Evaluating the Potential of Mobile Applications for Mental Health Prediction: A Review

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Abstract. The human mind is a remarkable cognitive powerhouse, influencing perception, decision-making, and behavior. Its effectiveness lies in its ability to process information, solve problems, adapt to new situations, and experience emotions. A healthy mind is essential for well-being, productivity, and personal growth. However mental health issues have become a global concern, with increasing attention to accessible and cost-effective interventions. This meta-analysis endeavors to fill this critical gap by systematically investigating the efficacy of standalone psychological interventions for mental health delivered via smartphone application. By synthesizing insights from previous research and analyzing trends in mobile health interventions, this study aims to delineate effective behavior change techniques and ascertain participant perceptions regarding the feasibility and functionality of mental health applications, evaluates the precision of many popular machine learning techniques.

Keywords: Mental health, Mobile Application, mHealth interventions, Machine Learning.

1 Introduction

The widespread availability of mobile phones and the rapid growth of mobile health (mHealth) applications have transformed the understanding of care management in behavioral health. The focus has transitioned from patients and healthcare providers to individuals who can independently practice self-care continuously beyond the confines of traditional healthcare environments [1-2]. The technological revolution, harnessing the capabilities of mobile devices and advanced tech, offers a hopeful approach to tackle the widespread issue of mental disorders, which continue to burden societies globally. Even though evidence-based treatments are available, a significant number of individuals dealing with mental health issues still do not receive treatment, especially in affluent nations. Obstacles like accessibility, cost, and long-standing societal

attitudes hinder the timely and efficient delivery of treatment, resulting in a troubling gap in care [3]. According to the Global Digital Statshot report for Q2 2019, approximately 5.11 billion people, or about 66% of the global population, own a mobile phone. The IQVIA Institute states that there are currently over 318,000 health applications available worldwide, which is nearly double the number from 2015. Furthermore, more than 200 new health applications are introduced to app stores daily. Despite this significant growth, the majority of health applications (60%) are aimed at wellness management, and mental health is the primary focus for disease-specific mobile applications, accounting for 28% of this category [4]. Mobile devices, omnipresent in today's society, present an opportune solution to circumvent these barriers and bridge the treatment gap. These devices offer a low-threshold, flexible, and often anonymous means of engagement for individuals in need of mental health support. The evolving landscape of mental health applications, teeming with a multitude of offerings, has the potential to revolutionize mental health treatment accessibility and delivery. The advent of mobile health applications holds the promise of reshaping how mental health services are accessed and consumed, potentially democratizing mental health care in an unprecedented manner. However, this rapid growth in mental health applications, a testament to their perceived potential, has not been matched by a corresponding understanding of their overall efficacy and impact on mental health outcomes [5]. Utilizing unsupervised applications has the capacity to enhance care accessibility at a larger scale by lowering the expenses linked to receiving services [6-7]. Nevertheless, the effectiveness of digital interventions is constrained by their capacity to involve users in therapeutic tasks and to facilitate user commitment to the therapeutic journey [8-9]. Digital interventions necessitate individuals to participate in self-care activities beyond conventional settings. Consequently, individual engagement must contend with various daily commitments and cope with varying levels of motivation to engage in demanding tasks . Hence, without human assistance, user involvement with mobile applications and websites for behavior change remains minimal. Mobile health applications cover fitness, chronic disease management, personalized tracking, and are increasingly focused on mental health. They reduce appointment wait times, promote self-care, and have shown effectiveness in reducing stress, depression, and substance abuse. SMS text messaging aids medication adherence and reduces risky behaviors. This review evaluates mHealth interventions' general effectiveness, usability, and feasibility due to the expanding market and the need for systematic assessment, focusing on physical and mental health issues [10]. Research has highlighted the potential benefits and warned about the limitations of using mobile applications for mental health. Technical issues like screen size and battery life need addressing for improved effectiveness. Data security is also a concern. Despite the growing market, comprehensive studies assessing the overall impact on mental health outcomes are scarce. Evaluations covering diverse aspects are necessary for future development and deployment [11].

2 Literature Review

In recent years, the field of mental health has witnessed a surge in research focusing on the development and application of mobile technologies, particularly mobile applications, to assess and predict mental health outcomes. M Srividya et al. presents a framework for determining an individual's mental health state. It demonstrates that support vector machines (SVM), k-nearest neighbors (KNN), and random forest algorithms perform almost equivalently in predicting mental health, with ensemble classifiers significantly enhancing prediction accuracy. Furthermore, the paper suggests that incorporating physiological parameters such as electrocardiogram (ECG) and respiratory rate can further improve the prediction of mental states. It also mentions the utility of feature subset selection strategies to streamline the model-building process and the potential of deep learning methods for large datasets [12].

Jamie M Marshall et al. underscores the widespread use of mental health mobile applications but highlights the lack of published evidence for their effectiveness. The paper introduces a novel multiple baseline across-individuals design to evaluate the effectiveness of selected mental health applications in reducing anxiety and depression symptoms, with the goal of improving access to mental health services, especially for underserved populations. This methodology is suggested to strengthen the independent evidence base for digital mental health interventions [13]. Md. Aminul Islam et al. offers insights into the types of mental health applications available. It identifies that these applications primarily focus on various mental health symptoms and offer multiple approaches for improving mental health. The paper underscores the popularity of these applications due to their ease of use and availability but highlights the challenges in assessing their trustworthiness and effectiveness [14]. Tania Lecomte reviewed a collection of meta-analyses and systematic reviews to assess the quality of evidence regarding mental health applications' effectiveness. The paper concludes that applications targeting anxiety and depression exhibit promise, but more research is needed for other mental health issues and specific populations [15].

Royan Dwi Saputra published a paper which presents mental health application prototype called Soodo, which utilizes machine learning and augmented reality during the COVID-19 pandemic to maintain and improve people's mental health. The application received a satisfactory assessment through system user testing, and the use of augmented reality provides accurate visualization to users [16]. Md Iqbal Hossain Nayan et al. conducted a study to predict mental illness, particularly depression and anxiety, among university students using machine learning algorithms. It revealed that specific algorithms, like random forest (RF) and support vector machine (SVM), are more suitable for predicting the mental health status of university students. This research is particularly important for understanding the mental health challenges faced by students, especially during the COVID-19 pandemic [17].
Arfan Ahmed et al. conducted a scoping review to explore the characteristics of mobile and web-based applications used for mental health self-care. The review identifies a lack of rigorous studies evaluating the effectiveness of these applications and

emphasizes the need for user-friendly and scientifically valid applications [18]. Won Ju Hwang et al. conducts a scoping review of 14 studies. These studies focus on mobile mental health applications for the general adult population and highlight the efficacy of various intervention programs such as mindful meditation, cognitive behavioral therapy, and stress-reduction techniques [19]. Chanchal Bhangdia et al. created a comprehensive mental health app featuring habit questions, assignments, progress tracking, gaming, and music elements. The app employs sentiment analysis, emotion detection algorithms, and a text-based counseling chatbot for continuous 24/7 accessibility. In situations where traditional therapy is unavailable, this app serves as a valuable resource, ensuring ongoing support and engagement for users in managing their mental health. [20]. Jetli Chung et al. published a paper highlighting the potential of machine learning approaches in predicting mental health problems. It emphasizes the significance of features used in algorithms and the integration of various sensor modalities in technologically advanced devices for recognizing mood states. Validation of results and preprocessing activities are acknowledged as crucial. The study encourages researchers to manage limitations effectively to improve clinical practice in mental health [21]. Grand View Research conducted a survey and published " The global mental health applications market is poised for significant growth, with a projected CAGR of 15.9% from 2023 to 2030. This expansion is attributed to the increasing utilization of mental health applications, growing awareness regarding mental health, and their proven benefits in enhancing treatment outcomes and lifestyles. Funding for key players like the Calm meditation app surged from $28 million in 2018 to $218 million in 2020, reflecting substantial market potential " [22].

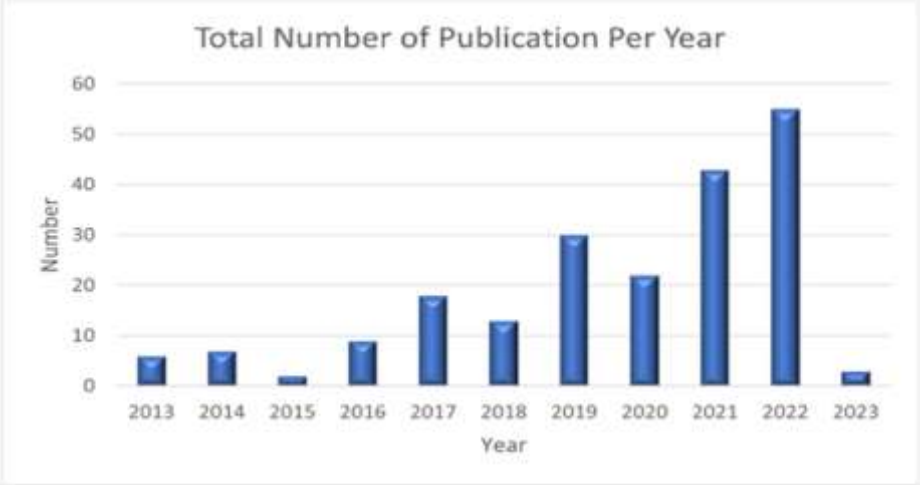

Fig. 1. Reviewed paper distribution by year of publication

Author(s)	Machine Learning Model	Sample Data Set	Performance (Accuracy)	Description
Kamde et al. [23]	SVM (Support Vector Machine)	Social media posts from individuals with mental illnesses	98%	Used for predicting stress levels based on visual inputs, effective for diagnosing mental health conditions
E Syed Mohamed et al. [24]	SVM (Support Vector Machine)	Reputable psychiatric clinic's real-world preclinical mental health dataset:	97.68%	Utilized for predicting anxiety stages in preclinical mental health dataset.
Jetli Chung et al. [10]	Random Forest	It highlights the use of various datasets, including the dataset for diagnosing schizophrenia.	97%	Focuses on early detection and effective treatment of psychological
E Syed Mohamed et al. [24]	Random Forest	Reputable psychiatric clinic's real-world preclinical mental health dataset.	98.13%	Utilized for predicting anxiety stages in preclinical mental health dataset.
Tatiur Rahman et al. [27]	KNN (K Nearest Neighbour)	Examining closed eye (CE) and open eye (OE) states with varied recording durations.	91.26%	Focuses on the analysis of mental workload's effect on mental stress and proposes a method for recognizing mental stress using K-Nearest Neighbor (KNN) classifier.
Jetli Chung et al. [10]	Naive Bayes	It highlights the use of various datasets, including the dataset for diagnosing schizophrenia.	82.1%.	Focuses on early detection and effective treatment of psychological
Sheila Shevira et al. [28]	Naive Bayes	Collected and stored 3,037,226 tweets from Twitter in MongoDB.	85.5%	The study detects suicidal messages in tweets from users with mental health issues using lexicon-based and Naive Bayes algorithms.

Table 1. Accuracy of Different Algorithms

3 Research Gaps

Despite the growing awareness of mental health issues and the increasing popularity of mental health applications, there is a notable gap in the literature regarding a comprehensive evaluation of the efficacy of standalone psychological interventions delivered through smartphone applications. This review aims to address this gap by systematically analyzing existing research, identifying potential behavior change techniques, and assessing participant perceptions. The specific focus on predicting mental health outcomes using machine learning techniques adds a unique dimension to understanding the potential of mobile applications in this context.

4 Analysis of the Mental Health App Landscape

4.1 Introduction to the App Landscape

The mental health app landscape has experienced significant growth, as reflected in reports citing the availability of over 318,000 health-related mobile apps, with a focus on mental health and behavioral disorders. The proliferation of such apps underscores their potential impact on well-being [3].

4.2 Quantitative Overview

Analyzing reports from 2017 and 2016 provides a comprehensive view, revealing a significant number of mental health apps—490 and 208, respectively. These apps often focus on symptom relief and general mental health education. Notably, a substantial percentage (59%) fails to provide information on their effectiveness [3].

4.3 Quality Assessment of Depression Apps

A 2018 study assessing the quality of depression apps in German app stores found a mere 11% (4/38) demonstrating face validity, lacking evidence on effectiveness and safety. This evaluation underscores the need for careful scrutiny when contemplating the integration of mental health apps into treatment strategies [3].

4.4 Advantages and Potential Pitfalls

While mental health apps are lauded for their potential contributions to physical and mental health treatments, they come with inherent challenges. These include technical aspects like screen size, battery life, and system updates. Additionally, issues such as frequent but brief daily smartphone interactions, attentional competition between apps, short app lifespans, non-private settings, and data-security concerns pose potential disadvantages [29].

4.5 Implications for App Integration

Understanding both the advantages and pitfalls of mental health apps is imperative for informed decision-making regarding their integration into mental health treatments. Recognizing these factors provides insights into potential areas for improvement and underscores the importance of evidence-based evaluations to ensure the efficacy and safety of such applications [30].

5 Conclusion and Future Scope

The reviewed literature suggests that mobile applications hold significant promise in predicting and improving mental health outcomes. Novel research methodologies, like the multiple baseline across-individuals design, can provide valuable evidence for the effectiveness of mental health applications. Many of the applications present in the market offer valuable tools for self-help, mood tracking, and relaxation techniques, which can benefit users by promoting self-awareness and emotional regulation. However, the field still faces many challenges that includes lack of personalization, privacy concerns, varying effectiveness, and limited scope. These applications should complement, not replace, professional care. User engagement and quality control issues persist, and inequitable access to technology exacerbates disparities. Integration with healthcare systems and evaluation complexities are additional challenges. Hence more rigorous research and systematic reviews are essential to establish a robust evidence base for the efficacy of mobile applications in predicting and managing mental health. As technology is emerging the research in this domain is experiencing exponential growth, as reflected by the increasing volume of studies and findings provided in the table below, which increases the potential for mobile applications to play a significant role in mental health prediction and care becomes increasingly evident.

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