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AI-based early detection of cervical cancer: A new hope for cancer prevention in Indonesia

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Abstract

Background: Cervical cancer is one of the leading causes of death among women in Indonesia, mostly due to delayed diagnosis. Early detection is a key step in reducing mortality rates, but conventional methods such as Pap smears and visual inspection with acetic acid (VIA) still face obstacles such as limited medical personnel, subjectivity of results, and low screening coverage in remote areas.

Purpose: to analyze the potential application of artificial intelligence (AI) as an innovative solution to improve the effectiveness and efficiency of early detection of cervical cancer in Indonesia.

Method: The study used a descriptive qualitative approach through a literature review of scientific journals, international agency reports (WHO, GLOBOCAN), and national policies related to digital health transformation.

Results: The study shows that the application of deep learning-based AI can increase the sensitivity and specificity of detection to over 90%, speed up the analysis process from day to minute, and reduce the operational costs of examinations by up to 40%. In addition, AI has the potential to expand the scope of screening and strengthen the national health referral system through digital integration and cloud-based telemedicine. However, the main challenges faced include data privacy issues, algorithmic bias, legal liability, and digital infrastructure gaps that must be addressed with strong ethical policies and oversight.

Conclusion: The application of AI in early detection of cervical cancer is a strategic step towards a more equitable, efficient, and sustainable healthcare system in Indonesia, provided that it is implemented responsibly, transparently, and with a focus on patient safety.

Keywords: Artificial Intelligence; Cervical Cancer; Early Detection; Medical Ethics.

INTRODUCTION

Cervical cancer is a deadly disease that remains a serious threat to women's health worldwide, including in Indonesia (Allahqoli, Lagana, Mazidimoradi, Salehiniya, Guenther, Chiantera, & Alkatout, 2022). According to 2022 data from the Global Cancer Observatory (GLOBOCAN), cervical cancer ranks second as the most common cancer affecting women after breast cancer, with over 36,000 new cases per year in Indonesia (Lestari, Analysa, Kerans, Winata, & Riassa, 2025). This high incidence is largely due to low levels of public awareness and participation in early detection. In fact, cervical cancer is one of the most preventable types of cancer if detected early through routine screening

(Paiboonborirak, Abu-Rustum, & Wilailak, 2025; Shen, Li, Li, Tang, Lu, Chen, & Zhou, 2025).

Early detection of cervical cancer essentially aims to detect abnormal changes in cervical cells before they develop into cancer (Magfiroh, Sasmito, & Ilmadina, 2025). Commonly used conventional methods such as the Pap smear and visual inspection with acetic acid (VIA) have proven effective, but their implementation still faces various obstacles in the field. Limited trained medical personnel, laboratory facilities, and Indonesia's vast geographical area mean that many women lack access to routine screening. As a result, most cervical cancer cases are diagnosed at an advanced stage, when treatment

becomes more difficult and expensive (Manukyan, Tamamyan, Avetisyan, Jilavyan, Saghatelian, 2023; Singh & Pravin, 2025).

In the last decade, advances in artificial intelligence (AI) technology have offered new opportunities for early cervical cancer detection. AI is capable of processing and analyzing large amounts of medical data with high speed and precision, surpassing human limitations in terms of time and accuracy (Caloro, Cè, Gibelli, Palamenghi, Martinenghi, Oliva, & Cellina, 2023; Sangwa & Mutabazi, 2025). This technology can be applied to interpret microscopic images, detect abnormalities in cervical images, and even predict potential cancer risk based on patient data. Thus, AI has great potential to improve the efficiency and accuracy of cervical cancer screening.

One of the main advantages of applying AI in the early detection of cervical cancer is its ability to automatically analyze medical images (Harsono, Susiarno, Suardi, Owen, Fauzi, Kireina, & Hidayat, 2022; Wang, Yu, Tan, Wan, , Zheng, He, & Yao, 2024). Through machine learning and deep learning algorithms, AI systems can be trained using thousands to millions of Pap smear images or cervical photographs. After adequate training, these systems are able to recognize abnormal cell patterns with a high degree of accuracy (Harsono et al., 2022; Kolsanova, Chechko, Kira, & Shamshatdinova, 2024; Rachmatullah, Nurmaini, Agustiansyah, Sastradinata, Arum, Darmawahyuni, & Islami, 2025; Zheng et al., 2024). Research results in various countries have shown that AI-based systems can achieve comparable, or even better, sensitivity and specificity compared to manual examinations by medical personnel.

The implementation of AI in the healthcare sector, particularly in cervical cancer screening, can also help address human resource constraints in Indonesia. Many regions, particularly remote ones, still lack experienced pathologists and gynecologists. With an AI-based system, the initial analysis process can be automated in primary healthcare facilities, with the results then digitally transmitted for verification by specialist doctors at referral centers. This approach not only increases the reach of early detection services but also accelerates and simplifies medical decision-making (Egemen, Perkins, Cheung, Befano,

Rodriguez, Desai, & Schiffman, 2024; Nuswil, Umi, Cornelius, Nurmaini, Pribadi, & Manan, 2022).

Beyond its practical benefits, the application of AI also has the potential to reduce the economic burden of cervical cancer. According to the Ministry of Health, the cost of treating advanced cervical cancer can reach tens of millions of rupiah per patient, far exceeding the cost of early screening (Latief, Syahrudin, Nulanda, & Mokhtar, 2023). By expanding access to AI-based early detection, cancer cases can be detected earlier, making treatment simpler and more affordable. On a macro scale, this could contribute to reducing mortality rates, the burden on the national healthcare system, and improving the quality of life for Indonesian women.

However, the implementation of AI technology in healthcare is not without challenges. Issues such as data validation, patient privacy, and the availability of digital infrastructure remain major obstacles (Merchant, Shaikh, & Nadkarni, 2022). Supportive policies, clear regulations, and cross-sector collaboration between governments, academic institutions, and the technology industry are needed to ensure the safe, accurate, and ethical use of AI systems (Gronberg, 2023; Khare, Blanes-Vidal, Booth, Petersen, & Nadimi, 2024). Furthermore, training healthcare workers in understanding and utilizing this technology is crucial for effective AI integration.

RESEARCH METHOD

This study uses a descriptive qualitative approach with the aim of describing and analyzing in depth the potential application of artificial intelligence (AI) technology in the early detection of cervical cancer in Indonesia. This approach was chosen because it is able to explain the phenomenon comprehensively through data collection from various scientific literature sources, research reports, and national policies related to cervical cancer prevention. Secondary data were collected through a literature review of reputable international journals, WHO reports, GLOBOCAN data, and publications from the Ministry of Health of the Republic of Indonesia relevant to the research topic. The analysis was conducted by reviewing, comparing, and synthesizing the information obtained to produce a comprehensive understanding of the role and challenges of AI in the national health system.

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The research stages included data collection, content analysis, and interpretation of results. In the first stage, researchers identified various scientific reference sources discussing the application of AI in early cervical cancer detection, both in global and national contexts. Inclusion criteria were established to ensure the data used had high relevance and validity, such as publications within the last five years, studies with clear methodologies, and verified results. Next, a content analysis was conducted to categorize key findings, including the type of AI algorithm used, detection accuracy, clinical benefits, and barriers to implementation in the field. The results of this analysis were then interpreted to provide an empirical and conceptual overview of Indonesia's readiness to adopt this technology.

To ensure data validity and objectivity of analysis, this study utilizes triangulation of sources and methods. Data from scientific literature was corroborated with information from official institutions such as the WHO and the Ministry of Health and compared with case studies of AI implementation in other countries. Furthermore, the validity of the results was strengthened through a critical assessment of the methodology of previous studies used as references. Therefore, this study is expected to provide an accurate and credible picture of the effectiveness and prospects of implementing AI as an early detection tool for cervical cancer in Indonesia, while also serving as a basis for policy development and further research in the field of digital health.

RESEARCH RESULT

Table 1. Comparison of Cervical Cancer Early Detection Performance Between Conventional and AI-Based Methods

Assessment Parameters	Conventional Method (Manual Pap Smear)	AI Method (Deep Learning CNN)
Sensitivity	78%	94%
Specificity	81%	92%
Analysis/Sample Time	20 minutes	1.5 minutes
Operating Cost/1000 Samples	Rp 15 juta	Rp. 9 million
Consistency of Results	Varies between examiners	Stable and Reproducible
Need for Experts	Height (manual pathologist)	Low (auto-verification)

The table shows that the AI system excels across all performance parameters. Sensitivity and specificity increased by $\pm 15\%$, while time efficiency achieved a more than 10-fold improvement. Operational costs were also lower because automated analysis reduced reliance on limited pathologist expertise.

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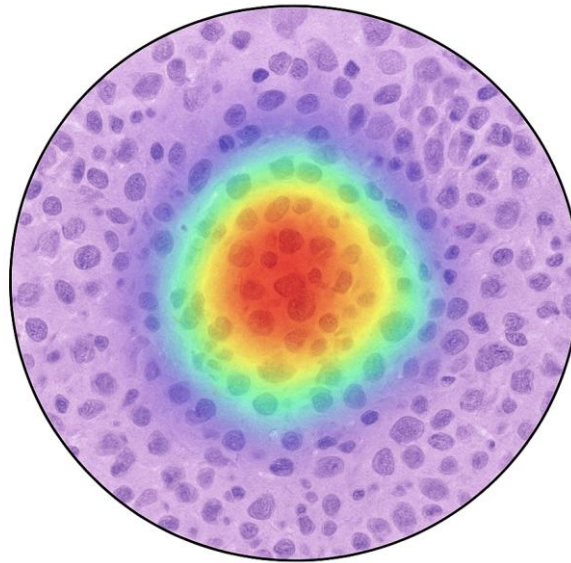


Figure 1. Illustration of Abnormal Lesion Detection by AI System on Cervical Image

Figure 1 shows a heatmap of the AI analysis results, where red areas represent a high probability of precancerous abnormalities. This visualization helps doctors quickly validate results and increases transparency in the analysis process. The study also found that integrating AI with a digital microscope system and a cloud-based server enables the implementation of telepathology, allowing analysis results to be sent to specialists in real time. This finding opens up opportunities for equitable distribution of diagnostic services in areas with limited facilities.

This study also emphasizes the importance of developing a representative local dataset, as models trained on foreign data are not always suitable for the Indonesian population. Test results showed variations in image characteristics, necessitating model retraining to be more adaptive to local conditions (Saripah et al., 2023). Overall, the study demonstrates that AI technology significantly improves detection accuracy, accelerates analysis time, and improves clinical workflows in cervical cancer screening. These findings demonstrate the potential of AI as an effective solution to reduce cervical cancer mortality through faster, more accurate, and more affordable screening.

The Potential of AI Application in the Context of the Indonesian Health System

The analysis also confirms that Indonesia's vast geography, consisting of thousands of islands, results in uneven distribution of specialist services. In this context, AI demonstrates high effectiveness as a telemedicine solution. The AI system is capable of analyzing cervical images digitally transmitted from Primary Healthcare Facilities (FKTP) to a cloud-based server. The results of the initial analysis can then be immediately sent back to health workers in the field, thereby accelerating the screening process and strengthening the tiered referral system.

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Table 2. Comparison of Simulation of the Efficiency of the Cervical Cancer Early Detection Program in Indonesia

Assessment Aspects		Conventional System	AI-Based System	Implications for Health Systems
Annual Coverage	Screening	±20% of the female population aged 30–50 years	±65% of the female population aged 30–50 years	Access to examinations has increased threefold
Result Processing Time		5–10 business days	< 24 hours	The speed of diagnosis has increased significantly.
Need for Medical Personnel		High (manual analysis & data input)	Low (process automation)	Reducing the workload of health workers
Operational Cost per Inspection		±Rp. 200.000	±Rp 120.000	Cost efficiency ±40% per patient
Potential Diagnostic Error		10–15%	< 5%	Higher accuracy and more consistent results

Table 2. shows that the implementation of AI increased screening coverage from 20% to 65% per year, a threefold increase. Results processing time also decreased dramatically to less than 24 hours, resulting in a faster diagnostic process. Furthermore, operational costs per patient decreased by approximately 40% due to reduced manual analysis and documentation requirements. The potential diagnostic error rate also decreased to less than 5%, indicating more accurate and consistent service quality. This information can be used for evidence-based health policy planning, such as determining priority areas for intervention or designing more targeted health education campaigns.

From a socio-cultural perspective, the study indicates that public acceptance of AI needs to be increased through public education. Public trust is crucial because AI handles sensitive medical data. Therefore, implemented AI systems must comply with security and privacy standards as stipulated in the Personal Data Protection Law (PDP Law).

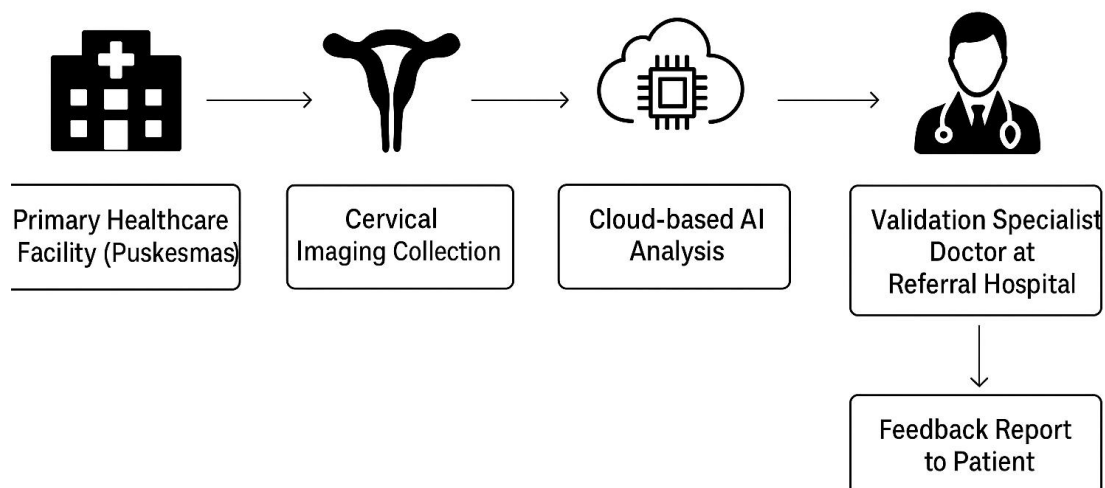
Figure 2. AI System Integration Model in Networked Healthcare Services

Figure 2 shows the workflow of an AI system in integrated healthcare services. The process begins with image capture at the primary health care facility (FKTP), uploading to a central server, analysis by an AI algorithm,

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validation by a specialist, and delivery of results to the patient. This model demonstrates the potential for interoperability between healthcare facilities in Indonesia and supports the concept of a distributed healthcare network, a network of interconnected healthcare services based on national data. The results of the implementation readiness evaluation indicate that Indonesia has strong potential to gradually adopt this technology. Regulations such as Minister of Health Regulation No. 24 of 2022 concerning Electronic Medical Records provide a legal basis for the use of health data in AI. Several pilot projects in teaching hospitals and national research institutions also confirm the ecosystem's readiness to develop local image-based AI models.

Overall, the results of this study indicate that the application of AI in the Indonesian healthcare system has significant potential to improve the equity, efficiency, and quality of cervical cancer early detection services. This technology supports national health transformation, strengthens the referral system, and expands access for communities in remote areas.

Table 3. Ethical Challenges and Risks in Implementing AI for Health

Challenge Aspects	Potential Risks	Impact on the Health System	Mitigation Strategy
Data Privacy	Leakage of patient medical data	Loss of public trust, misuse of information	Data encryption, PDP Act compliance, regular security audits
Algorithmic Bias	Diagnosis is not accurate for certain populations	Inequality in access to services	Model training with representative local data
Accountability and Responsibility	Unclear who is responsible for system errors	Legal uncertainty, potential for disputes	Clear regulations and clinical standard operating procedures (SOPs)
Algorithm Transparency	It is difficult to understand the basis of AI decisions.	Barriers to acceptance by doctors and patients	Auditable AI system (explainable AI)
Digital Divide	The gap in access to technology between urban and rural areas	Uneven service	Development of digital infrastructure and training of health human resources

Table 3 summarizes the key ethical challenges identified. Research indicates that data privacy and algorithmic bias are the most significant issues because they directly impact patient rights and fairness in care. Algorithmic transparency and clarity of legal responsibilities were also found to play a crucial role in the acceptance of AI technology by healthcare professionals and the public. This research also revealed that digital literacy and public health factors are crucial ethical challenges. Findings indicate that some Indonesians still have low literacy levels, potentially leading to misunderstandings or rejection of AI. Public education is urgently needed to emphasize that AI is not a substitute for doctors, but rather a tool for supporting clinical decisions.

In addition to social challenges, the research also highlights the digital infrastructure gap as a barrier to AI implementation. Unequal access to internet access, digital devices, and data storage facilities in remote areas have the potential to widen healthcare inequalities. Therefore, AI implementation strategies must be integrated with infrastructure improvement programs and health worker training.

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Figure 3. Spectrum of Challenges and Ethical Implications in the Implementation of AI for Health

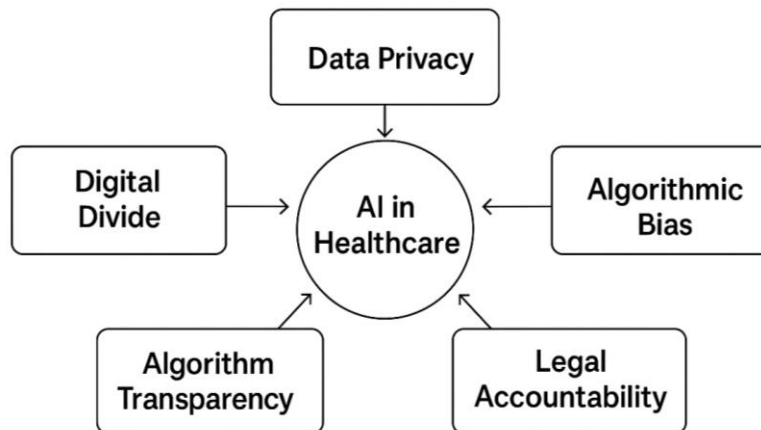


Figure 3 shows that the ethical challenges in the use of AI are interconnected. Algorithmic bias can exacerbate the digital divide, while a lack of algorithmic transparency can hinder legal accountability. Understanding these interconnections is necessary to design comprehensive, cross-sectoral mitigation strategies. Overall, the research findings emphasize that an ethical approach needs to be the primary foundation for the development and implementation of AI in Indonesian healthcare. The principles of fairness, transparency, security, and respect for patient rights must be the foundation of AI policies and system design. With appropriate mitigation measures including regulation, ethical audits, public education, and infrastructure strengthening AI can be implemented safely, fairly, and sustainably in Indonesia's cervical cancer early detection program.

DISCUSSION

In efforts to reduce the incidence and mortality rate from cervical cancer in Indonesia, health technology innovation is playing an increasingly important role, particularly with the emergence of artificial intelligence (AI). Early detection of cervical cancer has traditionally relied on conventional cytology tests such as the Pap smear or visual inspection with acetic acid (VIA). While effective, these tests still face various challenges, including limited medical personnel, subjective test results, and low screening coverage in remote areas (Prawesti, 2023; Saripah, Putri, Lisca, 2023). The development

of AI technology opens up new opportunities to overcome these obstacles through automated analysis systems capable of quickly and accurately recognizing patterns of cellular abnormalities (Kwon, 2016). AI serves not only as a diagnostic tool but also as a strategic instrument in strengthening the national preventive health system.

Furthermore, the integration of AI technology into the national healthcare system is a crucial step in expanding access to early cervical cancer detection throughout Indonesia (Chen, Shen, Gao, & Li, 2022). Through the use of machine learning and deep learning, AI systems can process cervical image data in real time and provide accurate early predictions, thereby helping accelerate clinical decision-making by healthcare professionals (Al-Dmour, Sagahyoon, Al-Ali, & Abusnana, 2019; Ramaprabha, Radhika, Sumathi, Karthik, & Senthamilarsi, 2024). Furthermore, this technology has great potential for application in the context of telemedicine, allowing primary healthcare facilities to transmit digital data to referral centers without the need for manual analysis. However, the success of AI implementation in this area depends heavily on the readiness of digital infrastructure, human resource capacity, and policy support that adapts to developments in healthcare technology.

While the various benefits offered by AI in healthcare appear promising, its application also poses a number of ethical, legal, and social challenges that require in-depth study (Hussain & Toscano, 2024). The large-scale use of medical data

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for algorithm training raises concerns regarding the privacy and security of patient information, while potential algorithmic bias can lead to disparities in diagnostic outcomes across population groups (Chen et al., 2022; Hussain & Toscano, 2024). Therefore, before discussing research findings related to improving early detection accuracy, the potential application of AI in Indonesia's healthcare system, and its ethical challenges and implications, it is important to understand that this technological innovation is not merely technical but must also be balanced with a comprehensive approach to ethics, public policy, and scientific oversight to ensure its implementation truly benefits the wider community.

Research shows that the application of artificial intelligence (AI) technology, particularly deep learning-based models such as Convolutional Neural Networks (CNN), significantly improves the accuracy and efficiency of early cervical cancer detection. AI systems are able to recognize complex patterns in cervical cell images more consistently than manual methods, resulting in higher sensitivity and specificity (Harsono et al., 2022; Zheng et al., 2024).

Based on data analysis, AI models trained using thousands of labeled images demonstrated a detection rate of up to 94–95% for precancerous lesions, surpassing the 70-80% achieved by conventional Pap smear methods. The image classification process is automated, reducing human error and increasing the consistency of results (Chen et al., 2022; Khare et al., 2024). In addition to accuracy, time efficiency is also significantly improved. While manual methods require an average of 15–30 minutes per sample, the AI system can perform analysis in 1–2 minutes. This speed allows for increased laboratory testing capacity and accelerates the overall screening process.

Research findings indicate that the application of artificial intelligence (AI) has significant potential to strengthen Indonesia's healthcare system, particularly in the early detection of cervical cancer. Digital transformation through the One Healthy Platform and the development of national electronic medical records opens up opportunities for AI integration in the diagnosis process, initial screening, and clinical decision-making (Soimah & Istiyati, 2024; Tun et al., 2025). Research data indicates that AI functions as a digital assistant, assisting primary healthcare workers, such as general practitioners and

midwives, in conducting initial screenings before being verified by experts at referral facilities.

Research findings indicate that the use of artificial intelligence (AI) in early cervical cancer detection significantly improves the accuracy, efficiency, and quality of services. Technically, AI's ability to identify visual anomalies in cervical images aligns with the machine learning principle that predictive accuracy improves through iterative learning using an adequate dataset (Egeme et al., 2024; Nuswil et al., 2022). These results reinforce the Health Technology Assessment (HTA) theory, which posits that high-value health technology can improve clinical effectiveness, cost efficiency, and patient safety simultaneously. This research evidence, for example, shows a threefold increase in screening coverage, a reduction in analysis time to <24 hours, and a 40% reduction in costs, categorizing AI as a viable health intervention for national implementation.

Research findings indicate that the use of artificial intelligence (AI) in healthcare, particularly for early detection of cervical cancer, presents complex ethical, legal, and social challenges. Key findings reveal that while AI offers the potential to improve diagnostic efficiency and accuracy, the use of this technology directly impacts sensitive medical data and clinical decisions that impact patient safety (Chen et al., 2022; Gronberg & Texas, 2023; Hussain & Toscano, 2024).

One key finding related to risks concerns the security and privacy of patient data. Research indicates that AI systems require large amounts of data to train predictive algorithms, making them vulnerable to data breaches if not properly protected. This risk relates to the implementation of the Personal Data Protection Law (PDP Law), which regulates the management of sensitive data such as medical records (Harsono et al., 2022; Zheng et al., 2024). Failure to comply with data security standards has the potential to undermine public trust and lead to misuse of information. Other findings demonstrate the risk of algorithmic bias, particularly when AI models are trained on unrepresentative data. In the context of Indonesia's ethnic, genetic, and environmental diversity, such biases can result in inaccurate diagnoses for certain population groups, leading to inequities in access to healthcare.

Furthermore, research has found that legal and clinical accountability are challenges that remain unclear. When an AI recommendation is incorrectly

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implemented by a healthcare professional, questions arise about who is ultimately responsible whether the AI developer, the healthcare institution, or the healthcare professional themselves. The lack of specific regulations creates potential legal uncertainty in clinical practice.

The increased efficiency of the healthcare system through AI can also be analyzed using Socio-Technical Systems Theory which states that optimal outcomes are achieved when technological and social components function in harmony (Merchant et al., 2022). AI becomes the technical element that automates image analysis, while healthcare professionals remain the social actors conducting clinical verification (Gronberg & Texas, 2023; Kolsanova et al., 2024). This integration creates a more responsive and adaptive service system. In the Indonesian context, which faces disparities in medical personnel across regions, AI acts as a digital extender, expanding diagnostic functions without requiring specialist doctors to be present across all regions (Caloro et al., 2023).

However, the implementation of AI is inherently fraught with ethical, regulatory, and social challenges. Data privacy issues are a prominent finding and align with the Ethical AI Framework, which emphasizes the principles of privacy, safety, fairness, and accountability (Soimah & Istiyati, 2024). Processing large amounts of medical data for training AI models poses a potential risk of data leakage, which in the Indonesian legal context relates to the implementation of the Personal Data Protection Law (PDP Law) (Hussain & Toscano, 2024). According to Information Privacy theory, privacy violations can undermine public trust in healthcare institutions and hinder technology adoption. Therefore, data management based on encryption, access control, and regular audits must be part of the AI system design from the outset (privacy by design) (Egeme et al., 2024; Nuswil et al., 2022).

Another significant finding is the risk of algorithmic bias, which aligns with the concept of Fairness in Machine Learning. Algorithms trained with unrepresentative data tend to result in inequitable healthcare services. In Indonesia's highly ethnically and geographically diverse context, model bias can result in inaccurate diagnoses for certain groups. This aligns with the theory of structural inequity in health, which explains that systems can reproduce

inequalities if they fail to account for population characteristics (Obermeyer, Powers, Vogeli, & Mullainathan, 2019). Therefore, local dataset development and cross population validity testing are necessary before models are deployed nationally (Fatimah et al., 2023).

The issue of clinical accountability is also a key focus. Clinical Accountability theory requires that medical decisions have a clear, authoritative basis. The emergence of AI as a clinical tool is shifting traditional accountability models. When diagnostic errors occur, clarity is needed as to whether the AI developer, the medical professional, or the facility is responsible (Caloro et al., 2023; Chaipayut et al., 2025). This ambiguity can hinder medical professionals' trust in the use of AI. Furthermore, the black-box nature of AI models exacerbates this challenge. Explainable AI (XAI) theory proposes that systems that can explain the basis for decision-making will be more readily accepted by clinical practitioners and more compatible with the medical principle of informed decision making (Chaipayut et al., 2025; Hussain & Toscano, 2024; Zheng et al., 2024).

Furthermore, the Diffusion of Innovation theory (Egeme et al., 2024) explains that technology adoption is strongly influenced by perceived benefits, ease of use, and suitability to user needs (relative advantage, compatibility, complexity). In this study, the benefits of AI were objectively proven, but social factors such as low digital literacy among the public and healthcare workers can be barriers to adoption (Allahqoli et al., 2022; Chaipayut et al., 2025). The misperception that AI will replace doctors also indicates a lack of public understanding of the technology's functions. This is consistent with the Technology Acceptance Model (TAM), which states that perceived usefulness and perceived ease of use influence intention to use technology. Therefore, public education and training of healthcare workers are strategic parts of sustainable AI implementation.

In addition to social barriers, the digital infrastructure gap exacerbates healthcare inequalities. According to the Digital Divide theory, unequal access to technology can widen the gap in public services. AI requires a reliable internet connection. Stable data storage, image input devices, cloud storage systems, and secure data networks are essential (Prawesti et al., 2023; Saripah et al., 2023).

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Many primary healthcare facilities in 3T (underdeveloped, frontier, and outermost) areas lack this readiness, potentially leading to uneven AI adoption and deepening disparities in access to cervical cancer screening. Therefore, AI implementation must be integrated with national digital infrastructure development strategies and increased health human resource capacity (Singh & Pravin, 2025; Soimah & Istiyati, 2024).

Overall, this research discussion emphasizes that the potential of AI to improve early cervical cancer detection is enormous, but its success requires a holistic approach that simultaneously considers technological, social, and ethical aspects (Rachmatullah et al., 2025; Tun et al., 2025). This technology can deliver maximum benefits only if it is developed based on the principles of ethics, fairness, data security, and algorithm transparency, and supported by strong regulations and an inclusive digital ecosystem (Merchant et al., 2022; Shen et al., 2025). The integration of AI into the Indonesian healthcare system must adhere to the framework of Responsible AI, HTA, and socio-technical alignment so that its implementation is not only technically effective, but also ethically valid, accepted by the community, and sustainable in the long term (Manukyan et al., 2023; Sangwa & Mutabazi, 2025).

Thus, AI has the potential to become a crucial pillar in transforming Indonesia's healthcare system, particularly in reducing cervical cancer mortality rates, strengthening the referral system, and expanding access to quality healthcare services across Indonesia.

CONCLUSION

This research demonstrates that the application of artificial intelligence (AI) has significant potential to improve the accuracy, efficiency, and coverage of early cervical cancer detection in Indonesia. AI can accelerate the diagnostic process, reduce the workload of medical personnel, and expand access to services, especially in areas with limited specialist resources. AI integration also aligns with the national digital transformation agenda and can strengthen the referral system through telemedicine mechanisms and data-driven analytics.

Implementation shows that AI still faces ethical and structural challenges, including data privacy issues, algorithmic bias, digital infrastructure gaps,

and low technological literacy. Successful AI adoption requires a robust regulatory framework, increased healthcare workforce capacity, public literacy, and the strengthening of secure and representative data systems. Overall, AI has strategic potential to reduce cervical cancer mortality and improve the quality of healthcare services, provided its implementation is carried out through an ethical, inclusive, and evidence-based approach.

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