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Systematic Review
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Application of Artificial Intelligence (AI) and Machine Learning (ML) in Health Applications for HIV/AIDS Prevention: A Systematic Review

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ABSTRACT

Background: HIV/AIDS has become a global problem that continues to increase every year, despite various prevention efforts such as health education and HIV screening. To overcome this challenge, innovative strategies are needed by integrating artificial intelligence and digital technology to develop more effective HIV/AIDS prevention interventions. The aim of this study is to determine the effectiveness of using AI and ML in applications for HIV prevention and can be an evidence base for the development of Health applications for HIV Prevention.

Subjects and Method: The research method used was a systematic review based on PRISMA 2020. The databases used are PubMed, Science Direct, and Google Scholar with study criteria published in 2015-2024. The keywords used are "Artificial Intelligence and Machine Learning and HIV","Artificial Intelligence and HIV", "Machine Learning and HIV, 'Artificial Intelligence and HIV' and Systematic Review", and "Artificial Intelligence and Machine Learning in HIV/AIDS Prevention". The Joanna Briggs Institute (JBI) checklist was used to assess the quality of the included studies.

Results: Based on the results of the review, AI and ML have proven to be effective in improving HIV/AIDS prevention programs. Benefits include the use of digital data to detect at-risk groups, virtual reality programs to help with status disclosure, chatbots for education, and data analysis to understand the causes of transmission and how to prevent it. An HIV prevention chatbot that can aid in prevention messaging, encourage self-testing, and personalized treatment strategies would be transformational in a low-resource setting.

Conclusion: AI and ML approaches can be an important solution in improving the effectiveness of HIV/AIDS prevention programs, although they are still at an early stage and face various challenges. Future research should identify the potential of AI and ML to be developed and implemented more widely.

Keywords: Artificial Intelligence (AI), Machine Learning (ML), HIV/AIDS

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BACKGROUND

HIV/AIDS is a disease that is still a global problem today. It is estimated that there will be 39.9 million people living with HIV by the end of 2023 an estimated 630,000 people will die from HIV-related causes and around 1.3 million people will contract HIV (WHO, 2024a). Meanwhile, in Indonesia, the cumulative number of people living with HIV reported up to December 2023 was 407,577, while the cumulative number of AIDS cases reported up to December 2023 was 159,130 (Kemenkes RI, 2024). There is no definitive cure for HIV infection.

However, with access to effective HIV prevention, diagnosis, treatment, and care, including for opportunistic infections, HIV infection has become a manageable chronic health condition, enabling people living with HIV to lead long and healthy lives (WHO, 2024b). Therefore, innovative strategies are needed to improve the implementation of HIV/AIDS prevention in the current era of digitalization. One of them is the integration of AI and digital technology in developing effective HIV/AIDS prevention intervention strategies (Xiang et al., 2023).

Artificial Intelligence (AI) is a technology that allows machines to mimic various complex human skills (Sheikh et al., 2023). This artificial intelligence can make predictions or take actions based on patterns in existing data and can then learn from its mistakes to improve its accuracy. Then Machine learning (ML) helps machines recognize patterns and make decisions automatically with algorithms created (Peter et al., 2021). AI and ML can process new information very quickly and accurately, which makes them useful as virtual assistants or chatbots in HIV/AIDS prevention (Cheah et al., 2024; Ardiana et al., 2020). Therefore, a systematic review is needed to see how effective the use of AI and ML is in HIV/AIDS prevention. Systematic Reviews attempt to collate all empirical evidence that conforms to pre-specified eligibility criteria to answer a particular research question (Duque et al., 2021).

SUBJECTS METHOD

1. Study Design

This was a systematic review.

2. Steps of Systematic Review

This method is carried out by collecting, critically assessing, and synthesizing several research results that match the inclusion and exclusion criteria set by the researcher. Article selection must be done to find quality articles. The selection starts from keyword selection, database selection, determining article inclusion and exclusion criteria, and assessing the quality of journals and articles.

a. Keywords:

The keywords used are “Artificial Intelligence and Machine Learning and HIV”, “Artificial Intelligence and HIV”, “Machine Learning and HIV, ‘Artificial Intelligence and HIV’ and Systematic Review”, “Artificial Intelligence and Machine Learning in HIV/AIDS”

b. Database :

The databases used were PubMed, Science Direct, and Google Scholar. The search covered worldwide research published between 2015 and 2024.

c. Data Extraction :

All eligible article was collected in one folder with Mendeley and article duplicates were removed.

d. Quality Assessments :

The Joanna Briggs Institute (JBI) checklist was used to assess the quality of the included studies. JBI appraisal checklist is assessed by scoring (yes=1), (no=0), and (unclear or not applicable=0). The total score obtained from each study was presented as percentages and each study was categorized according to different

levels (Siddiqui et al., 2021). A study was considered low quality if it scored less than 50%, moderate quality if it scored between 50 and 70%, and high quality if it scored above 70% (Nasuuna et al., 2024).

Two reviewers (A.D.Y and N.M.) assessed the quality of the included studies independently. They evaluated the complete text and abstract of the qualifying articles upon score criterion. In case of any differences, a third member (A.B.A) was asked to give input and make the final decision based on the reviews of the two members.

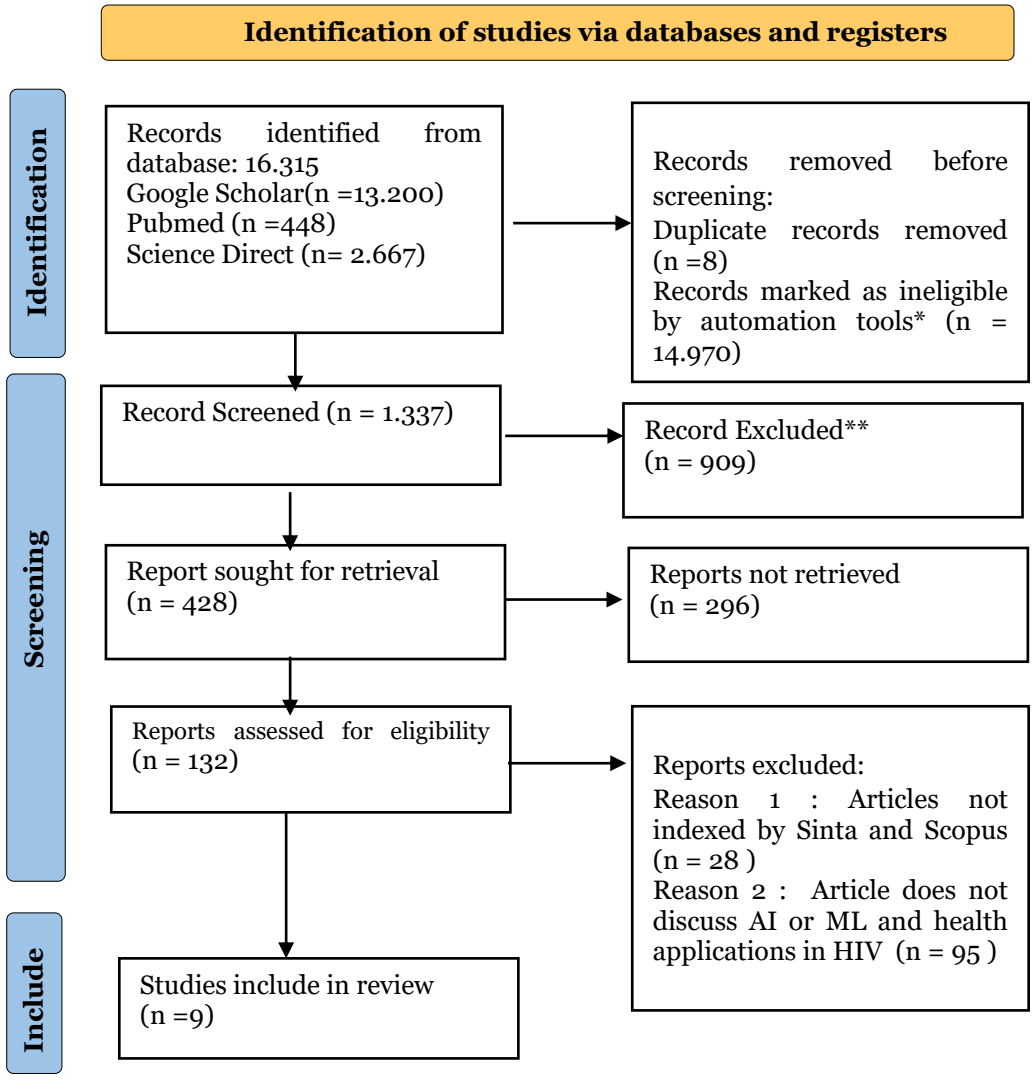

Figure 1. PRISMA Flow Diagram

*Ineligible records are automatically deleted in the database according to year, article type, language, and open access journal.
***Articles that were excluded in general and manually by the researcher by reading

3. Inclusion Criteria

a. Articles published in 2015-2024
b. Articles using Indonesian or English
c. Articles can be accessed in full text or open access.

4. Exclusion Criteria

a. Articles not indexed by Sinta and Scopus
b. Articles do not discuss Artificial Intelligence and Machine Learning or health applications in HIV.

5. Operational Definition of Variables

a. **Artificial Intelligence (AI) :** Technology that allows machines to mimic various complex human skills
b. **Machine Learning (ML) :** Machines recognize patterns and make decisions automatically with algorithms created.
c. **Health Application:** Software programs on mobile devices that process health-related data on or for their users.
d. **HIV Prevention :** Some of the precautions taken to prevent HIV such as health promotion and the use of pre-exposure prophylaxis (PrEP).

6. Research Instruments

The instruments in this study are using Prisma flow diagram for article selection and JBI checklist for quality assesment. The JBI checklists used were the checklist for systematic reviews (11 question items), the checklist for narrative reviews (6 question items), the checklist for qualitative research (10 question items), and the checklist for analytic cross sectional studies (8 question items).

7. Data Analysis

The data were analyzed and the quality of journal articles was assessed using JBI. The results of this study begin with an analysis of each journal article used, namely author, year, country, research title, methods, results, recommendations, and journal quality assessment. Then the content of the discussion is to review journal articles on the effectiveness of using AI and ML in health applications for HIV prevention.

RESULTS

The following is a table of article review results **(see Table 1).** Table 1 shows that there are 9 articles reviewed. All articles are in English and Scopus indexed. Articles were reviewed based on author, year, the country of origin of the article, research title, study design, research results, recommendations, and article quality assessment. Then based on the results of the article quality assessment, most articles have high (above 70%) quality scores and moderate (between 50-70%) quality scores.

Table 1. Article Review Results

No.	Author, Year, Country	Research Title	Study Design	Research Results	Recommendation	Quality Assessment
1.	(Xiang *et al.*, 2023), UK	Review of Application of Artificial Intelligence and Machine Learning for HIV Prevention Interventions to Eliminate HIV	Narrative Review	AI supports health efforts by identifying risks, detecting vulnerable groups, assisting with the notification process to the spouse of an infected person, and providing counseling.	This review shows that the application of AI techniques in this field is still in its infancy, and many challenges remain.	High
2.	(Kamitani *et al.*, 2024), US	Improving HIV preexposure prophylaxis uptake with	Systematic Review	The research found 12 studies that showed AI interventions in PrEP	Future research needs to identify specific areas of PrEP support	High

No.	Author, Year, Country	Research Title	Study Design	Research Results	Recommendation	Quality Assessment
		artificial intelligence and automation: a systematic review		care were acceptable, improved patient understanding and adherence, and helped healthcare providers by reducing workload and providing clinical decision support.	that are most appropriate for optimization through AI/ automation technologies.	
3.	(Marcus *et al.*, 2020) US	Artificial Intelligence and Machine Learning for HIV Prevention: Emerging Approaches to Ending the Epidemic	Literature Review	Machine learning (ML) has been used to identify potential PrEP users in US, Danish, and East African health services. Although still in its infancy, ML also has several other promising potential uses, such as: data collection through smartphones and social media to reduce HIV risk, use of virtual reality to help disclose HIV status, chatbots for education, cause-effect analysis in HIV prevention.	A collaborative approach involving stakeholders is essential to ensure the success, sustainability and impact of HIV prevention interventions. As well as obtaining stakeholder input	High
4.	(Mutai *et al.*, 2021) UK	Use of machine learning techniques to identify HIV predictors for screening in sub-Saharan Africa	Machine learning approaches for building model	Utilizing social and behavioral data with advanced algorithms like XGBoost can improve HIV-positive identification efforts for more targeted interventions.	Further research is needed to optimize, integrate, and implement predictive models into primary healthcare	High
5.	(Cheah *et al.*, 2024) Canada	Testing the Feasibility and Acceptability of Using an Artificial Intelligence Chatbot to Promote HIV Testing and Pre-	Mix Method Study	A total of 93% of participants found the chatbot useful, with a simple design and quick responses. 79% were willing to continue using it, with suggestions to add	The chatbot should be customized into Bahasa Malaysia and enhanced to provide HIV-related information, including mental	High

No.	Author, Year, Country	Research Title	Study Design	Research Results	Recommendation	Quality Assessment
		Exposure Prophylaxis in Malaysia: Mixed Methods Study		Bahasa Malaysia and mental health information. The chatbot was found to be effective in reducing stigma and potentially increasing HIV testing and PrEP uptake.	health, sexually transmitted infection risk assessment, AIDS treatment, and the impact of HIV transmission.	
6.	(Jaiteh *et al.*, 2024) Switzerland	Utilization of Machine Learning Algorithms for the Strengthening of HIV Testing: A Systematic Review	Systematic Review	Machine Learning models have higher accuracy in predicting HIV risk/ testing than traditional approaches. ML models can: Improve early prediction of HIV transmission, Facilitate appropriate testing strategies to improve service efficiency, Optimize resource allocation, Improve accuracy of HIV diagnosis.	Researchers highly recommend the integration of machine learning (ML) into HIV testing programs for efficient and accurate HIV testing.	High
7.	(Braddock *et al.*, 2023) Canada	Increasing Participation in a TelePrEP Program for Sexual and Gender Minority Adolescents and Young Adults in Louisiana: Protocol for an SMS Text Messaging–Based Chatbot	Conceptualization and development	Chatbot development tools are easily accessible, user-friendly and relatively inexpensive. Our experience proves that HIV prevention researchers can program rule-based chatbots feasibly and efficiently with the help of commercially available tools.	Future HIV researchers and practitioners may consider integrating chatbots as part of their programs.	Moderate
8.	(He *et al.*, 2022) Switzerland	Application of machine learning algorithms in predicting HIV infection among	Cross-sectional Model development and valida-	Machine learning, particularly Random Forest optimized with SMOTE technology, demonstrates	Additional researches are needed to further optimize these algorithms, expand useful	High

No.	Author, Year, Country	Research Title	Study Design	Research Results	Recommen-dation	Quality Assess-ment
		men who have sex with men: Model develop-ment and validation	tion	superior per-formance compared to traditional models in predicting HIV infection among MSM, enabling better identification of high-risk indivi-duals for timely intervention.	models to the entire country, and evaluate their usefulness and effects of them on HIV prevention	
9.	(Heerden *et al.*, 2023) US	Chatbots for HIV Pre-vention and Care: a Narrative Review	Narrative Review	Chatbots enable confidential HIV-related discussions that can enhance prevention and care strategies, with user engagement primarily driven by information reliability and accuracy.	Encouraging future research, collaboration among stake-holders, and bold innovative thinking will be pivotal in harnessing the full potential of chatbot interventions	High

DISCUSSION

Based on the results of the review, it can be seen that Artificial intelligence (AI) has made a significant contribution to health efforts, especially in HIV prevention and treatment. Through advanced technology, AI is able to identify risks, detect vulnerable groups, assist in the notification process to infected partners, and provide in-depth counseling (Xiang *et al.*, 2023). Other studies have also shown that AI inter-vention in PrEP (Pre-Exposure Prophy-laxis) treatment is acceptable and markedly improves patient understanding and adhe-rence, thereby helping healthcare providers reduce their workload (Kamitani *et al.*, 2024).

Particularly generative AI models like GPT, in healthcare, is increasingly being recognized such as ChatGPT and Claude AI, have shown a remarkable ability to com-prehend and generate human-like text, leveraging medical data and knowledge to transform clinical decision support, patient communication, and data management in healthcare (Singhal *et al.*, 2023). In Ukraine, they have increased HIV screening by implementing innovative approaches to their work, including the use of artificial intelligence (AI) to identify individuals at high risk of HIV (Holt, 2024). There is a positive impact in the application of AI in Cameroon which is patient engagement: AI-powered chatbots or virtual assistants can provide assistance and information to patients in managing their HIV. Patients can benefit from a better understanding of their disease and be more engaged in their care as a result (Andigema *et al.*, 2023).

Based on the review, Machine Learn-ing (ML) has been used to identify potential PrEP users in US, Danish and African

health services. Although still in its infancy, ML also has several other promising potential uses, such as: data collection through smartphones and social media to reduce HIV risk, the use of virtual reality to help disclose HIV status, and chatbots for education (Marcus *et al.*, 2020). Other studies have found chatbots to be very useful with the main strengths being their simple design and ability to provide quick and precise responses. And among them expressed willingness to continue using chatbots. Therefore, chatbots are considered effective in reducing stigma and potentially increasing HIV testing and PrEP uptake (Cheah *et al.*, 2024).

Several chatbots, such as the pioneering “Amanda Selfie” in Brazil, have been developed with a focus on key populations. Amanda Selfie, a transgender chatbot used to stimulate PrEP interest in adolescents, can facilitate sensitive discussions on sex, STIs, and PrEP, and even identify individuals at higher risk for HIV (Massa *et al.*, 2023). In Indonesia, a technological breakthrough has been presented in the form of an innovative chatbot application designed to support efforts to disseminate information about HIV/AIDS. The research conducted developed a mobile application by utilizing Artificial Intelligence Markup Language (AIML), which aims to assist the Spirit Paramacitta Foundation in disseminating reliable information to the public. The choice of AIML as the basis for chatbot technology is based on its ability to make bots able to approach human communication capacity, so as to create interactions that approach the quality of conventional counseling sessions (Ardiana *et al.*, 2020).

An HIV prevention chatbot that can aid in prevention messaging, encourage self-testing, and personalized treatment strategies would be transformational in a low-resource setting. They would have the potential to reach many individuals, especially those who may face barriers to accessing traditional healthcare services. Future work should rigorously address the optimization of chatbot design and functionality to ensure maximal utility, safety, and user-friendliness (Heerden *et al.*, 2023).

Tools like chatbots, such as "Amanda Selfie" in Brazil and projects in Indonesia, have helped reduce stigma and increase HIV testing. However, these technologies are still in early stages, with challenges in optimizing their broad implementation. Future research is recommended to identify specific areas of PrEP support that are most optimal for AI intervention, with particular emphasis on the effectiveness, adaptability, and sustainability of the strategy (Xiang *et al.*, 2023; Kamitani *et al.*, 2024). A collaborative approach involving various stakeholders is key to ensuring the success and impact of HIV prevention interventions (Marcus *et al.*, 2020).

This study concludes that AI and ML approaches can be an important solution in improving the effectiveness of HIV/AIDS prevention programs, the use of PrEP for people at risk of contracting HIV and reducing stigma. These technologies can make significant contributions ranging from identifying risks, detecting vulnerable groups, assisting the notification process, to providing counseling through innovations such as chatbots and mobile applications. However, the application of AI and ML in HIV prevention is still at an early stage and faces many challenges. Future research needs to be conducted to conduct a deeper identification of AI and ML, so that they can be developed and implemented widely.

AUTHORS CONTRIBUTIONS

Aulia Dwi Yuliana and Nurholis Majid conducted and designed the research; Ahnav Bil Auvaq and Eksa Satya Pertiwi

collected and analyzed data; Jessica Febe Immanuela interpreted data and report writing; Aulia Dwi, Nurholis Majid, and Ahnav Bill assess the quality of the article together. All Authors discussed the result and contributed to the final manuscript.

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CONFLICT OF INTEREST

There are no conflicts of interest.

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