Advances in Medical Education and Practice

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

The Revolution in Midwifery Education: How AI and Deep Learning are Transforming Outcome-Based Assessments?

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Video Abstract

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Background: Currently, midwifery education is confronted with a variety of obstacles, such as inadequate resources and conventional learning methods that are less effective in enhancing the clinical skills of students. Technological advancements and the rapid evolution of maternal and neonatal health services necessitate the transformation of midwifery education to a competency-based curriculum and outcome-based assessment paradigm. Artificial intelligence (AI) and deep learning have the potential to provide adaptive, personalized, and precise learning in this context. Nevertheless, its implementation continues to encounter a variety of challenges.

Purpose: This study reviews the role of AI and deep learning algorithms in enhancing outcome-based assessments in midwifery education, focusing on improvements in objectivity, personalized learning, and students' clinical readiness.

Patients and Methods: This study employed a systematic literature review from Science Direct, Semantic Scholar, Springer Nature, and Taylor and Francis databases. Rayyan's software was employed to select 15 articles from the 771 articles that were discovered, in accordance with the inclusion and exclusion criteria. To guarantee objectivity and quality, two researchers conducted an independent evaluation.

Results: Our review indicates that algorithms including Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), Random Forest, and Support Vector Machine (SVM) are proficient in facilitating objective evaluations, delivering tailored feedback, and enhancing clinical learning simulations. Artificial intelligence has demonstrated the capacity to enhance students' communication, critical thinking, and clinical decision-making abilities. The primary challenges encompass infrastructure preparedness, digital literacy, and ethical concerns pertaining to data protection and algorithmic prejudice.

Conclusion: Artificial intelligence and deep learning possess significant promise to revolutionize achievement-based assessments in midwifery education through accurate, adaptable, and scalable evaluations. The successful implementation relies on the management of technological, pedagogical, and ethical restrictions, along with thorough integration into the curriculum to equip graduates for global maternal and neonatal health concerns.

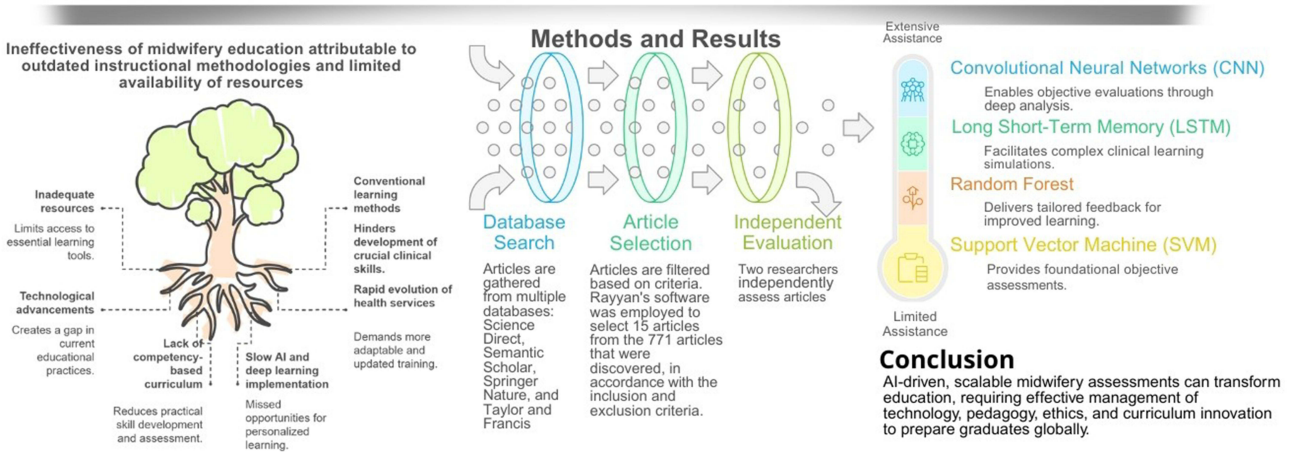
Keywords: midwifery, artificial intelligence, AI, outcome learning, learning assessment, challenges, teaching and learning

Introduction

Transformations in the maternal and neonatal health care system are presently occurring swiftly, imposing new requirements on midwifery education.[1,2] Midwifery education has evolved into a domain for cultivating professionals equipped with sensitivity, empathy, and a contextual comprehension of the culture and needs of each individual client, rather than merely a venue for acquiring theoretical knowledge or technical abilities.[3] As the healthcare system transitions to a value-based care paradigm that prioritizes service value and patient focus, education must evolve accordingly.[4] The curriculum is now required to be competency-based, while assessment is transitioning to an outcome-based approach that prioritizes tangible results. Within this framework, success is evaluated not alone by the mastery of

Received: 13 June 2025
Accepted: 15 August 2025
Published: 30 August 2025

Graphical Abstract



theory, but also by the acuity of practice, the sophistication of professional attitudes, and the emotional competencies of students that can be objectively quantified.[5,6] Outcome-Based Assessment (OBA) emphasizes the achievement of tangible and measurable outcomes, focusing on competencies that can be directly applied in the workplace, such as technical skills, clinical decision-making, and patient interactions.[7]

Advancements in Artificial Intelligence (AI) and deep learning are revolutionizing teaching and learning, transforming not just the tools used, but also the educational and developmental processes of midwifery students.[8] From the capacity to customize education to the development of authentic clinical simulations,[9] AI enhances decision-making by analyzing vast data, enabling adaptive and relevant learning. Key skills like clinical decision-making, once gained through experience, can now be developed using digital methods, especially in resource-limited areas.[10]

Numerous research indicate that AI can deliver real-time feedback,[6] tailored to the needs of each student, so they can learn from mistakes firsthand and develop essential clinical skills.[11–13] Convolutional Neural Networks (CNN) are among the technologies that have been employed to integrate various categories of data in order to generate more objective and precise evaluations.[14] With the rise of hybrid learning models post-COVID-19, AI plays a key role in creating a more adaptable and personalized learning experience.[15] AI systems use algorithms like CNN and Long Short-Term Memory (LSTM) to tailor learning materials to each student's style and abilities, creating a more adaptive and effective learning experience.[16] LSTM, which is a type of neural network in deep learning, is highly effective for analyzing sequential data, such as vital signs or partograph data used in midwifery, to predict the progression of labor and support more accurate clinical decision-making.[17]

Not only does AI increase learning effectiveness, but it also plays an important role in increasing student engagement.[18] Tailoring learning to individual preferences boosts knowledge retention, deepens understanding of clinical material, and sharpens decision-making skills.[19,20] For example, CNN and LSTM algorithms enable automated image interpretation and sequential data analysis, both of which are valuable in simulating clinical decision-making processes. In daily midwifery education practice, CNN can be applied in ultrasound image classification to help students identify fetal positions or anomalies, while LSTM support labor progression prediction based on sequential vital signs or partograph data.[21] Moreover, in Indonesia, AI adoption in midwifery education is gaining traction, but challenges such as digital literacy gaps, limited resources, and the lack of clear regulations at the local level hinder its full integration into the curriculum. Despite these challenges, AI holds promise in enhancing both the teaching and assessment of clinical competencies, offering a powerful tool for improving the quality of maternal health services in regions where resources are limited.[22]

Learning chatbots provide real-time feedback and facilitate interactive, question-based engagement, such as simulating patient interviews or guiding students through clinical scenarios step-by-step, which enhances diagnostic reasoning.[23] Similarly, Virtual Reality (VR) based midwifery simulation platforms allow students to virtually manage obstetric emergencies like postpartum hemorrhage or shoulder dystocia in safe, immersive environment.[24] These tools personalize instruction based on student learning styles and progress, leading to better knowledge retention, deeper understanding of clinical content, and stronger decision-making skills than traditional methods such as lectures or manual Objective Structured Clinical Examinations (OSCEs).[25] Furthermore, the application of AI in outcome-based assessment allows for more precise competency evaluations aligned with real-world practice, ultimately contributing to improvements in the quality of maternal health services.[26]

AI use in midwifery education assessments is not yet optimal, with many institutions using it separately rather than as part of an integrated system. Most studies focus on technical aspects or short-term results, while holistic approaches integrating pedagogy and technology remain scarce.[27] There is an urgent need to explore how AI can be used more strategically not just as an aid, but as part of an assessment system that shapes competencies in a sustainable and comprehensive manner.[28]

AI in OSCE enhances objective and efficient clinical assessments by analyzing student performance in real-time, including movements and communication. It offers quick, personalized feedback and reduces anxiety. ChatGPT aids self-paced exercises and scenario practice. However, ethical concerns like algorithmic bias and misuse must still be addressed.[25,28,29]

This study aims to provide an original contribution through an in-depth literature review on the role of AI and deep learning in outcome-based assessments in midwifery education. Unlike previous approaches that separate technology and pedagogy, we propose an integrative framework combining technology, assessment, and pedagogy. This study is expected to guide lecturers, curriculum developers, and researchers in designing adaptive, measurable assessment strategies that align with future needs. Additionally, it supports the development of a predictive evaluation system based on student performance, in line with outcome-based education. The results aim to strengthen midwifery graduates' readiness for clinical challenges and contribute to reducing maternal mortality through responsive, integrity-based, and technology-driven practices.

Materials and Methods

Search Strategy

This study uses literature review methodology. In this literature review, we conducted a search in four databases, namely Taylor and Francis, Science Direct, Semantic Scholar and Springer Nature Link in March 2025, in compliance with the PRISMA 2020 guidelines. Table 1 presents the search terms (keywords) used for literature retrieval across the respective databases. Each database integrates a combination of keywords tailored to the research topic, which focuses on the application of deep learning algorithms in midwifery education and outcome-based assessment.

A total of 771 articles were identified through a systematic search across four major databases: Taylor and Francis (356 articles), ScienceDirect (27 articles), Semantic Scholar (351 articles), and Springer Nature Link (37 articles). A rigorous screening process was conducted using Rayyan software, which included the removal of duplicate records and an initial selection based on titles and abstracts. Subsequently, two independent reviewers performed a full-text

Table 1 Search Keywords Based on Database

Database	Keywords (Search Terms)
Taylor and Francis	Deep learning algorithms AND midwifery education AND outcome-based assessment OR learning outcomes
Science Direct	Deep learning AND midwifery education AND outcome-based assessment AND learning assessment
Semantic Scholar	Deep learning logarithms AND outcome-based education OR outcome-based assessment OR learning assessment AND midwifery student OR midwifery education.
Springer Nature Link	Deep learning logarithms AND outcome-based education OR outcome-based assessment OR learning assessment AND midwifery student OR midwifery education.

https://doi.org/10.2147/AMEP.S543098

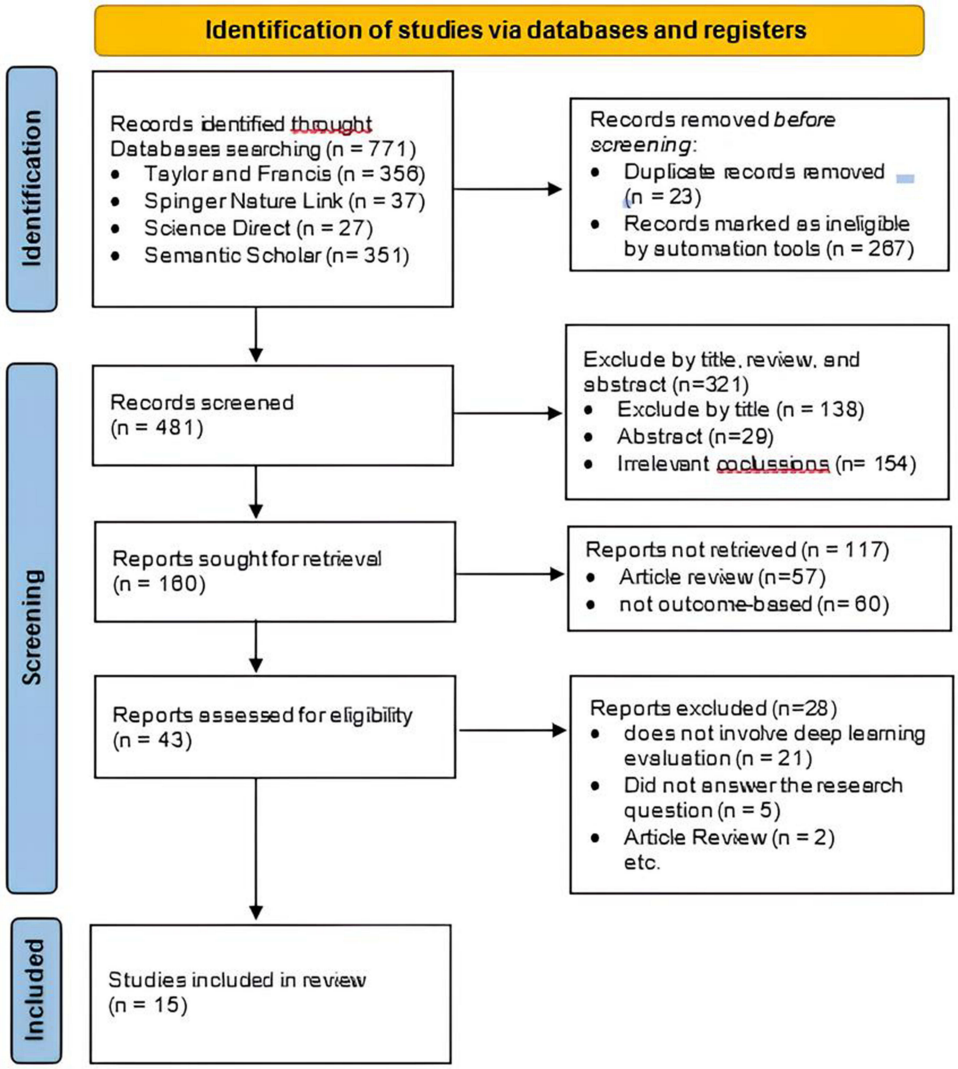


Figure 1 Flowchart of Study Selection Process for Literature Review on the Integration of Deep Learning in Midwifery Education.

assessment to evaluate each study's eligibility according to predefined inclusion and exclusion criteria, resulting in 15 articles selected for further analysis.

The data analysis was conducted using a narrative synthesis approach. Two independent reviewers extracted key information from each study, including research design, types of AI or deep learning algorithms employed, educational focus within the context of midwifery education, and the nature and outcomes of the assessments. The findings were then categorized thematically through iterative discussion, highlighting how artificial intelligence contributes to enhancing objectivity, personalized learning, and clinical readiness in outcome-based assessments.

The analysis revealed that algorithms such as CNN, LSTM, Random Forest, and learning chatbots have strong applicability in midwifery education. These technologies facilitate clinical simulation, deliver real-time feedback, and enable more objective and competency-based evaluations. The entire process adhered to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), and the article selection process is illustrated in the PRISMA flow diagram (Figure 1).[30]

Eligibility Criteria

The research to be included in this review will include qualitative and quantitative studies, such as experiments, quasi-experiments, surveys, or cross-sectional studies that address the application of AI and deep learning in midwifery

Table 2 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Studies published between 2020 to 2025	Studies published before 2020
Empirical research (eg, RCTs, qualitative, cross-sectional, retrospective, quasi-experimental, longitudinal, quantitative, simulation-based studies)	Review articles, opinion papers, or reports
Focus on the application of AI or deep learning algorithms in midwifery education	Studies that only address non-AI learning technologies, such as videos or tutorials
Utilization of outcome-based assessment frameworks	Studies with no clear application of outcome-based assessment
Involving students of midwifery or related clinical education programs	Studies focusing solely on healthcare practitioners without student participation
Available in open access or full-text format	Articles not fully accessible
Published in English	Non-English articles

education or that relate to health education that can be applied in midwifery, Table 2 describes the criteria for selecting articles used in the literature selection process. Especially in the context of results-based assessment. In addition, research using a qualitative approach that explores the experiences of students or teachers related to the use of AI and deep learning in midwifery education will also be considered. Studies involving midwifery students enrolled in midwifery education programs or related programs at accredited institutions, either at the bachelor's, master's, or diploma levels, will be included, especially if the research addresses how AI and deep learning can improve clinical skills, clinical decision-making, and learning outcomes of midwifery students. The focus of this research is on AI or deep learning technologies, such as simulation-based learning models, gamification, or Natural Language Processing (NLP), as well as how these technologies play a role in personalizing the learning experience and improving the clinical competence of midwifery students. Studies published in the last five years (2020–2025) will be prioritized to ensure the relevance of the latest technologies in midwifery education, by including only research that is freely accessible or that has full access at no cost.

Instead, studies that do not use AI or deep learning and cannot be applied in midwifery education will be excluded from this review. Research that only addresses technology-based learning without involving deep learning or AI algorithms, such as online learning platforms or video tutorials that do not use AI elements, will also be excluded. In addition, research that does not compare AI-based learning methods with traditional methods in midwifery education, or that does not examine the impact of technology on the practical skills or decision-making of midwifery students, will be ignored. Studies involving experienced health practitioners or professionals will also be excluded without involving relevant midwifery students or health education students. Research published before 2020 will be reviewed to ascertain the relevance of the technology used in the study to the latest developments in midwifery education. Only studies that are freely accessible or have a full-access version at no cost will be considered, ensuring that all selected literature is accessible to general readers without cost barriers.

Results

Overview of Included Studies

A total of 15 articles included in this review are summarized in Table 3, which presents an overview of the deep learning algorithms employed in each study published between 2020 and 2025. The analysis of publication year characteristics indicates that most studies were published in 2025, representing seven articles, which accounts for 47% of the total. The year 2022 ranks second with four publications (27%), while 2023 and 2024 each contributed two articles (13%). This distribution reflects a significant increase in publication volume in recent years, particularly in 2025, which indicates growing academic attention and shifting research focus within the field. The analyzed references provide a detailed account of annual contributions, underscoring the dynamic and continuously expanding nature of scholarly discourse in this domain. These details are comprehensively presented in Figure 2: Analysis of Publication Year Characteristics in Studies from 2022 to 2025. These studies came from 12 countries, such as China,[31–34] South Korea,[23,35] Iran,[36] Ghana,[37]

https://doi.org/10.2147/AMEPS543098

Table 3 Summary of Research on the Application of Deep Learning Algorithms in Midwifery Education (2021–2025)

NO	Year	Research Location	Article Title	Research Methods (Design, Sample, Sampling Techniques)	Deep Learning Algorithms Used	Focus of Midwifery Education	Results-Based Assessment Model	Impact on Learning Outcomes	Outcomes (Key Findings)
1.	2025	China	Development Of Nonverbal Communication Behavior Model For Nursing Students Based On Deep Learning Facial Expression Recognition Technology.[31]	Design: Cross-sectional study, Sample: 88 nursing students, Sampling technique: Purposive sampling	CNN and Extra Trees Regressor	Development of nonverbal communication skills	Facial expression-recognition based assessment	Reduce student anxiety, improve nonverbal communication skills	Deep learning-based models are effective in improving the empathy and communication skills of nursing students
2.	2022	China	Using deep learning to predict the outcome of live birth from more than 10.000 embryo data.[32]	Design: Retrospective study, Sample: 33,738 embryo sample data, Sampling technique: No inclusion or exclusion criteria on basic characteristics. Data taken from the Reproductive Medicine Center	SGD optimizer, Deep Learning (CNN-like architecture)	The use of deep learning in embryo selection to predict the outcome of live births. It can be a knowledge development for midwifery students.	A deep learning-based model to predict the outcome of live births based on time-lapse image data. Modern obstetrics education should prepare students to master the AI and deep learning technologies that are increasingly used to diagnose and assess clinical outcomes.	The application of AI and deep learning in the field of pregnancy and fertility has the potential to introduce new technologies in midwifery education, especially in terms of technical skills improvement, data-driven decision-making, and technology-based education. This knowledge and these skills are essential for midwifery students to respond to the latest developments in maternal and pregnancy health care.	AI and deep learning technologies used to predict live birth outcomes could introduce a new paradigm in midwifery education, where midwifery students can be trained to use advanced technology in clinical decision-making processes.
3.	2023	Iran	Effect Of Webquest-Based Education On Critical Thinking And Academic Self-Efficacy Of Midwifery Students: Study Protocol Of A Randomized, Controlled Crossover Trial.[36]	Design: Crossover randomized controlled experiment, Sample: Fifth-semester midwifery students, Sampling technique: Block randomization	Approach with AI	Development of critical thinking skills and self-efficacy	Assessment based on tests of critical thinking and self-efficacy	Improving critical thinking skills and academic self-efficacy of midwifery students	WebQuest is effective in improving critical thinking skills and academic self-efficacy.

4.	2025	China	Construction of Teacher Learning Evaluation Model Based on Deep Learning Data Mining.[33]	Design: Experimental study with educational data, Sample: Data taken from a project involving 200 teachers and 300 students, Sampling technique: Random sampling	Convolutional Neural Networks (CNN)	Focus on developing deep learning-based learning evaluation models for effectiveness assessment. Teaching.	Data mining and deep learning-based assessments to analyze the effectiveness of classroom teaching	The use of deep learning models for teaching assessment results in increased accuracy in teacher performance evaluations and enables continuous improvement in teaching.	This study developed an evaluation model that uses CNN to mine educational data such as student feedback, lesson plans, class interactions, and performance indicators to produce more objective and timely evaluations. This model shows an increase in the accuracy of teaching evaluations and supports the professional development of teachers. In midwifery education, this technology helps students improve their clinical skills directly and allows teachers to provide more effective support.
5	2025	Bulgaria	Application Of Virtual Reality, Artificial Intelligence, And Other Innovative Technologies In Healthcare Education (Nursing And Midwifery Specialties): Challenges And Strategies.[38]	Design: Experiment, Sample: Health students, Pre-test and post-test, two groups (experiment with VR and AI, control by traditional method)	Deep learning in AI and VR-based training	Midwifery Education, with a focus on patient care skills (eg, injection techniques)	Pre-test and post-test-based assessments	Improve student engagement, motivation, and learning outcomes	The use of VR and AI in midwifery education improves students' patient care skills and clinical thinking.
6.	2025	Ghana	Revolutionizing Nursing And Midwifery Informatics Curriculum Evaluation In Ghana: A Data-Driven Machine Learning Approach.[37]	Design: Cross-sectional, Sample: 1500 students from 5 institutions in Ghana, Sampling technique: Purposive sampling	Random Forest, Gradient Boosting, Support Vector Machine, Logistic Regression	Development of nursing and midwifery informatics curriculum	Assessment based on student satisfaction and academic performance	Increased student engagement and predicted academic performance	The machine learning model improves the accuracy of students' academic performance predictions with high accuracy (95%).
7.	2024	China	Evaluation Of Influencing Factors Of China University Teaching Quality Based On Fuzzy Logic And Deep Learning Technology.[34]	Design: Experimental; Sample: 60+ lecturers and students; Sampling technique: Survey with an open-ended questionnaire	LSTM and Fuzzy Logic	Evaluation of the quality of teaching in colleges	Assessment based on the influence of teaching factors	Improve the accuracy of teaching quality assessment	The combined SIF-LSTM model provides 98.4% accuracy in assessing teaching quality.

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Table 3 (Continued).

NO	Year	Research Location	Article Title	Research Methods (Design, Sample, Sampling Techniques)	Deep Learning Algorithms Used	Focus of Midwifery Education	Results-Based Assessment Model	Impact on Learning Outcomes	Outcomes (Key Findings)
8.	2024	Estonia, USA and South Korea	Augmenting Deep Neural Networks With Symbolic Educational Knowledge: Towards Trustworthy And Interpretable AI For Education.[35]	Experimental design with a neural-symbolic AI approach to improve the interpretability and reliability of AI predictions in education. Method: simulation-based experiment. Sample: data from 427 players of the AutoThinking game. Sampling technique: purposive sampling	Deep Neural Networks (DNN), NSAI (Neural-Symbolic AI)	Development of computational thinking skills, adaptation of personalized learning using AI in education.	Knowledge-based assessments that combine training data and symbolic knowledge.	Positive impact on model generalization and the ability to identify low and high performance in data that has not yet been seen. It can provide more interpretable and more accurate predictions on real-world situations.	The NSAI model shows the best performance in terms of generalization, followed by the deep NN and deep NN-Autoencoder models. Using symbolic knowledge alongside training data allows the model to provide more precise and understandable predictions in an educational context.
9.	2022	South Korea	Analysis of the effect of an artificial intelligence chatbot educational program on non-face-to-face classes: a quasi-experimental study.[23]	Design: Quasi-experimental (non-equivalent control group pretest–posttest). Sample: 61 level 3 nursing students in Province G, South Korea; 30 participants in the experimental group (with an AI chatbot) and 31 in the control group (no chatbot, video lecture only). Sampling technique: Purposive sampling	AI chatbots are developed using LandBot.io platform, with NLP (Natural Language Processing) algorithms.	focuses on Electronic Fetal Monitoring (EFM), which aims to improve the skills of nursing students in monitoring fetal conditions, an important skill in midwifery practice.	Pretest and posttest-based assessments on various educational variables: EFM knowledge, clinical reasoning competence, confidence in conducting EFM, interest in learning, independent learning ability, and satisfaction with feedback.	AI chatbot programs have shown a positive impact on several learning outcomes, specifically increased interest in EFM and self-learning capabilities. However, there were no significant differences for other learning outcomes such as EFM knowledge or clinical competence.	Key findings show that the use of AI chatbots is effective in increasing students' interest and learning independence in non-face-to-face learning. Although there is no significant improvement in clinical knowledge and skills compared to conventional methods, chatbots have been shown to increase students' motivation and active role in learning. This program has great potential as an innovation in midwifery education, especially in the context of distance learning.
10.	2024	Australia	Evidence-based multimodal learning analytics for feedback and reflection in collaborative learning.[39]	Design: Two-year longitudinal study, Sample: 399 students and 17 teachers, Sampling technique: Purposive sampling	No deep learning algorithms are used, focusing on the application of multimodal learning analytics (MMLA) in health education	Focus on the application of MMLA in health education, with health learning simulations to improve feedback and reflection in collaborative learning	MMLA-based assessments to support reflection and feedback, measure team collaboration, task prioritization, and communication interactions	The application of MMLA in collaborative learning increases more effective data-driven feedback, accelerates learning reflection, and helps more adaptive and data-driven teaching	MMLA facilitates faster feedback and deeper reflection, increases students' self-awareness, and encourages adaptation in their learning behavior. However, challenges arise in the complexity of the design and the interpretability of data by users
11.	2025	Indonesia	Hybrid Learning in Post-Pandemic Higher Education Systems: An Analysis Using SEM and DNN.[40]	Design: Quantitative research, Sample: 500 students in Indonesia, Sampling technique: Stratified random sampling	DNN (Deep Neural Networks), SEM (Structural Equation Modeling)	Hybrid Learning in Higher Education, including Midwifery	Assessment based on student satisfaction and interest in hybrid learning	Increased academic satisfaction and interest in hybrid learning among students. Hybrid learning allows midwifery students to access theoretical materials online and apply them in hands-on clinical practicum. The use of AI in clinical simulations improves technical skills without risk to patients.	SEM results show that academic satisfaction has a great effect on students' interest in continuing hybrid learning. DNN shows high prediction accuracy in predicting student interest.

12.	2022	Syria	Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Syria: A cross-sectional online survey.[42]	Design: Cross-sectional research; Sample: 1,494 respondents (255 doctors, 1,252 medical students); Sampling technique: Convenience sampling	No deep learning algorithms are mentioned, focusing on the use of AI in education	The use of AI in medical education that can be applied to midwifery education	AI-related knowledge-based assessments, attitudes, and practices	Increase knowledge, positive attitudes towards AI, and reduce gaps in practice. The application of AI in midwifery education can improve students' knowledge and practical experience, particularly in the diagnosis of complications and monitoring of maternal and infant conditions. AI can be used in AI-based simulations for training without clinical risk.	Most respondents showed basic knowledge of AI, but they lacked a good understanding of its application in medical practice, despite having a positive attitude towards the use of AI in diagnosis and treatment.
13.	2023	India	Midwifery learning and forecasting: Predicting content demand with user-generated logs.[41]	Design: A quantitative study using time series forecasting to predict the demand for learning content. Sample: Safe Delivery App user log data from 20,422 users in India. Sampling technique: Data is randomly retrieved based on the user's interaction with the application module.	DeepAR (Autoregressive Recurrent Network), SARIMA (Seasonal ARIMA), Neural Networks (with categorical embedding)	Mobile application-based midwifery learning (mHealth), especially for nurses and midwives in the context of maternal and neonatal care	Predicted learning content demand-based assessments through user log data.	Improve personalization of learning content and tailoring training needs according to user profiles.	DeepAR and GP-Copula have proven to be more effective at predicting content requests compared to other models. These predictions allow for personalization of learning content for midwifery app users, increasing user engagement and more effective training planning. This approach can be adapted to improve learning experiences and learning outcomes in midwifery education if applied to materials that are more relevant to midwifery.
14.	2022	United States	Impact of accountability, training, and human factors on the use of artificial intelligence in healthcare: Exploring the perceptions of healthcare practitioners in the US.[45]	Design: Quantitative experimental research, Sample: 265 healthcare workers in the USA, Sampling Techniques: Semi-structured survey	Not focusing on deep learning specifically, but using AI for clinical decision-making support	Application of AI in clinical decision-making, patient care, and medical technology training	Assessment based on medical personnel's perception of AI, required training, and patient safety	Positive impact on clinical decision-making, willingness to use AI, and reduced workload if AI training is provided	Effective training can increase trust and use of AI in clinical decisions, although AI accountability remains a major challenge in wider acceptance. Provide insights to address ethical challenges and privacy issues in the application of AI in midwifery education.

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Table 3 (Continued).

NO	Year	Research Location	Article Title	Research Methods (Design, Sample, Sampling Techniques)	Deep Learning Algorithms Used	Focus of Midwifery Education	Results-Based Assessment Model	Impact on Learning Outcomes	Outcomes (Key Findings)
15.	2025	Greece (Greece)	Maternal Health Risk Detection: Advancing Midwifery with Artificial Intelligence.[44]	Design: Experiment, Sample: 1014 cases (attributes: Age, SystolicBP, DiastolicBP, BS, BodyTemp, HeartRate, RiskLevel), Sampling Technique: Preprocessing dataset with 10-fold cross-validation	Random Forest, Naive Bayes, MLP (Multilayer Perceptron), Fully Connected Neural Networks (FCNN)	Predict maternal health risks (high, mid, low)	Classification model-based assessment (accuracy, precision, recall, TP Rate)	The use of Machine Learning algorithms that show high accuracy in predicting maternal health risks, with the Random Forest model providing an accuracy of up to 88.03%	This study shows that the use of Machine Learning, especially with Random Forest, can improve the accuracy of maternal health risk detection and improve maternal care risk prediction by considering various physiological factors. The application of AI models in midwifery education can focus on clinical decision-making simulation training using health risk prediction datasets that provide direct feedback, allowing midwifery students to practice in real-world situations without risk to patients.

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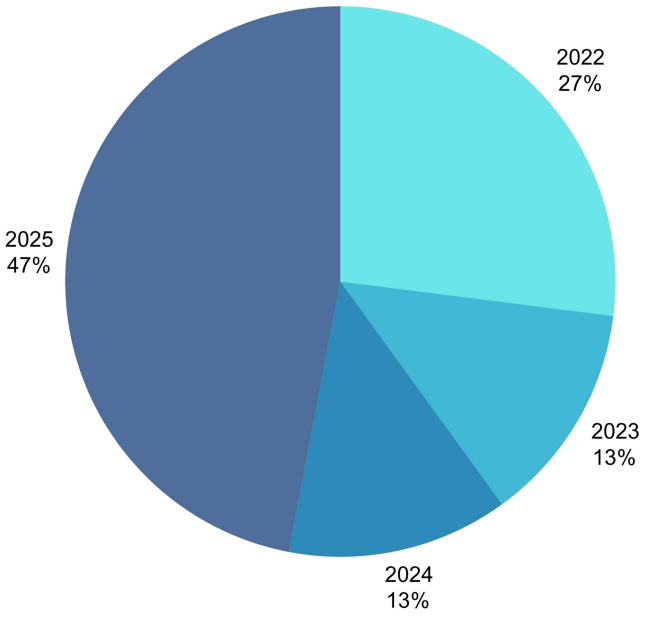

Figure 2 Analysis of Publication Year Characteristics in Studies from 2020 to 2025.

Bulgaria,[38] Australia,[39] Indonesia,[40] India,[41] Syria,[42] Estonia,[35] United States,[35,43] and Greece,[44] which shows that the adoption of artificial intelligence (AI) in midwifery education is a global issue that crosses cultural boundaries and education systems. Relevant data are presented Figure 3, which illustrates the distribution of studies based on their country of origin and corresponding study references.

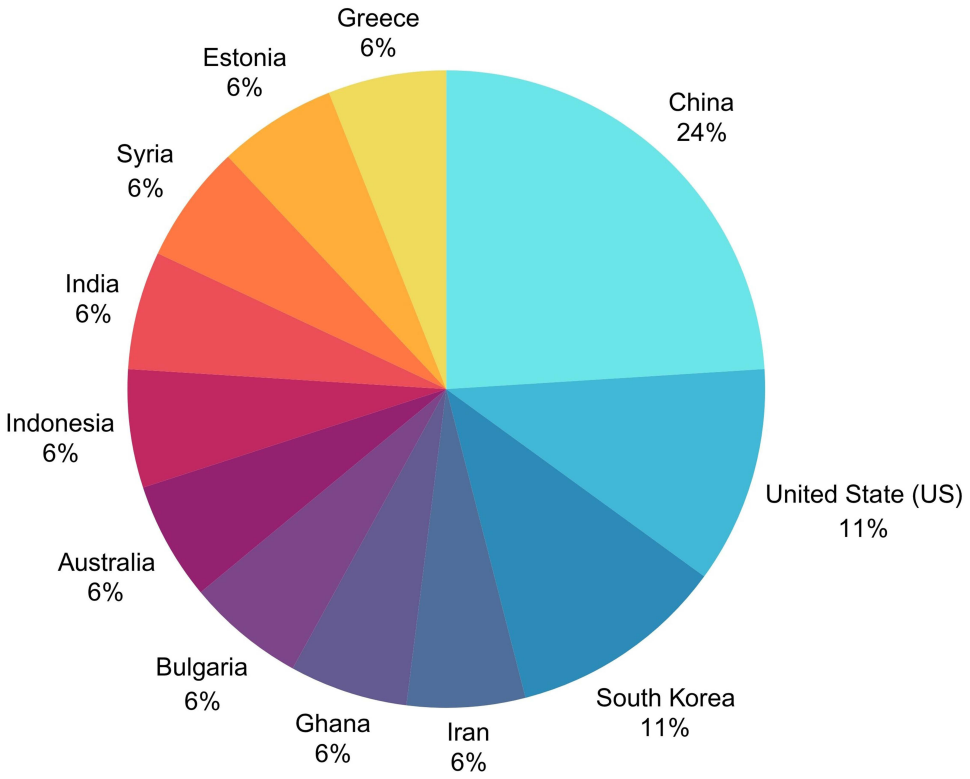

Figure 3 Distribution of Studies Based on Country of Origin and Study References.

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Table 4 Distribution of Studies Based on the Main Research Objectives

Study Main Objective	Studies N (%)	Studies Reference Numbers
Midwifery education	8 (53)	[31,32,36,38,39,41,44]
Teaching evaluation	4 (27)	[33,35,39,43]
AI in clinical recruitment	2 (13)	[32,43]

The primary focus of these studies is midwifery education as many as eight studies,[31,32,36–39,41,44] teaching evaluation four studies,[33,35,39,43] and the use of AI in clinical decision-making or pregnancy prediction two studies.[32,43] The data on the distribution of studies based on the primary research objectives is illustrated through the table representation in Table 4.

In research in the field of Obstetrics Education and the Use of AI for Pregnancy Prediction, the cross-sectional study design of 3 studies[31,37,42] and a retrospective 1 study[32] is used to analyze phenomena at a specific point in time or look at patterns in historical data. To develop critical thinking skills in midwifery students, a randomized controlled trial crossover 1 study[36] is an effective option, allowing researchers to test the changes that occurred before and after the intervention. On the other hand, in the Evaluation of Teaching and the Use of AI in Clinical Decision Making[34] The design of the experimental study there are 6 studies[23,33,38,44,45] and simulation-based experiments there was 1 study[35] is widely applied to test new methods or technologies that can improve teaching outcomes and support data-driven decision-making. Finally, a quantitative study with time series forecasting 1 study,[41] is used in mobile app-based Midwifery Education to analyze user interaction data and personalize students' learning experiences according to their needs. Figure 4 provides a detailed depiction of the diverse research designs utilized throughout this study.

Based on the analysis of 15 studies, deep learning algorithms applied in the context of midwifery education can be classified into three main categories. First, CNN and its derivatives are widely used for visual analysis, such as in facial expression recognition to improve students' nonverbal communication,[31] prediction of the success of the birth from the image of the embryo,[32] and evaluation of the effectiveness of teaching based on learning data.[33] Second, the Deep Neural Networks (DNN) algorithm, including its variations such as Multilayer Perceptron (MLP) and Fully Connected Neural Networks (FCNN), was used in research related to the prediction of learning interest in hybrid systems,[40] integration of symbolic knowledge in AI learning,[35] and maternal health risk classification.[44] Third, types of Recurrent Neural Networks (RNNs), such as LSTM and Deep AR, are applied to evaluate factors that affect the quality of teaching,[34] as well as in predicting the demand for learning content in real-time-based midwifery applications.[41] In addition, some studies have chosen general AI-based approaches or non-deep learning machine learning such as Random Forest and

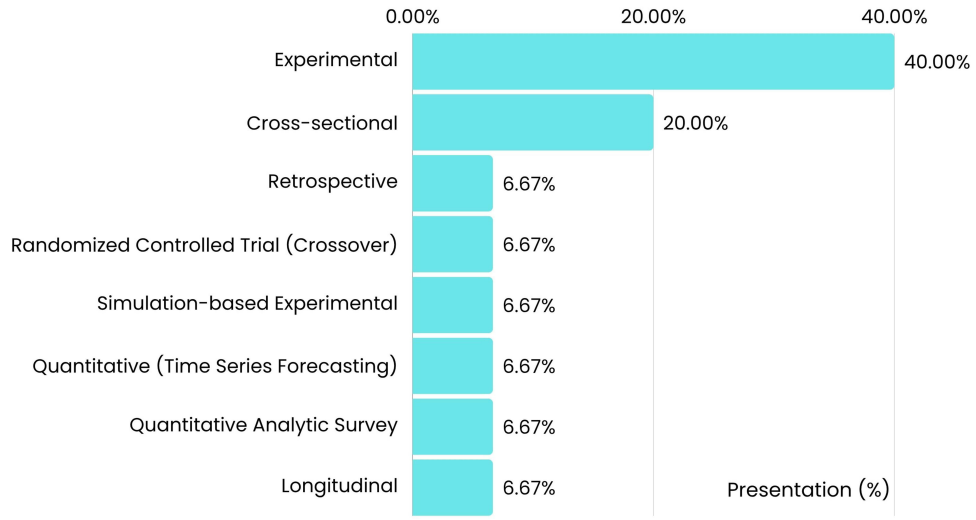

Figure 4 Distribution of Studies According to Research Design.

Table 5 Deep Learning Algorithm Types and Their Roles in Midwifery Education Research

Deep Learning Logarithms Used	Studies N (%)	Studies Reference Numbers
CNN and its derivatives	3 (20)	[31–33]
DNN and other variations	3 (20)	[35,40,44]
RNN and variants	2 (13)	[34,41]
Not specific to deep learning or combined	7 (47)	[23,36–39,42,43]

Support Vector Machine (SVM), or even do not explicitly mention the type of algorithm used. Table 5 provides a detailed representation of the various deep learning algorithms utilized within the scope of this study. These findings show that deep learning algorithms are increasingly growing in supporting innovation and effectiveness of midwifery learning in the digital era.

AI Application Across Midwifery Competency Domains

AI has been applied to support the development of all domains of obstetric competencies, namely cognitive, affective, and psychomotor. In the cognitive domain, technologies such as Random Forest and LSTM are used to predict pregnancy risk and maternal complications.[32,44] These models help students understand complex clinical patterns through data-driven analysis. In the affective domain, AI approaches are used to develop emotional and interpersonal aspects, for example with a CNN-based facial recognition system that has been shown to improve the emotional awareness and nonverbal communication skills of midwifery students.[31] Additionally, the use of technology-based reflective learning allows students to evaluate their learning process in a more in-depth and evidence-based manner.[39] In the psychomotor realm, technologies such as VR and AI simulation are used to improve students' technical and procedural skills, providing a safe and realistic practical experience.[38]

Types and Functions of AI Technologies Used

The variety of AI technologies used in these studies is quite wide, including CNN algorithms, Random Forest, LSTM, Deep Neural Networks (DNN), Neural-Symbolic AI (NSAI) approaches, and NLP-based chatbots. Its functions are also diverse, ranging from classification and clinical prediction,[32,44] evaluation of learning with fuzzy logic and CNN models,[34] to text-based interaction through chatbots for Electronic Fetal Monitoring (EFM) training.[23] Other studies show the use of AI for personalized learning based on user behavior patterns, such as in DeepAR-based mobile apps.[41] The implementation of NSAI is also an important breakthrough in increasing interpretability and transparency in the education decision support system. AI technology in general has served not only to speed up the decision-making process, but also to create a more responsive and adaptive learning experience.[35]

Pedagogical Frameworks Supporting AI Integration

The integration of AI in midwifery education goes hand in hand with the application of modern pedagogical approaches such as experiential learning, reflective practice, and constructivism. For example, experiential learning is realized through the use of VR and interactive simulations that allow students to experience clinical scenarios firsthand without real risks.[38] Meanwhile, reflective practice is supported by multimodal learning analytics (MMLA) technology, which provides data-driven feedback that helps students evaluate their own learning process.[39] A constructivist approach is also seen in the use of WebQuest and hybrid learning, where students actively build understanding through exploration with the guidance of individually tailored AI systems. Thus, AI becomes an integral part of shaping a meaningful and contextual learning ecosystem.[36] A synthesis of the findings of previous studies is presented in the form of a diagram in Figure 5.

The diagram illustrates the application of artificial intelligence (AI) in midwifery education, focusing on three main competency domains: affective, cognitive, and psychomotor. Technologies such as NLP-based chatbots, deep learning algorithms, and clinical prediction models play an important role in supporting more personalized learning, data-driven decision-making, and safer and more realistic practical skills training. Deep learning algorithms analyze complex data to

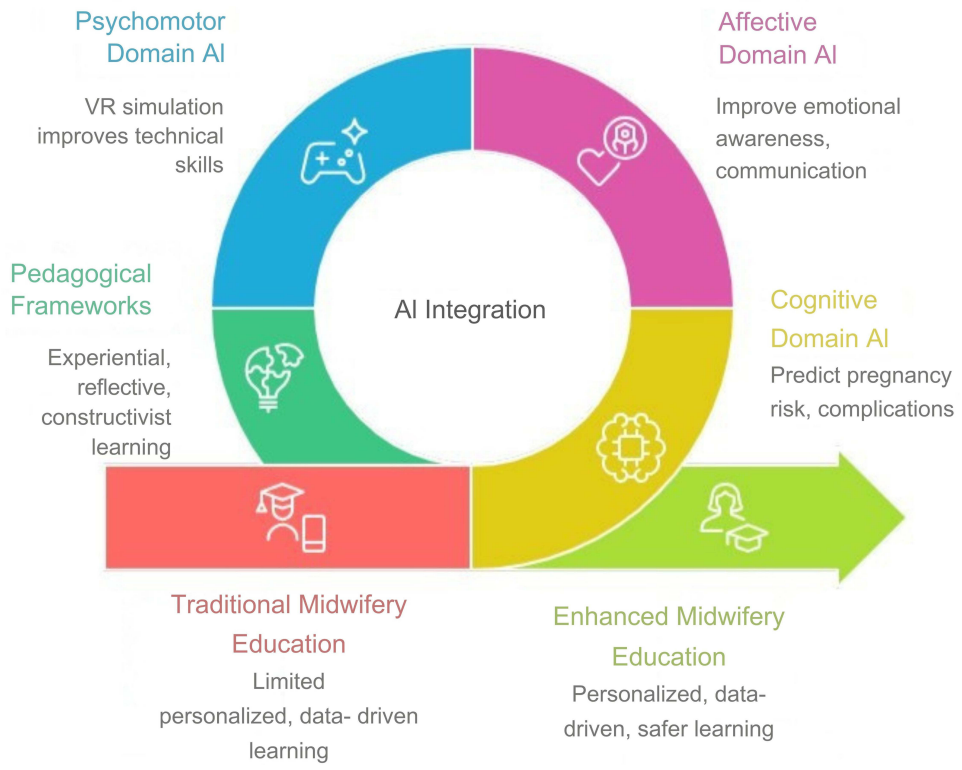

Figure 5 AI Enhances Midwifery education.

uncover deep patterns, enriching the learning experience. This diagram shows how innovative technology can create more adaptive and meaningful midwifery learning.

Discussion

Transformation of Midwifery Education Through AI and Deep Learning

The incorporation of AI and deep learning algorithms in midwifery education is becoming a transformative influence that improves multiple areas of student proficiency, including cognitive, affective, and psychomotor dimensions[46–48] The fifteen studies included in this literature review provide a comprehensive overview of the diverse applications of AI technology, such as pedagogical evaluation, curriculum personalization, clinical decision-making support, and enhanced communication.

Investigate innovative applications of CNN to develop models proficient at recognizing facial expressions. This strategy seeks to assist nursing students in enhancing their nonverbal communication skills, a facet that is frequently challenging to impart through traditional methods. CNN, proficient in visual data processing, can identify intricate patterns of emotional expression and deliver real-time feedback during student interactions in clinical simulations. In midwifery education, interpreting and reacting to a client's body language transcends mere technique; it fundamentally involves cultivating empathy and trust.[31] This aligns with Burgoon and Hale's theory of interpersonal communication, which posits that most emotional messages are transmitted through nonverbal language.[49–51] This approach also supports Kolb's theory of experiential learning, where the most effective learning occurs through hands-on experience. With CNN technology, students not only practice, but can also adapt their communication style based on the feedback received, so that interpersonal skills can be honed in a more in-depth and sustainable manner.[52–54]

Clinical Decision Support and Contextual Learning

Conversely, a comparable technique, specifically CNN, is employed to analyze photos of embryos to predict live birth outcomes with remarkable precision. This method provides fresh insights into how AI might enhance clinical decision-

making, especially in the reproductive domain, which is replete with intricate visual data that is challenging to comprehend manually.[32] From an educational standpoint, this necessitates that midwifery students comprehend both theory and practice, while also acquiring the ability to incorporate new technologies to facilitate evidence-based decision-making. The cognitive apprenticeship hypothesis, which highlights learning through expert mentorship, is especially pertinent in this context, as students are instructed to emulate and comprehend the application of technology by specialists in actual clinical scenarios. AI-enhanced case-based simulations serve as an excellent medium for developing these skills, situating learning within a more contextual and practical framework.[9,55]

Cognitive Learning Innovation Through AI-Based WebQuest

In the cognitive domain, the WebQuest model is an innovative learning technique, comprising a structured online activity aimed at promoting active exploration and resolution of clinical problems by students. In health education, AI-based WebQuest enables students to engage in contextual and collaborative learning, addressing genuine clinical difficulties with advanced analytical methods. The implementation of this technology has demonstrated efficacy in enhancing student engagement, fortifying critical thinking abilities, and cultivating academic self-efficacy.[36]

Data-Driven Learning and Teaching Evaluation

The evaluation methodology utilizes CNN in conjunction with data mining techniques to examine diverse educational data sources, including student feedback, lesson planning, classroom interactions, and teacher performance. This system is executed as a digital platform capable of real-time data collection and processing, subsequently offering an interactive dashboard for lecturers as a means of evaluation and instructional reflection.[33]

This feature enables teachers to proactively modify learning strategies based on student needs and recent advancements in clinical practice. This evaluation, grounded in data, enhances objectivity in teaching quality assessment and facilitates ongoing professional development for lecturers, leading to notable improvements in students' practical skills.

Data-driven evaluations enhance objectivity in the assessment of teaching quality and directly support the professional development of lecturers as well as the enhancement of students' practical skills. The study conducted in Ghana presents an innovative approach by utilizing machine learning to evaluate the nursing and midwifery informatics curriculum. This study achieved high accuracy in predicting students' academic performance, reaching up to 95%, by employing algorithms including Random Forest, Gradient Boosting, SVM, and Logistic Regression. This model has enhanced student engagement in the learning process, representing a significant achievement in the context of global challenges, including resource limitations and a substantial maternal health burden. To implement this approach effectively, educational institutions must possess adequate digital infrastructure and strategies to address the data literacy gap among both lecturers and students.[37]

The establishment of a teaching quality assessment system through the integration of fuzzy logic and LSTM algorithms within the same framework. This combination demonstrated the capability to yield a very accurate rating of 98.4% in identifying the primary factors influencing teaching quality. This method facilitates the development of learning modalities in midwifery education that are more attuned to student needs. The successful application of this technology is contingent upon the preparedness of institutions to offer technical training and establish trustworthy data management infrastructure, particularly in nations with restricted internet access.[34,56]

The NSAI approach enhances the learning assessment perspective by integrating the data processing capabilities of deep neural networks with the precision of symbolic knowledge-based reasoning. The primary benefit of this method is its capacity to deliver predictions of academic achievement that are both precise and logically comprehensible. NSAI is highly pertinent in obstetric education, particularly for clinical decision-making that necessitates high accountability and openness.[35] Nonetheless, the incorporation of this technology continues to encounter obstacles, including the intricacy of system architecture and the requirement for substantial computational resources. Consequently, a strong partnership among educational practitioners, technology specialists, and policymakers is essential to guarantee the inclusive adoption of these technologies and their significant influence on future midwifery learning environments.[57]

In a global context influenced by the pandemic, accelerating digitalization, and mobility of health workers, the integration of technology in learning and evaluation such as AI-based WebQuest and CNN-based evaluation has become

particularly relevant. Both maintain the continuity of quality learning in crisis situations, and also become an important foundation in shaping future health workers who are resilient, critical, and able to face multidimensional challenges ranging from climate change and global health crises, to service complexities due to urbanization and globalization.[48]

AI and VR-Based Simulations for Psychomotor Skill Development

Aligned with the emphasis on assessing and enhancing learning quality, the research conducted by Aabaah, Yu, and Hooshyar has further advanced the application of deep learning technology in midwifery education. The integration of VR technology with AI has been recognized as a significant advancement in facilitating the development of students' psychomotor abilities in the health sector, especially in midwifery education. Utilizing an innovative, immersive, and secure simulation-based learning methodology, it enables students to engage in many clinical procedures within a three-dimensional virtual environment that closely mirrors actual practice.[37] Moreover, AI integration enables the system to deliver automatic feedback, perpetually monitor user performance, and adaptively modify the exercise's complexity according to individual progress. The integration of VR and AI establishes a learning environment that facilitates repetitive practice without jeopardizing patient safety, simultaneously enhancing students' clinical proficiency and professional preparedness prior to their entry into practical settings.[38]

This strategy addresses the growing complexity of global concerns, particularly the restricted access to clinical practices intensified by the COVID-19 pandemic. As hospitals and health facilities restrict student involvement, the necessity for alternate educational resources that uphold the quality of training becomes increasingly imperative. Despite its potential, the deployment of this technology is fraught with numerous challenges[58,59] Substantial investment expenditures for hardware acquisition and software development continue to be a significant obstacle, particularly for institutions with constrained resources. Moreover, differences in digital literacy between educators and students, opposition to the adoption of long-standing instructional methodologies, and concerns over ethics and data protection constitute problems necessitating a holistic management plan.[60–63]

This approach, which is based on VR and AI, not only resolves technical issues in the learning of clinical skills, but also makes a strategic contribution to the endeavor to prepare healthcare workers across countries and adapt to international competency standards in an increasingly digitized global education landscape.[64] The ability to create a flexible and adaptive learning ecosystem renders it pertinent in the context of transnational challenges, including rapid urbanization, climate change, and the global mobility of health workers. This technology integration should be regarded not merely as a temporary remedy for existing practice limitations, but as a fundamental component of the long-term evolution of midwifery education towards a more inclusive, responsive, and evidence-based framework.[65]

Adaptive Learning and Chatbot Models for Learning Autonomy

The digital change in midwifery education has markedly increased with the integration of artificial intelligence (AI) and data-driven learning tools, particularly with the transition to remote and hybrid learning models prompted by the COVID-19 pandemic. The creation of a chatbot-based educational model utilizing NLP to enhance students' motivation and learning autonomy on EFM. The chatbot operates as a virtual instructor, delivering real-time explanations, contextually answering queries, and offering individualized emotional support, so enhancing the human learning experience in an online environment. The significance of this strategy in midwifery education is considerable, as subjects like cardiotocography interpretation (CTG) necessitate a profound clinical comprehension that is challenging to attain without continuous mentorship.[23,66]

This approach employs multimodal learning analytics to enhance collaborative learning by analyzing students' digital interactions encompassing text, audio, and visual elements. This method offers predictive and formative feedback that enhances the reflection and modification of student learning strategies. In midwifery education, where teamwork and data-informed decision-making are crucial, these tools facilitate the development of vital professional qualities.[39] Research indicates that academic satisfaction is a crucial factor in sustaining students' engagement in hybrid learning. These findings validate that good and significant learning experiences can enhance the sustainability of digital learning models among midwifery students worldwide.[40]

Ethical Challenges, Digital Literacy, and Infrastructure Gaps

The integration of AI in education is inherently linked to several issues. Capable of recognizing deficiencies in AI literacy among educators and students as the primary obstacles affecting the efficacy of technology implementation.[42] Research by Guitart et al indicates that predictive analytics in mobile learning applications possesses significant potential for material customization; nevertheless, its efficacy is substantially affected by the user's comprehension of algorithmic input. Additional obstacles encompass ethical considerations and data protection concerns.[41] Emphasize the significance of stringent laws to guarantee privacy and responsibility in the application of AI within educational and maternity healthcare environments.[45] The ethical significance is enhanced by demonstrating AI's capacity to identify maternal dangers promptly inside safe and evidence-based clinical decision-making scenarios. This strategy provides an alternative training that is both pragmatic and very contextual in the cultivation of clinical skills for midwifery students.[44]

Paradigm Shift in Learning Toward Adaptive and Competency-Based Models

These studies highlight a change from conventional teaching methods to more adaptable, reflexive, and competency-based learning. AI serves as a facilitator in assessment for learning, providing feedback that is both formative and capable of guiding students' sustained self-development. This necessitates a curriculum that clearly incorporates digital competency, technological ethics, and data literacy within the midwifery education framework. This type of integration necessitates institutional preparedness to furnish sufficient infrastructure and professional development for educators.[67]

Global Implications and Future Research Directions

In a global context, particularly in low and middle income countries confronting significant maternal health challenges and a deficit of educators, AI technology and digital learning analytics can be essential in addressing disparities in educational quality[48,68,69] However, equal access to digital technology and infrastructure is an absolute prerequisite to ensure further inclusivity,[70] Long-term challenges such as climate change, cross-border migration of health workers, and the globalization of health care systems also reinforce the need for a flexible, data-driven, and systemic disruption-resistant approach to education.[59] Consequently, subsequent research ought to concentrate on a longitudinal assessment of the influence of AI integration on the development of professional capabilities among midwifery students, emphasizing algorithm transparency, system accountability, and global technology affordability.

Conclusion

Impact of AI on Midwifery Education

The integration of AI and deep learning algorithms significantly enhances outcome-based assessment in midwifery education. Technologies such as CNN, LSTM, Random Forest, and SVM not only improve assessment objectivity but also personalize learning and better prepare students for clinical practice. These tools foster the development of clinical decision-making, communication skills, and evidence-based reasoning, which are essential for effective midwifery practice.

Challenges in AI Implementation

Despite its potential, challenges such as technological literacy gaps among educators and students, digital infrastructure limitations, and ethical concerns related to data privacy and algorithm transparency remain significant barriers to AI adoption in midwifery education. These issues must be addressed to ensure equitable and effective implementation at all levels.

Recommendations for Educators

To optimize AI's impact, educators must receive comprehensive training to enhance digital literacy and ethical understanding of AI in midwifery contexts. This training should focus on personalized learning, improving clinical communication, and evidence-based decision-making, ensuring that educators are equipped to leverage AI effectively while addressing ethical concerns.

Recommendations for Educational Institutions

Institutions must invest in robust digital infrastructure to support AI-based tools like CNN and SVM. Clear policies on data privacy and algorithm transparency are also essential to mitigate ethical issues and ensure that AI is used responsibly.

Competency-Based Curriculum Development

Midwifery curricula should be competency-based and tailored to local contexts, addressing the specific needs of students. Collaboration between academic institutions, technology developers, and policymakers is critical to ensure AI implementation is sustainable and inclusive.

Limitations of the Study

This review highlights that many of the studies included focus primarily on the technical aspects of AI, with limited exploration of long-term effects or real-world applicability. There is a need for more research on how AI technologies can be scaled and adapted in diverse educational settings, especially in low-resource environments.

Strengths and Weaknesses

The strengths of AI integration in midwifery education include its potential to provide personalized learning and enhance clinical competencies. However, there is a notable weakness in the ethical considerations surrounding AI, particularly concerning data privacy and transparency, which must be addressed in future developments.

Future Research

Further longitudinal studies are required to assess the long-term effects of AI on midwifery competencies. Additionally, research should focus on developing AI models that are both ethically sound and contextually adaptable, reducing algorithmic bias and enhancing transparency in midwifery education.

Final Conclusion

AI offers significant potential to transform midwifery education, but its integration must be done cautiously and comprehensively. It is essential to maintain social justice and ethical standards in maternal and child health services while improving educational outcomes. The inclusive adoption of AI will not only enhance midwifery education but also contribute to improving maternal health outcomes, particularly in low- and middle-income countries with high maternal and infant mortality rates.

Data Sharing Statement

Data are reported in the current study.

Acknowledgments

The author expresses gratitude to all colleagues whose contributions have facilitated this literature review. We extend our sincere gratitude to the Master of Midwifery Program, Faculty of Medicine, for granting access to invaluable academic resources. Gratitude is extended to the supervisors for their indispensable direction during this review, along with the anonymous reviewers for their helpful criticism that enhanced the quality of this article.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

There is no funding to report.

Disclosure

The authors wish to confirm that there are no conflicts of interest associated with this research.

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