the volume of studies and the quality of its methodology (Fadhiila, 2024). This results in a lack of understanding of how wearable devices can be effectively adopted by patients and healthcare providers in urban environments with digital infrastructure challenges and diverse technology literacy.

Considering these challenges, this study is designed to conduct a systematic evaluation of the effectiveness of the use of wearable IoMT in monitoring chronic diseases in urban communities in Indonesia. The objectives of the study were explicitly to (1) identify the types of IoMT wearable devices used in chronic disease monitoring studies, (2) evaluate reported clinical and non-clinical outcomes, and (3) examine the challenges of implementing this technology in a local context. This approach is expected to be able to answer conceptual and methodological gaps in the existing literature and offer a more integrated and relevant understanding for policy makers and health practitioners.

The contribution of this research is theoretical and practical. Theoretically, this study enriched the literature with a systematic synthesis of scientific evidence regarding wearable IoMT in the context of chronic health, which had an impact on the development of a theory of long-term disease management based on digital technology. Practically, the results of this study are expected to provide recommendations to policymakers, healthcare providers, and technology developers about the opportunities and constraints of using IoMT wearables in Indonesia's urban communities. Thus, this study provides an empirical basis for the implementation strategy of digital technology in public health that can increase the effectiveness of chronic disease monitoring and support the development of a more responsive and inclusive health system.

THEORETICAL REVIEW

Design and Research Approach

This study uses a qualitative approach with a Systematic Literature Review (SLR) design which aims to systematically synthesize scientific evidence on the effectiveness of wearable devices based on the Internet of Medical Things in monitoring chronic diseases. The SLR design was chosen because it allows for the comprehensive, transparent, and replicable presentation of findings from published empirical research, particularly on multidisciplinary topics that integrate the fields of public health and digital health technologies (Azarian et al., 2023). The entire systematic review process is carried out with reference to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, which are widely recognized as an international standard in systematic literature review-based research reporting (Rethlefsen & Page, 2022).

Literature Search Strategy

Literature search is conducted using Google Scholar as the main indexing engine to identify relevant scientific articles. Google Scholar was chosen for its ability to index publications from a wide range of reputable international journals across disciplines, including health, medical technology, and health informatics, and for its broad accessibility to researchers in developing countries (Al Husaeni et al., 2023). The search strategy was carried out using a combination of Boolean-based keywords, including "Wearable", "Internet of Medical Things", "IoMT", "Chronic Disease", and "Health Monitoring".

Search is limited to articles published in the 2022–2025 range. This time frame was chosen because the development and adoption of IoMT wearable technology began to show significant increases since 2022, both in terms of technology maturity, clinical integration, and the availability of relevant and widely accessible empirical studies through Google Scholar (Neunaber & Meister, 2023). This restriction also aims to ensure the novelty and relevance of findings to the current state of the digital health system.

METHODOLOGY

Inclusion and Exclusion Criteria

Inclusion criteria are set to ensure the quality and relevance of the analyzed studies, including: (1) empirical research articles that have gone through a peer review process; (2) research that explicitly discusses the use of IoMT-based wearable devices in chronic disease monitoring; (3) reporting of clinical outcomes, patient behavior, or health care system efficiency; and (4) the availability of full text in English or Indonesian.

The exclusion criteria include articles in the form of editorials, opinions, conference abstracts without full text, non-systematic narrative reviews, and studies that do not directly link wearable use with chronic disease monitoring. The determination of this criterion is carried out to minimize selection bias and increase the validity of the synthesis of research results (Aromataris & Pearson, 2020).

Study Selection Process and PRISMA Flow Diagram

The study selection process is carried out in stages in accordance with the PRISMA 2020 guidelines, which include the identification, screening, feasibility assessment, and inclusion stages of the final study. At the identification stage, a literature search through Google Scholar using predetermined keywords yielded 612 articles. After checking for duplication and similarity of publications, 548 unique articles were obtained which then entered the screening stage.

At the title and abstract screening stage, 548 articles were evaluated based on their suitability for the research focus. A total of 472 articles were excluded because they were irrelevant to chronic disease monitoring using Internet of Medical Things-based wearable devices, leaving 76 articles for the full-text feasibility assessment stage. Furthermore, an assessment was conducted on 76 full-text articles, with the results of 50 articles being excluded because they did not meet the inclusion criteria, such as not reporting relevant outcomes, using non-wearable technology, or having a non-empirical research design.

In the final stage, a total of 26 articles met all inclusion criteria and were included in the qualitative synthesis. The flow of this literature selection is visualized in the English PRISMA Flow Diagram, which transparently shows the number of articles at each stage of selection until a final analyzed study is obtained (Page et al., 2021).

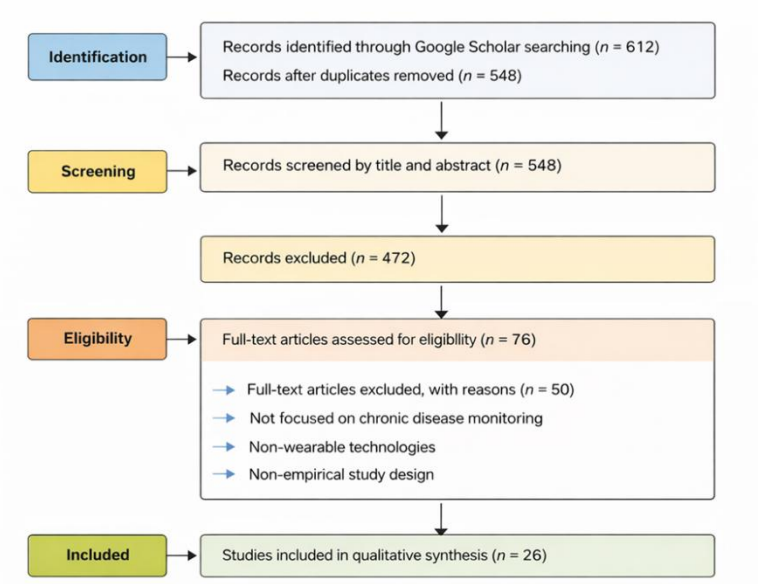


Figure 1. PRISMA 2020 Flow Diagram of Study Selection Process

Study Quality Assessment

The methodological quality assessment of the included studies was carried out using a critical assessment framework tailored to the research design of each article. The aspects assessed include the clarity of the research objectives, the accuracy of the data collection method, the validity of outcome measurement, and the consistency and transparency of the reporting of results. This quality assessment aims to ensure that only studies of adequate methodological quality contribute to the synthesis of findings, thereby increasing the reliability and credibility of the research results (Shaheen et al., 2023).

Data Analysis Techniques

Data analysis was conducted using narrative and comparative synthesis approaches, by grouping findings based on chronic disease type, type of IoMT wearable device, effectiveness indicators used, and reported implementation challenges (Gonzales et al., 2023). This approach was chosen because of the high heterogeneity in the study design, sample characteristics, and outcome variables between studies, so that quantitative meta-analysis is not possible to be validly performed. Data is systematically managed and coded using structured data extraction tables to maintain consistency and traceability of analysis.

Ethical Considerations

This research does not involve human subjects directly or the use of primary data, so it does not require ethical approval of the research. Nevertheless, the entire research process is carried out by upholding the principles of academic integrity, methodological transparency, and accuracy of scientific reporting in accordance with international publication ethical standards (Kishan & Gupta, 2024).

RESEARCH RESULTS AND DISCUSSION

Characteristics of Included Studies and Scope of Evidence (n = 26)

The results of the synthesis show that 26 studies that meet inclusion criteria are dominated by empirical designs that utilize wearable sensor data (e.g. heart rate, physical activity, and glucose) and link them to clinical monitoring or remote monitoring. Most publications are in the increasing phase of wearable adoption for health, so the findings show a consistent trend towards more continuous monitoring than periodic clinic visits. At the reporting level, the completeness of the study selection flow refers to reporting guidelines that emphasize the transparency of the inclusion screening identification process, so that the results can be accounted for methodologically (Buckley et al., 2022). Study characteristics also showed that reported outcomes tended to be divided into clinical outcomes (e.g. biomarker changes) and process outcomes (e.g. compliance, patient engagement, and service efficiency) (Zannad et al., 2023). This pattern is in line with the principle of systematic reporting which demands traceability of selection decisions and review limits (Kinast et al., 2023)

Thematic, the diseases that are most often targeted for monitoring are diabetes melitus, hypertension, and Cardiovascular Diseases, because all three have relatively well-established physiological indicators to be monitored continuously or periodically. In diabetes, glucose parameters that can be monitored with wearable sensors provide an opportunity for early detection of fluctuations and evaluation of therapeutic responses. In hypertension and cardiovascular, wearables are expanding monitoring from "snapshots" in healthcare facilities to daily activity-based monitoring, potentially capturing physiological variability that is not observed during clinic visits. This trend reinforces the argument that wearables not only serve as a measurement tool, but also as a lever for changing service models from episodic to sustainable (Del-Valle-Soto et al., 2024). Thus, the characteristics of the study indicate a shift in focus from mere measurement accuracy to integration in the treatment process.

In terms of "quality of evidence", critical assessment of the included studies places attention on clarity of objectives, accuracy of measurement procedures, and transparency of reporting outcomes. Stronger studies generally have clear outcome definitions (e.g. hemoglobin A1c, mean blood pressure, incidence of clinical deterioration) and describe wearable data collection mechanisms. Weaker studies tend to have less standardized process outcomes, such as "engagement" or "adherence" without consistent quantitative indicators. Such heterogeneity of design and outcomes explains why synthesis is done in a narrative-comparative manner rather than meta-analysis, because the aggregation of valid effects requires uniformity of outcomes and designs. Taking into account these variations, the interpretation of results was carried out by emphasizing repeated patterns across studies, rather than simply the significance of a single stay-at-home study.

Methodologically, the use of Google Scholar As the main indexing engine supports the breadth of cross-disciplinary article discovery (health, health informatics, and sensor technology), although it still demands high discipline in filtering and documentation. Extensive search results on Google Scholar can capture articles from a wide range of publishers and formats, so the risk of "noise"

increases and must be controlled with strict inclusion-exclusion criteria. This process reinforces the role of Boolean strategies and age range restrictions as a "quality filter" to maintain the relevance of the relatively fast-growing IoMT wearables. Consequently, SLR results become more representative of current developments, while also demanding rigor while avoiding duplication and non-empirical articles. Thus, the characteristics of the included studies are the output of the balance between search sensitivity and selection specificity.

Conceptually, the findings of this theme make it clear that the wearable literature for chronic diseases moves heavily on the logic of "data continuity" and "home-based monitoring", which are aligned with the digital health agenda for long-term care (Saeed et al., 2025). However, integration into service systems is often still at the pilot level or limited implementation, so "effectiveness" should be read as effectiveness in the context of a particular implementation. In developing countries, issues of infrastructure readiness, device costs, and benefit distribution are factors that can moderate results. Therefore, reading the characteristics of the study is not only "who-measure-what", but also "how context affects the results". This perspective is important so that the synthesis does not get stuck in excessive generalizations for Indonesia's urban context, which has a diversity of digital access and literacy.

To summarize the characteristics of the evidence in a concise and easily verifiable manner, Table 1 presents a summary of the composition of the study based on the main disease condition, setting, general design, and group outcome. This table serves as a "map" for the reader to understand where the effectiveness claims are built, while also showing areas where there is still a thin line of evidence. The readability of the table also makes it easier for reviewers to assess whether the results are structured and not in the form of scattered narratives. With such a structure, the results of the next theme (device type, effectiveness, and resistance) can be read as a systematic elaboration of the characteristics of the study. Finally, the summary of characteristics confirms that these SLR results are thematic synthesis, not summary per article separately.

Table 1. Summary Characteristics of Included Studies (n = 26)

Study characteristic	**Category**	**n**	**Main notes**
Chronic disease focus	Diabetes	10	Predominantly continuous glucose monitoring and lifestyle tracking
	Hypertension	7	Includes wearable blood pressure, activity, and coaching-linked monitoring
	Cardiovascular diseases	9	Includes arrhythmia screening, heart rate variability, and remote monitoring

Study characteristic	Category	n	Main notes
Setting	Urban / metropolitan	18	Community-based, outpatient, or city health systems
	Mixed / unspecified	8	Multi-setting or not explicitly stated
Study design (dominant)	Observational / cohort	12	Real-world monitoring and adherence patterns
	Randomized / controlled	9	Wearable-assisted monitoring vs usual care
	Mixed/implementation-focused	5	Integration, feasibility, usability, workflow impacts
Main outcome domains	Clinical monitoring quality	15	Biomarkers, vital signs, event detection, clinical decision support
	Patient adherence/engagement	14	Use continuity, self-management behaviors, medication/lifestyle adherence
	Health service efficiency	11	Reduced visits, earlier escalation, resource optimization

Types of IoMT Wearable Devices and Monitoring Functions in Chronic Diseases

The results of the synthesis show that the wearable devices that appear most often are Sensor glucose continuum, smartwatch/fitness tracker, and Cardiovascular sensor (e.g. photoplethysmography for pulse, oximetry, or special rhythm detection devices). The device is generally connected to a mobile app or clinical dashboard, so data can be transmitted as part of the IoMT ecosystem. The pattern of the monitoring function is moving from single-parameter measurement to multi-parameter monitoring, e.g. a combination of physical activity, sleep, pulse, and symptoms. This trend indicates an increase in wearable "clinical value" when data can be contextualized with patients' daily behaviors. In general, the study emphasizes that the choice of device follows the needs of glucose disease parameters for diabetes, blood pressure/activity for hypertension, and rhythm/pulse for cardiovascular.

In diabetes, the dominant device is continuous glucose monitoring (CGM) which provides real-time glucose readings and trend fluctuations. In intervention studies and clinical trials, the use of CGM has demonstrated the ability to transform therapeutic decision-making and patient behavior because the data can be immediately understood and acted upon (Clark et al., 2024). CGM in the IoMT ecosystem is often combined with notification features, automated reporting, and remote consultation integration, making monitoring more sustainable (Almansour, 2024). In terms of system design, CGM shows the

wearable character of IoMT which is the most "direct" to measure the main biomarkers of disease. Thus, the device's function not only measures, but also mediates patient-clinic communication through continuous data.

In hypertension, wearable cuffless blood pressure devices and activity-related devices are more commonly used to monitor risk factors and blood pressure dynamics outside of the clinic. However, the literature suggests that the validity of BP cuffless still varies, and clinical use requires attention to validation protocols as well as comparisons to reference devices (Stergiou et al., 2022). The validation study highlights that most devices are photoplethysmography based or sensor combinations, which demand signal processing to estimate blood pressure (Medina et al., 2022). The heterogeneity of technology and validation protocols causes results between studies to not always be comparable, so the synthesis emphasizes general trends, rather than "single accuracy" claims. These findings place the function of hypertension monitoring in two domains: activity-based risk monitoring and blood pressure monitoring that still depends on validation maturity.

In cardiovascular disease, wearable devices are often used to screening/monitoring rhythm, monitoring of heart rate, pulse variability, and signs of worsening (e.g. decreased activity or sleep changes). The literature emphasizes that cardiovascular wearables contribute through "continuous passive monitoring" so that sporadic events (e.g. arrhythmias) are more likely to be caught than episodic examinations (Stachteas et al., 2025). However, the findings also point to clinical interpretation challenges and the need for workflow integration so that wearable signals do not add to the clinical burden. Thus, wearable functions in cardiovascular are not only detection, but also data triage and signal-based decision-making. This point is important for urban contexts, as the volume of users and data is potentially high

In terms of IoMT architecture, several studies highlight the trend of integrating wearables with artificial intelligence, edge computing, or data security mechanisms, aimed at improving system prediction and resiliency (Putra et al., 2024). In the context of chronic diseases, such integrations are positioned to enrich analytics (e.g. risk prediction) while ensuring data can be transmitted and stored securely. The emerging results show that when wearables are combined with adequate analytics, the value of implementation increases as the data becomes actionable "clinical information." However, technical complexity is also increasing, so the issues of interoperability and data standards are becoming more prominent. Consequently, the choice of device is not only a matter of sensors, but also the readiness of the accompanying data ecosystem.

To briefly clarify the variations of monitoring devices and functions, Table 2 presents a mapping of the types of IoT wearables, key parameters, and the most commonly monitored disease conditions. This table helps show that "wearable IoMT" is not a single category, but rather a collection of devices with different parameters, validation levels, and usage contexts. With this structure, the reader can assess why effectiveness in diabetes tends to be more consistent (because the main biomarkers are directly measured), while hypertension is more diverse (due to cuffless estimation and validation protocols). In addition, the table shows

that multi-parameter devices are more commonly used for process outcomes (compliance, behavior), while specific biomarker devices tend to be used for clinical outcomes. This summary ties the device theme to the effectiveness theme in the next section.

Table 2. Wearable IoMT Types and Monitoring Functions Across Chronic Diseases

Wearable IoMT type	**Key monitored parameters**	**Typical connectivity**	**Most frequent chronic disease use**
Continuous Glucose Monitor (CGM)	Interstitial glucose trends, time-in-range proxies	Mobile app + cloud sharing	Diabetes mellitus
Smartwatch / activity tracker	Heart rate, step count, sleep, activity intensity	Mobile app + clinician dashboard (optional)	Cardiovascular risk, multimorbidity
Cuffless BP wearable (PPG/ECG-based)	Estimated systolic/diastolic BP, pulse wave features	Mobile app + analytics	Hypertension
Wearable ECG / rhythm monitoring	Rhythm episodes, arrhythmia flags	App + remote clinician review	Cardiovascular diseases
Multi-sensor wearables (patch/band)	Activity + HR + SpO_2 + temperature (varies)	App + cloud platform	Complex chronic monitoring, post-acute follow-up

Wearable IoMT Effectiveness on Clinical Monitoring Quality and Key Outcomes

The results of the synthesis show that wearable IoMT in general improves Quality of clinical monitoring through the continuity of measurement and the availability of longitudinal data. In diabetes, the most consistent outcome is improved glycemic control when CGMs are used regularly, as patients and clinicians gain a picture of glucose variability that was not previously seen. In clinical trial studies, CGM showed better hemoglobin A1c reduction than conventional glucose monitoring in certain contexts, which reinforces the claims of the effectiveness of wearable-based monitoring (Jafleh et al., 2024). However, the magnitude of the effect and its durability are greatly influenced by the intensity of mentoring, the frequency of use of sensors, and the integration of clinical follow-up. Thus, effectiveness is interpreted as the result of a combination of devices and support ecosystems, rather than devices alone

In addition to clinical trials, real-world evidence shows that real-time CGM use correlates with improvements in clinical indicators and a decrease in certain events (e.g., hypoglycemia-related emergency visits) in clinically selected populations (Gilliam et al., 2024). The findings indicate that IoMT wearables can

improve patient safety by accelerating the detection of risk patterns. However, real-world studies also show heterogeneity due to differences in access, affordability, and variation in clinical practice (Torab-Miandoab et al., 2023).

Therefore, the SLR results place observational studies as a reinforcement of the consistency of the direction of the effect, not a substitute for the control test. In the context of Indonesia's urban communities, the implication is the need for patient selection strategies and financing models so that benefits are not concentrated in a specific group only.

In hypertension and cardiovascular, the effectiveness of wearable IoMT is more commonly reported in the dimensions of "more frequent monitoring" and decision-making support, rather than a uniform single clinical outcome (Shankar et al., 2024). For hypertension, e-health and telemonitoring of blood pressure (including app-connected devices) are seen as strengthening out-of-clinic monitoring and improving monitoring compliance, especially when accompanied by feedback or mentoring. However, the literature also underlines that effective monitoring requires validated devices and interpretation that is consistent with the guidelines (Beger et al., 2025). As such, the apparent effects on blood pressure and risk control are often the output of "monitoring programs" that utilize wearables rather than wearables as a single intervention. This explains why the results between studies were more varied than in diabetes.

In cardiovascular disease, wearables make a major contribution through early detection and continuous monitoring, but their effectiveness depends on how the data is integrated into the service. The literature emphasizes that wearable data can be an early signal for intervention, but it also has the potential to generate over-alarm if thresholds and algorithms are not tailored to the patient's profile (Adeghe et al., 2024). Therefore, some studies assess effectiveness through process indicators, such as clinical response time, triage accuracy, or reduction in unnecessary visits. These findings are relevant for urban Indonesia because service density can make "process efficiency" a high-value outcome. At the same time, it takes data governance mechanisms and clinical workflows so that wearables don't add to the burden.

Effectiveness at the service system level is also seen in potential efficiencies, such as reducing non-essential face-to-face visits, post-care monitoring, and follow-up optimization (Stathakis et al., 2025). However, the evidence of service systems tends to be more varied because they are highly contextual, related to service organizations, telehealth readiness, and financing models. The results of SLR assessed that the efficiency benefits were most evident when the wearable was used in a remote monitoring framework that had a clear follow-up protocol and the role of the clinician. These findings suggest that implementation in Indonesia needs to prioritize program design, not just device distribution. Therefore, effectiveness evaluation should include clinical indicators and operational indicators simultaneously.

To confirm the linkage between the outcome and the research objectives, Table 3 summarizes the most frequently reported domains of effectiveness across 26 studies, including clinical indicators, patient behavior, and service efficiency. This table shows that three main pathways of effect—clinical monitoring quality,

adherence, and efficiency—occur repeatedly across diseases, although the specific indicators are different. A summary structure like this is important so that the results do not turn into speculative discussions, but remain rooted in the pattern of findings. In addition, the table makes it easy for readers to assess the suitability of the results with the SLR research question. Finally, this summary also serves as a logical bridge to the theme of barriers, as high effectiveness can still be hampered by implementation factors.

Table 3. Effectiveness Outcome Domains Reported Across Included Studies (n = 26)

Effectiveness domain	Examples of indicators reported	Typical direction of findings
Clinical monitoring quality	HbA1c changes, glucose variability trends, detection of rhythm events, continuous vital sign tracking	Generally improved monitoring continuity and earlier risk signaling
Patient adherence and self-management	Device wear-time, monitoring frequency, engagement with feedback, lifestyle tracking adherence	Often improved when feedback/coaching is present; variable without support
Health service efficiency	Reduced avoidable visits, faster escalation, streamlined follow-up, remote triage	Improved in structured RPM programs; context-dependent

Implementation Challenges: Digital Literacy, Data Security, and Technology Access Gap

The results of the synthesis showed that the most consistent barriers reported were Digital Literacy and the patient's ability to understand and utilize wearable data. Cross-contextual studies emphasize that effective digital interventions often require an educational or training component for users to be able to interpret information and take appropriate actions (Marcu et al., 2022). Without such support, real-time data risks underutilization or even anxiety, resulting in decreased usage compliance. Complex chronic disease conditions can also aggravate the cognitive burden of users, especially in the elderly or with comorbidities. Therefore, the SLR results place digital literacy as a key prerequisite for IoMT wearables to truly improve the quality of monitoring.

In addition to digital literacy, the issue of Technology Access Gap (device costs, stable internet availability, and utilization inequality) are recurring themes. Evidence suggests that remote patient monitoring and wearables can improve the management of chronic conditions, but their access is uneven across certain socioeconomic groups (Adepoju et al., 2024). In urban contexts, gaps can persist due to differences in income, technology preferences, or digital education levels, even though infrastructure is relatively better than in rural areas. Thus, the

effectiveness seen in the literature could tend to be "biased" towards a more technologically ready population. These results imply the need for equity-oriented program design, e.g. subsidies, integration with primary services, or community support.

Challenge Health Data Security and Privacy It also emerged as a limiting factor for implementation, mainly because wearables collect sensitive physiological data and are often transmitted over networks as well as stored in the cloud. The literature emphasizes that the risk of data leakage, re-identification, and access permission management can undermine user trust (Alhasan, 2025). For health systems, these risks not only impact individuals, but also on institutional reputations and regulatory compliance. The results of the SLR assess that privacy issues are not only technical issues, but also governance and ethical issues. Therefore, the effectiveness of the IoMT wearable program needs to be evaluated along with the level of data protection applied.

In line with that, the IoMT security study confirms that the connected medical device ecosystem has a wide attack surface, ranging from devices, applications, to servers. The literature suggests that security should be designed end-to-end, including authentication, encryption, software updates, and access control (Mwangi, 2024). Otherwise, the monitoring system that is supposed to improve services can actually become a weak point that threatens patient safety and confidentiality. The SLR findings view safety as an "enabler" of effectiveness: without safety, adoption and sustainability of use would be fragile. In the framework of implementation in Indonesia, this leads to the need for minimum security standards for service-integrated IoMT wearable solutions.

Other obstacles that are often implied are Data quality and interoperability, including sensor accuracy issues, population bias, and difficulties integrating wearable data into medical records or health information systems. The literature suggests that inconsistent wearable data can trigger erroneous clinical decisions or increase the burden of verification on clinicians (Emmanuel, 2025). In addition, representation bias can occur if the algorithm development dataset is dominated by a certain population, so performance decreases in other groups. This challenge is reinforced in developing countries due to the variety of devices used and the limitations of interoperability standards. Thus, the SLR results place data quality and interoperability as prerequisites for clinical benefits to be sustainable.

To summarize barriers in a structured manner and support practical recommendations, Table 4 presents the main barriers domains along with the implications of implementation in urban contexts. This table shows that barriers do not stand alone, but rather reinforce each other where literacy affects compliance, compliance affects data quality, and data quality affects clinician trust. Therefore, implementation strategies that focus only on devices tend to yield partial benefits.

Table 4. Key Implementation Barriers and Practical Implications for Urban Settings

Barrier domain	Typical events	Practical implications
Digital literacy	Difficulty interpreting data, low engagement with apps	Require onboarding, coaching, and user-centered education
Data privacy & security	Trust concerns, risk of breaches, unclear consent	End-to-end security, transparent data governance, compliance readiness
Access & affordability	Device cost, unequal connectivity, inequitable adoption	Subsidy models, integration with primary care, equity-focused roll-out
Data quality & interoperability	Sensor variability, missing data, non-standard formats	Standardization, validation protocols, interoperable health data pipelines

CONCLUSIONS AND RECOMMENDATIONS

Based on a systematic synthesis of 26 empirical research articles, this study concludes that Internet of Medical Things-based wearable devices have consistent effectiveness in improving the quality of clinical monitoring, patient adherence to disease management, and healthcare efficiency in major chronic diseases in urban areas, particularly diabetes mellitus, hypertension, and cardiovascular disease. Such effectiveness is primarily supported by continuous monitoring capabilities, real-time feedback, and remote monitoring integrations that strengthen patient engagement and clinical decision-making. However, the application of wearable IoMT still faces a number of limitations, including variations in users' digital literacy, health data security and privacy issues, heterogeneity of device quality, and technology access gaps that have the potential to limit the equitable distribution of benefits in the Indonesian urban context. In addition, the dominance of observational studies and the limitations of contextual evidence from developing countries limit the generalization of findings empirically.

Therefore, further research is recommended to develop local context-based intervention studies, evaluate implementation models oriented towards equity and data security, and integrate wearable IoMT into urban primary healthcare systems to strengthen the sustainability and practical impact of digital health technologies in Indonesia.

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