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Utilization of digital health in the screening, diagnosis, and management of Morbus Hansen

Bagja Prayitno*, Endang Triyanto

Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

Abstract

Background: Leprosy (Morbus Hansen) remains a significant global health problem, and delayed detection in areas with limited specialist access continues to drive permanent disability. Digital health offers a promising means of strengthening the screening, diagnosis, and management of the disease in such settings.
Purpose: To summarise the most recent evidence on the implementation of digital technologies in leprosy care.
Method: A systematic literature search was conducted in the Scopus, PubMed, ScienceDirect, and EBSCO databases up to 21 November 2025, using the keywords leprosy, digital health, mHealth, artificial intelligence, screening, diagnosis, and management. Eligible studies were original research that evaluated digital tools for the screening, diagnosis, or management of leprosy. Study selection followed the PRISMA 2020 guidelines, and the risk of bias was appraised using the Mixed Methods Appraisal Tool (MMAT).
Results: Of 80 records identified, five studies met the inclusion criteria. These covered an artificial intelligence (AI) web-based application for classifying leprosy type, a mobile application supporting primary health care, an e-Leprosy information system with SMS reminders, a machine-learning algorithm based on the Leprosy Suspicion Questionnaire (MaLeSQs), and the AI4Leprosy diagnostic assistant based on skin images. Reported sensitivity ranged from 85.7% to 93.97% and specificity from 69.2% to 90%.
Conclusion: Digital technologies such as mobile applications, health information systems, and AI can enhance leprosy screening and management. However, most studies remain at an early stage and require field validation and the evaluation of their long-term clinical impact.

Keywords: Artificial Intelligence; Diagnosis; Digital Health; Leprosy; mHealth; Screening.

INTRODUCTION

Leprosy, or Morbus Hansen, remains one of the most persistent public-health problems worldwide, even though effective treatment has long been available (White & Franco-Paredes, 2015; World Health Organization, 2024). The disease, caused by *Mycobacterium leprae* and *Mycobacterium lepromatosis*, primarily attacks the skin and peripheral nerves and may lead to permanent disability when it is not diagnosed and treated promptly. Delayed diagnosis is a major contributor to disease progression and to the lifelong impairment that can follow. The social stigma still attached to people affected by leprosy further compounds the problem, as it frequently discourages them from seeking timely and supportive care (Alderton, Ackley, & Trueba, 2024). The central challenge in leprosy control therefore lies not only in medical treatment but also in early detection, effective case management, and stigma reduction through greater public awareness.

Amid these challenges, digital technology offers considerable potential to overcome existing barriers in leprosy care. Innovations in digital health, such as mobile applications, teledermatology, web-based health-information systems, and artificial intelligence (AI), can accelerate screening, improve diagnostic accuracy, and support more efficient treatment

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monitoring (Carrion, Robles, Sola-Morales, Aymerich, & Postigo, 2020). Mobile applications designed to detect early signs of leprosy can be used by health workers in primary-care facilities, enabling earlier diagnosis and prompt treatment (Mwageni, van Wijk, Daba, Mamo, Debelo, Jansen, Schoenmakers, van Hees, Kasang, Mieras, & Mshana, 2024; Yotsu, Almamy, Vagamon, Ugai, Itoh, Koffi, Kaloga, Dizoé, Kouadio, Aka, Yeboue, Yao, & Blanton, 2023). Which is particularly valuable in remote areas where access to dermatology specialists is limited. Teledermatology, in turn, allows health workers to transmit patients' skin images to specialists through digital platforms, shortening the diagnostic and referral process when required (Joshi & Ren, 2021).

One of the most notable recent advances is the application of AI algorithms that analyse skin images to identify signs of leprosy with high accuracy. Recent studies report that AI-based systems can classify leprosy type with sensitivity of 85.7% to 93.97% and specificity of 69.2% to 90%, making them useful aids for more accurate and rapid diagnosis (Lynn, Gomes Vilar de Andrade, da Silva Rocha, de Carvalho Monteiro, Matos de Morais, Moura dos Santos, Cassimiro Nascimento, Dourado, & Takako Endo, 2025). Beyond classification, machine-learning approaches have also been applied to predict leprosy reactions, illustrating the breadth of AI applications in leprosy care (De Andrade, Heise, Hartmann, Rocha, Olandoski, de Araújo, Latini, Soares, Belone, Rosa, de Andrade, de Sá, Cruz, Penna, Carvalho, Fava, Bührer-Sékula, Penna, Moro, Nievola, & Mira, 2023). By reducing dependence on the individual skill and experience of clinicians, which often vary, these tools can deliver more consistent and objective results (Quilter, Butlin, Carrion, & Ruiz-Postigo, 2024). This is especially important because the clinical presentation of leprosy is highly variable, and misclassification can lead to delayed or inappropriate treatment that affects patients' quality of life.

Despite this potential, the literature also highlights important challenges to implementation. Although existing studies show promising results, several remain limited to early-phase or small-scale trials, which constrains the generalisability of their findings (Lynn et al., 2025). Differences in study design and methods further affect the quality and reliability of the evidence. Stronger and more broadly based studies are therefore needed to provide a clearer picture of the effectiveness of digital technology in the context of leprosy.

Field implementation raises additional considerations. The first is sustainable access to adequate technology and infrastructure: many of the areas that most need these tools still face unstable internet access and a shortage of suitable devices. The digital literacy of health workers is equally important, because advanced technologies require adequate skills and understanding; without proper training, misinterpretation of results or improper use of an application could harm patients. The ethics of handling sensitive health data collected through mobile applications and AI-based systems must also be addressed, with strict adherence to data-protection and medical-ethics standards. Finally, the success of digital health depends on active community participation, which can be encouraged through education on the benefits of these tools (Carrion et al., 2020).

Within this context, the present systematic review synthesises studies on the use of digital health in leprosy care. While these technologies show great promise, gaps in the evidence point to the need for further evaluation of sustainability, long-term impact, and cost-effectiveness. This review therefore aims to identify, appraise, and synthesise the current empirical evidence on digital health tools for the screening, diagnosis, and management of leprosy, and to outline the implications for practice and future research.

RESEARCH METHOD

This study is a Systematic Literature Review (SLR) conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review was designed to identify, appraise, and synthesise empirical evidence on the effectiveness of digital health in the screening, diagnosis, and management of leprosy. This systematic approach was chosen so that the literature could be reviewed transparently and reproducibly, while evaluating the strengths and limitations of each eligible study.

A systematic literature search was performed in four electronic databases (Scopus, PubMed, ScienceDirect, and EBSCO) using the following combination of keywords: (*leprosy OR* "*Hansen's disease*") *AND* ("*digital health*" *OR mHealth OR*

Bagja Prayitno*, Endang Triyanto

Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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eHealth OR telemedicine OR "mobile application" OR app OR "artificial intelligence" OR "machine learning") *AND* (*screening OR diagnosis OR management*). The search was limited to publications up to 21 November 2025. Duplicates were removed, and the remaining records were screened by title, abstract, and then full text against the inclusion criteria. The risk of bias was appraised using the Mixed Methods Appraisal Tool (MMAT) 2018. The search initially yielded 80 records, which were subsequently filtered for duplication and relevance in line with the review objective.

Studies were selected based on the PICOS framework. The population included leprosy patients, household contacts, or healthcare workers involved in the diagnosis and management of leprosy. The intervention comprised digital technologies, including mobile applications, health information systems, telemedicine, and artificial intelligence (AI) algorithms intended for the screening, diagnosis, or management of leprosy. The comparison was standard care or the absence of a comparator, depending on the study design. The outcomes of interest included diagnostic accuracy (e.g., sensitivity, specificity, and area under the curve [AUC]), improved treatment adherence, user acceptance, and data quality. Eligible study designs included primary research (experimental or observational studies) published in English and indexed in Scopus.

The exclusion criteria comprised literature reviews, studies that did not involve a digital intervention, non-primary research, conference abstracts, editorials, letters, and studies with insufficient data relevant to the review objectives. After the removal of duplicates, 80 records were screened by title and abstract. Ten full-text reports were assessed for eligibility, and five studies met all inclusion criteria. The selection followed the four PRISMA stages: identification (80 records identified), screening (70 records excluded for duplication or low relevance), eligibility (10 full-text reports assessed for methodological eligibility), and inclusion (5 studies retained for the final synthesis). The complete selection process is presented in Figure 1.

The review included five studies, from which data were extracted using a standardised worksheet based on the PRISMA format and the PICOS components (De Souza, Lopes, Branco, Fairley, & Fraga, 2021; Matos, Torres, da Silva, Dos Santos, de Oliveira, de Araújo, & de Oliveira Serra, 2022; Rachmani, Lin, Hsu, Jumanto, Iqbal, Shidik, & Noersasongko, 2020; Simões, Lima, Lugão, de Paula, Silva, Ramos, & Frade, 2025; Barbieri, Xu, Setian, Souza-Santos, Trivedi, Cristofono, Bhering, White, Sales, Miller, Nery, Sharmah, Bumann, Zhang, Goldust, Sarno, Mirza, Cavaliero, Timmer, Bongfiglioli, Smith, Scollard, Nvarani, Aerts, Ferres, & Moraes, 2022).

The methodological quality of each included study was appraised with the MMAT 2018, which permits the simultaneous appraisal of qualitative, quantitative, and mixed-methods designs. Because of the heterogeneity of designs and outcomes, the synthesis was qualitative (narrative); a quantitative meta-analysis was not feasible.

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Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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RESEARCH RESULTS

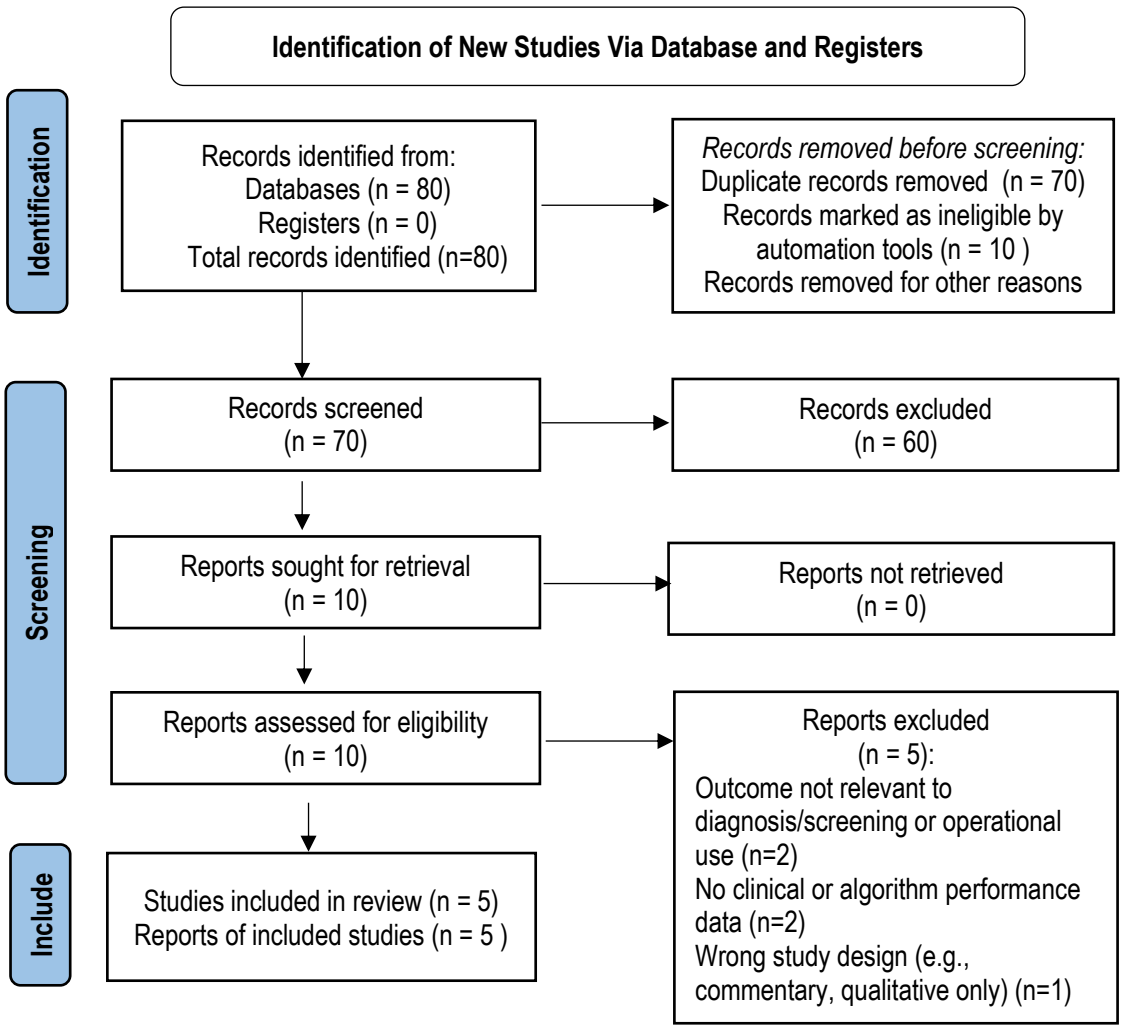


Figure 1. PRISMA 2020 Flow Diagram of The Study-Selection Process

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Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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Table Summary of Selected Articles

(Author, Year); (Country)	Purpose	Method	Results
(De Souza et al., 2021) JMIR mHealth and uHealth (Brazil)	To develop and validate a cross-platform web application using artificial intelligence to support operational classification of leprosy and treatment decision-making.	Random-forest classifier trained on Brazilian SINAN data; cross-validation; web deployment via shinyApp	Sensitivity 93.97%, specificity 87.09% for operational classification (paucibacillary vs multibacillary); provides an accessible screening tool for remote settings
(Matos et al., 2022) Tropical Medicine & International Health (Brazil)	To develop and validate a mobile application to assist primary healthcare professionals in the management of leprosy patients and surveillance of contacts.	Methodological development; integrative literature review; prototype design; expert and health-worker usability testing	Content-validity index 0.94–0.99; high relevance and usability; assists management, planning, monitoring, evaluation, and contact tracing
(Rachmani et al., 2020) International Journal of Medical Informatics (Indonesia)	To implement an integrated e-leprosy framework in primary healthcare centres and evaluate its usability, user involvement, acceptance, and impact on patient attendance in the leprosy control programme.	Mixed-methods implementation research across 27 primary health centres; baseline assessment; focus groups; longitudinal analysis	On-time attendance +13.9% (OR 2.41); acceptance linked to computer/internet fluency (r = 0.48) and age (r = 0.62); improved timeliness of treatment
(Simões et al., 2025) Scientific Reports (Brazil)	To develop and validate a machine-learning model based on the Leprosy Suspicion Questionnaire for screening new leprosy cases.	SVM, logistic regression, random forest, and XGBoost trained on LSQ responses; cross-validation; SVM selected	SVM: sensitivity 85.7%, specificity 69.2%, PPV 18.6%, NPV 98.3%, AUC 0.775; high NPV reduces false negatives
(Barbieri et al., 2022) The Lancet Regional Health – Americas (Brazil)	To develop and validate an artificial intelligence model that combines skin lesion images with demographic and clinical data to improve leprosy diagnosis	1.229 skin images and 585 metadata sets from 222 patients; CNN and logistic-regression models; independent test set	Elastic-net logistic regression: accuracy 90%, AUC 96.46%; identified key features; dataset made publicly available

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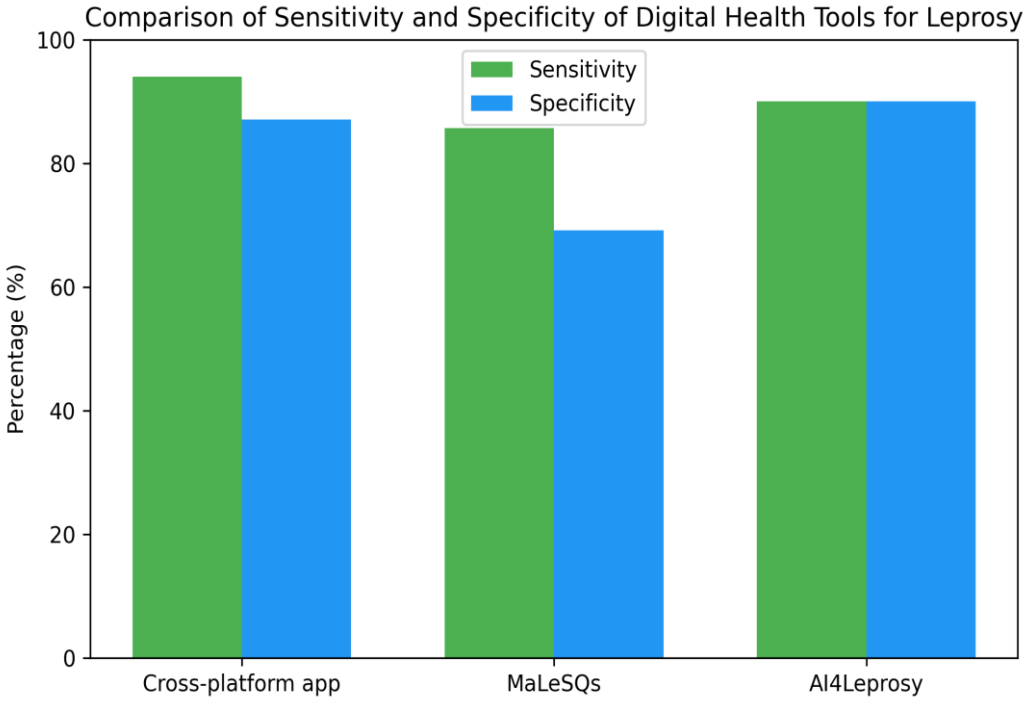


Figure 2. Reported diagnostic performance of the AI-based digital tools for leprosy

DISCUSSION

The literature search showed that only five studies met all inclusion criteria after a strict PRISMA-based selection, confirming that the use of digital health for Morbus Hansen, although progressing, is still relatively limited. The predominance of studies from countries with a high leprosy burden, especially Brazil, reflects the contextual need for technological innovation to strengthen early detection and disease management in endemic settings. Two studies that developed AI algorithms for leprosy screening showed promising diagnostic performance, with sensitivity ranging from 85.7% to 93.97% and specificity from 69.2% to 90% (De Souza et al., 2021; Simões et al., 2025). These findings indicate that machine-learning technology has substantial potential to function as an effective initial screening tool, particularly in areas with few dermatology specialists, and may help reduce the diagnostic delay that is a leading cause of disability in leprosy.

Extended this potential by presenting a diagnostic assistant based on skin-lesion images and clinical data using deep learning, achieving a high AUC relevant to early diagnosis (Barbieri et al., 2022). This shows that integrating visual data with AI algorithms can improve case classification while opening the possibility of using smartphones as diagnostic aids at the primary-care level. Two other studies focused on disease management through information systems and mobile applications. The implementation of e-Leprosy in Indonesia increased on-time patient attendance by 13.9%, indicating that integrating digital technology into routine services affects not only clinical outcomes but also patient behaviour and continuity of care (Rachmani et al., 2020). This is consistent with evidence that SMS-based reminders and digital records can minimise loss to follow-up and improve treatment continuity for chronic, communicable diseases.

The development of Hansenapp emphasised the importance of usability and technological adaptation for health workers. A high content-validity index (>0.9) indicated that the application was perceived as relevant, easy to use, and appropriate to field practice (Matos et al., 2022). This confirms that the success of digital health is determined not only by technological sophistication but also by user acceptance, contextual fit, and integration with existing service workflows. Nevertheless, several of the studies were limited to a local scale, used relatively small samples, and did not adopt large-scale experimental designs such as

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Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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randomised controlled trials. These limitations point to the need for further studies with stronger designs and larger, more heterogeneous populations to validate the effectiveness and generalisability of the current findings.

Overall, this qualitative synthesis confirms that digital interventions-whether mobile applications, health-information systems, or AI-have significant potential to strengthen leprosy screening, diagnosis, and management. Integrating these technologies could accelerate progress towards global leprosy-elimination targets by improving early detection, optimising therapy monitoring, and strengthening digital disease surveillance in endemic areas (Barbieri et al., 2022; De Souza et al., 2021; Matos et al., 2022; Rachmani et al., 2020; Simões et al., 2025). The characteristics of the included studies are summarised in Table, and the reported diagnostic performance of the AI-based tools is compared in Figure 2.

The reviewed evidence indicates clear progress in the use of artificial intelligence and digital applications to improve the accuracy of leprosy screening and diagnosis. Machine-learning models such as random forest and the support vector machine (SVM) were effective in classifying leprosy type and identifying individuals requiring further evaluation, with high sensitivity (>85%) (De Souza et al., 2021; Simões et al., 2025). Beyond early detection, AI also offers a means of extending the reach of screening, particularly in areas with limited access to specialist clinicians. A notable example is AI4Leprosy, which combined skin-lesion images with clinical data to achieve diagnostic accuracy of 90% and an AUC of 96.46%, demonstrating the value of a multimodal approach that integrates different data types (Barbieri et al., 2022). Such tools can reduce reliance on subjective clinical experience and support more consistent and objective diagnosis, although the field as a whole is still maturing towards routine clinical use (Lynn et al., 2025; Quilter et al., 2024).

Applications such as Hansenapp and e-Leprosy show parallel progress in supporting disease management, with their main focus on treatment adherence and sound clinical content validity. By delivering treatment reminders, facilitating therapy monitoring, and helping health workers manage patient information more systematically, these tools address a critical issue, since irregular or delayed treatment can cause the permanent disability that is among the greatest challenges in leprosy care (Matos et al., 2022; Rachmani et al., 2020). Although the results are promising, several of the studies relied on small datasets or populations that may not reflect clinical diversity, particularly the diversity of skin types in larger populations (Deps, Yotsu, Furriel, de Oliveira, de Lima, & Loureiro, 2024; Fernandes, Teles, Fernandes, Lima, Balhara, Gupta, & Teixeira, 2023). In real-world field testing, frontline health workers using such tools achieved only moderate diagnostic accuracy, underscoring the gap between controlled and field performance (Mwageni et al., 2024). Broader field trials involving larger and more diverse populations are therefore needed to evaluate the real-world effectiveness of these technologies.

Beyond accuracy and validity, implementation challenges also warrant attention. Gaps in digital literacy among both health workers and the community are a significant barrier to the optimal use of these technologies. Many health workers, especially in remote areas, may be unfamiliar with digital tools, which can limit adoption; likewise, limited infrastructure, such as unstable internet access, can reduce effectiveness in certain settings (Carrion et al., 2020; Dahoklory, Haryanto, & Indarwati, 2023; Joshi & Ren, 2021; Solanki & Chaurasia, 2025). The protection of personal data is a further concern, given the highly sensitive nature of the medical data involved, and the use of these technologies must comply with strict data-protection standards to safeguard patient privacy and prevent misuse.

As a next step, future studies should incorporate controlled trials to evaluate the clinical impact and cost-effectiveness of these technologies. Adaptation for offline use in areas with limited connectivity is also important, as it would broaden accessibility and enable deployment at scale in the regions of greatest need (Barnowska, Fastenau, Penna, Bonkass, Stuetzle, & Janssen, 2024). Field-adapted applications that operate offline have already shown promise in resource-limited settings (Yotsu et al., 2023). Thus, although early evidence shows that AI and digital applications can improve the diagnosis and management of leprosy, these practical and technical challenges must be addressed to ensure that the benefits reach the wider population.

Bagja Prayitno*, Endang Triyanto

Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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This review has several limitations. First, although four databases were searched, relevant articles may have been missed if they were not indexed or used different terminology. Second, the heterogeneity of methods and outcomes precluded a quantitative meta-analysis, so the analysis was restricted to a narrative description and simple comparison. Third, some data were extracted from open-access publications in which detailed information was sometimes limited. Despite these limitations, the review provides a comprehensive summary of the development of digital technology for leprosy.

CONCLUSION

Digital health plays an increasingly important role in strengthening the screening, diagnosis, and management of leprosy, particularly in areas with limited access to adequate health services. AI-based applications and mHealth tools can help health workers detect leprosy more quickly and support more accurate diagnosis and treatment monitoring; AI models that combine clinical data with skin-lesion images have improved diagnostic accuracy to more than 90%, enabling earlier detection and reducing the risk of permanent nerve damage (Barbieri et al., 2022). Information systems such as e-Leprosy, which provide treatment reminders and digital patient records, have improved treatment adherence—a crucial factor in preventing relapse and disability (Rachmani et al., 2020). Nonetheless, successful implementation depends heavily on data quality, the digital literacy of the health workforce, and supportive policies and infrastructure. For digital technology to deliver broad and sustainable impact, it must be integrated effectively into national and global leprosy-elimination programmes as part of a comprehensive strategy that includes community education, workforce training, and enabling policy.

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Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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Fakultas Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: bagja.prayitno@mhs.unsoed.ac.id

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