(REVIEW ARTICLE)

A Review of Machine Learning Approaches for Predicting Depression Readmission Risk and the Role of Mobile Health Technology in Early Intervention

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Abstract

Depression poses a significant global health burden, largely due to high rates of relapse and hospital readmission following initial treatment. This review synthesizes current research on leveraging machine learning (ML) models to predict depression readmission risk, exploring key predictive features derived from behavioural, physiological, and digital sources. It examines the integration of ML with mobile health (mHealth) technologies to facilitate real-time monitoring and early intervention. The review also addresses crucial ethical considerations, including data privacy, algorithmic bias, and fairness in deploying AI-driven mental health solutions. Emphasis is placed on the need for explainable and equitable AI, robust data governance, and the value of open, de-identified datasets. Finally, it identifies challenges and opportunities for future deployment in low- and middle-income countries (LMICs), with a focus on digital equity and culturally relevant applications.

1. Introduction

Depression is a leading global public health concern, affecting over 280 million people worldwide(Limenih et al., 2023). The disorder profoundly impacts individuals, families, and societies, often leading to substantial economic and health system burdens. A particularly challenging aspect of depression management is its recurrent nature. Despite initial treatment, many patients experience relapse, leading to readmission into psychiatric care facilities(Sim et al., 2015). Hospital readmission serves not only as an indicator of treatment inefficacy but also as a metric of the healthcare system's capacity to ensure continuity of mental health support(Byrne et al., 2010).

Advancement of AI technology, especially Machine learning (ML) has emerged as a promising tool in identifying patterns associated with relapse and readmission. By analysing large, complex datasets, ML can uncover latent variables and predictive markers that traditional statistical methods may overlook(Amanollahi et al., 2024). Simultaneously, mobile health (mHealth) technologies are redefining mental healthcare delivery, enabling real-time monitoring and early interventions through smartphones and wearable devices (Najjar, 2024). Combining these technologies could significantly enhance the detection of high-risk individuals and reduce preventable readmissions.

This review aims to consolidate existing research in this domain and propose a roadmap for integrating ML and mHealth for scalable, ethical, and effective depression care.

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2. Methodology

This review follows a structured literature synthesis methodology. Relevant peer-reviewed articles were identified from databases such as PubMed, IEEE Xplore, SpringerLink, and ScienceDirect. Search terms included "depression readmission prediction," "machine learning in mental health," "mHealth depression apps," "digital biomarkers for depression," and "AI ethics in mental health." Articles published between 2018 and 2025 were prioritized. Inclusion criteria were:

- Studies using ML/AI for depression prediction or readmission
- Use of digital or mobile tools for early intervention
- Ethical evaluations of AI in mental health

3. Literature Synthesis

3.1. Understanding Depression Readmission and Relapse Factors

Depression readmission involves re-hospitalization or re-entry into formal mental health treatment due to relapse. Factors contributing to readmission are diverse, including comorbid psychiatric disorders, medication nonadherence, lack of psychosocial support, and poor treatment response(Moriarty et al., 2020). Predictive variables also include digital behaviour patterns, sleep disruption, and physiological signals such as heart rate variability.

3.2. Fundamentals of Artificial Intelligence in Predicting Depression Readmission

Artificial intelligence (AI) is rapidly transforming healthcare, and predicting depression readmission is no exception. AI has the potential to enhance both the efficiency and effectiveness of clinical assessments, leveraging vast datasets to predict patient outcomes(D'Alfonso, 2020);(Kibibi, 2024).

3.3. Comparative Review of Artificial Intelligence, Machine Learning, and Deep Learning in Predicting Depression Readmission

AI serves as an overarching framework, while machine learning (ML) involves statistical algorithms trained on historical data. Deep learning (DL), a subfield of ML, utilizes layered neural networks for high-dimensional data such as clinical notes and voice signals. Supervised learning techniques like logistic regression and random forests perform well when trained on curated datasets(Shah et al., 2024); (Verma et al., 2023). Recurrent Neural Networks (RNNs) and Convolutional Neural Networks (CNNs) are gaining traction due to their ability to model temporal and unstructured data.

3.4. Mobile Health (mHealth) Technology for Early Intervention

mHealth tools are increasingly used for mental health support, especially in underserved communities. These tools offer real-time feedback and behavioural nudges, improving patient adherence and reducing relapse (Ben-Zeev et al., 2018). (Adler et al., 2022) emphasized the importance of open datasets to train accurate digital biomarkers. Wei et al. (2023) addressed the usability of AI tools for aging populations. However, data privacy remains a critical issue, particularly when sensitive behavioral data are used. Mandal et al. (2025) recommended federated learning and synthetic data techniques as mitigation strategies.

3.5. Ethical Considerations in AI-Based Mental Health Solutions

Deploying AI in mental health requires addressing algorithmic fairness, transparency, and privacy. Saeidnia et al. (2024) stressed responsible implementation, while Timmons et al. (2022) warned against training models on biased datasets. Rubeis (2022) highlighted the ethical need for explainable AI (XAI). Privacy-preserving methods such as differential privacy are necessary (Mandal et al., 2025).

4. Discussion

The synergy between ML and mHealth presents a novel paradigm for depression management. While ML models exhibit high predictive accuracy, their clinical translation remains limited by ethical concerns and regulatory constraints. mHealth tools offer real-time monitoring and behavioural nudges but require the integration of heterogeneous data. Future systems must address digital literacy, open data access, and inclusive design. Cross-disciplinary collaboration is essential for sustainable and ethical adoption.

5. Conclusion and Future Directions

This review highlights the potential of machine learning and mobile health technologies to predict depression readmission risk and enable early intervention. Future work should prioritize the deployment of explainable ML models, ethical frameworks, and privacy-aware systems. Emphasis should be placed on culturally sensitive approaches and open collaborations to accelerate innovation in low-resource settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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