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AI-Enabled Smartphone-Based Intervention Mental Health Application for University Students

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Full research paper

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Abstract

The novel COVID-19 outbreak has resulted in lockdowns and university campus closure which affected the mental health of university students negatively. This was reflected in mental disorders, with emotional, physical fitness, exercise, and studying as the most affected aspects during the pandemic. The design and development of a smartphone application is the objective of this paper. The app's goal is to assist university students in improving their mental health and overall quality of life by answering a structured questionnaire. Subsequently, the app uses artificial intelligence (AI) for sentiment analysis of a user's social interaction and the app uses biofeedback as an evidence-based therapy. Then the app connects the user with random peers who share similar mental sentiments to chat with and if there is no peer available, a chatbot is used. In case of significant loneliness, the app connects the user with caregivers, community volunteers, and health professionals.

Keywords Mental Health, Mobile Health, Artificial Intelligence, Chatbots, Mental Wellness.

1 Introduction

In most medium and high-income nations, mental health problems have become the major cause of long-term impairment in recent decades with depression being the largest source of illness burden globally (World Health Organization 2020). As a result of the outbreak of the COVID-19 pandemic, social isolation and stressful conditions have grown more prevalent, resulting in mental health issues in the majority of people who study or work from home (Cullen, et al. 2020).

One of the most pressing concerns regarding college students is their capacity to manage stress and anxiety. In many situations, enrolling in a higher education institution is a dream come true, but it can also be a challenging life-changing event that forces students to confront new obstacles, some of which are difficult to overcome. Furthermore, Higher Education (HE) acceptance is most common near the conclusion of adolescence, a time marked by psychological and emotional instability (Huberty, et al. 2019). High anxiety symptoms can be seen across the board, although they are more prevalent among freshmen, indicating the stressful events connected with the transfer and adaption to a new environment. Adaptation success is determined by a variety of factors, some of which are unrelated to the academic setting. Anxiety concerns in this demographic are becoming more prevalent, and HE plays a critical role in the adaption process, which can lead to psychiatric disease if not properly addressed (Zivin, et al. 2009).

The majority of the effort to minimize the burden of these illnesses has been focused on ensuring that people with evident symptoms receive treatment. Despite the availability of viable therapies, cost-effectiveness estimates show that even if all individuals in need received optimal care, only 35 to 50 percent of the overall burden of these diseases would be eased (Andrews et al. 2004). As a result, effective intervention prior to the beginning of a full diagnostic illness is critical in dealing with this issue (Cuijpers et al. 2012). There is growing evidence that mental illnesses can be prevented (Cuijpers et al. 2005). The expenses of delivering most traditional face-to-face preventive initiatives, on the other hand, limit scalability and make population-wide implementation impossible (Solomon et al. 2015). Health Information Systems (HIS), including mobile technologies for health (mHealth), are transforming traditional healthcare delivery by digitizing health care processes and facilitating access to health care services, with HIS having the potential to support effective and efficient wellness management.

Mobile health applications (mHealth apps) have shown promise in assisting users of healthcare systems by disseminating accurate health information widely, improving patients' health literacy and empowerment at a lower cost, fostering patient-centered care, facilitating stakeholders' long-term and active involvement in their own care, and improving users' communication and collaboration with healthcare providers (Rathbone, et al. 2017). According to a recent meta-analysis, typical psychotherapy approaches given through eHealth and mHealth (healthcare practices backed by the Internet or mobile phone technology, respectively) may be beneficial in avoiding common mental illnesses in general populations (Deady et al. 2017).

The rest of the paper is designed as follows: section 2 is a background and justification of app-based mental health. Section 3 reports the theoretical foundations and research methods. This is followed by a discussion of the modules of the smartphone-based intervention mental health app in section 4. Section 5 represents the future phases and conclusions in section 6.

2 App-Based Mental Health Background and Justification

Mobile health (mHealth) is a type of health care that is assisted by mobile devices. Apps for mental or general health can be utilized in a variety of ways. They can be used as stand-alone self-help programs or as a supplement to therapy, and they can contain therapeutic components such as cognitive therapy, behavioral activation, psychoeducation, and symptom monitoring, for example (Donker et al. 2013).

Apps can be used for prevention, early intervention, treatment, and therapy-related skill practice, among other things (Proudfoot 2013). Apps provide a convenient way to access databases and other healthcare information, as well as to broadcast live and recorded video and podcasts, and to deliver psychoeducation through text messaging (Luxton et al. 2011). Mobile health care, which uses mobile applications to offer mental health therapy, is a new frontier (Kazdin and Blase 2011).

According to Price et al. (2014), mobile health applications might be important tools in the development of evidence-based therapy. Mobile devices have several implications for mental health service delivery, and their effective use has the potential to increase access to evidence-based care and increase evidence-based practices, better inform consumers of care and more actively engage them in treatment and improve post-treatment care.

Researchers recognized the potential of mobile applications in health and mental health early on, with a systematic review of relevant research, that is, targeting mHealth apps, first emerging in 2011 (Mosa, et al. 2012). Smartphones offer a more diverse, powerful, and customized platform for a broader range of care activities, such as patient screening, symptom, and problem evaluation, psychoeducation, intervention delivery, progress tracking, and relapse prevention (Luxton, et al. 2011).

The number of barriers to mental health care is reduced by providing these health tasks via smartphone apps, albeit partially or in combination with a therapist's intervention, such as therapist workload, lack of qualified personnel, geographic barriers, and attitudinal barriers to seeking treatment. New opportunities emerge, such as enhancing evaluation by utilizing built-in smartphone sensors (e.g., biofeedback and motion) and monitoring device usage, as well as giving ecological treatments directly to the patient when they are most required, as indicated by in situ assessments (Bert, et al. 2014).

Previous literature review on mobile mental health is out of date, and newer research mainly look at a particular mental disorder, such as cognitive impairment (Bateman, et al. 2017), alcohol and substance abuse (Kazemi, et al. 2017), anxiety; only look at specific technologies, such as text messaging and SMS messages; or only concentrate on efficacy, usability, and feasibility of interventions realized by mHealth interventions (Payne, et al. 2015).

Biofeedback (BFB) is a self-regulation method in which patients learn to regulate previously thought-to-be involuntary bodily functions such as heart rate, temperature, and skin conductance level, intending to improve physical and mental health (Frank, et al. 2010). Electronic sensors or wearables are attached to various regions of the body during BFB training to measure physiological processes such as muscle electrical activity, temperature, electrodermal activity, respiration, heart rate, heart rate variability, blood pressure, and electrical brain activity.

This training allows the individual to become aware of how ideas, feelings, and mental pictures impact bodily reactions. The same ideas, sensations, or pictures might be utilized as signals or reminders to change the physiological condition or bodily functions at a later time. Subjects learn to regulate a particular physiological reaction and, with time, can detect troublesome indications and symptoms using various approaches such as muscular, respiratory, relaxation, or cognitive strategies, allowing them more control over their bodies and minds (Weerdmeester, et al. 2020; Yu, et al. 2018).

The quality of service offered by the mHealth app is a key determinant of its success. Varshney (2014) highlights the importance of context awareness, offers suggestions towards improving the quality of mobile health, and discusses an analytical model for the evaluation of the performance of such systems. Privacy concerns have been a key determinant in driving the adoption of apps. Hassandoust et al. (2021) discuss such concerns in the context of contact tracing apps during the pandemic and how technology features such as anonymity and the extent of sensitive data collection determine adoption. Pool et al. (2020) offer a rich perspective on Mobile Health Data Protection (MHDP) and emphasize the need for protecting sensitive data which is crucial for the success of mHealth interventions.

Engagement is a crucial aspect of the application's success. Several papers suggested useful insights on improving engagement of mHealth apps and addressing design issues from an Information Systems perspective. Vlahu-Gjorgievska et al. (2021) undertake an extensive review of mHealth applications and study how the features offered by these apps drive user motivation and influence behavioral changes in users. Li et al. (2020) highlight the role of patients' emotional bonding with mHealth apps which influences the relationship between user's needs satisfaction and well-being. Miah et al. (2017) discuss design issues and emphasize the potential of Design Science Research (DSR) in mHealth developments.

3 Theoretical Foundation and Research Methods

We did scoping research, utilized a multi-theory viewpoint, and co-designed the app with users and experts to produce a well-designed mHealth app to increase students' wellness. To complete the scoping study, we used Arksey and O'Malley's (2005) five-stage framework, which includes: (1) identifying the research question, (2) identifying relevant studies, (3) selecting relevant studies for the review, (4) charting information and data from the selected literature, and (5) summarizing and reporting the review results.

3.1 Theoretical Background

To that aim, we performed a thorough assessment of research in the fields of mental health, student engagement, mobile health, and mobile app design, and established a theoretical framework to guide the development of a mHealth app to improve students' emotional, social, and mental health (Wrigh et al. 2018). The design of our proposed mHealth app uses principles from social support theory and other

related theories. Our theoretical framework, which is a blueprint for building a prototype that would improve students' emotional, social, and mental wellbeing, is the result of the review.

Social support and social belongingness could be established and shared which may increase the psychological well-being of online community users based on seven theories as shown in figure 1. Previous research, as well as principles from nudge theory (NT), social support theory (SST), belongingness theory (BT), social presence theory (SPT), theory of planned behavior (TPB), social information processing theory (SIPT), and sociocultural theory (SCT) inspired our theoretical framework.

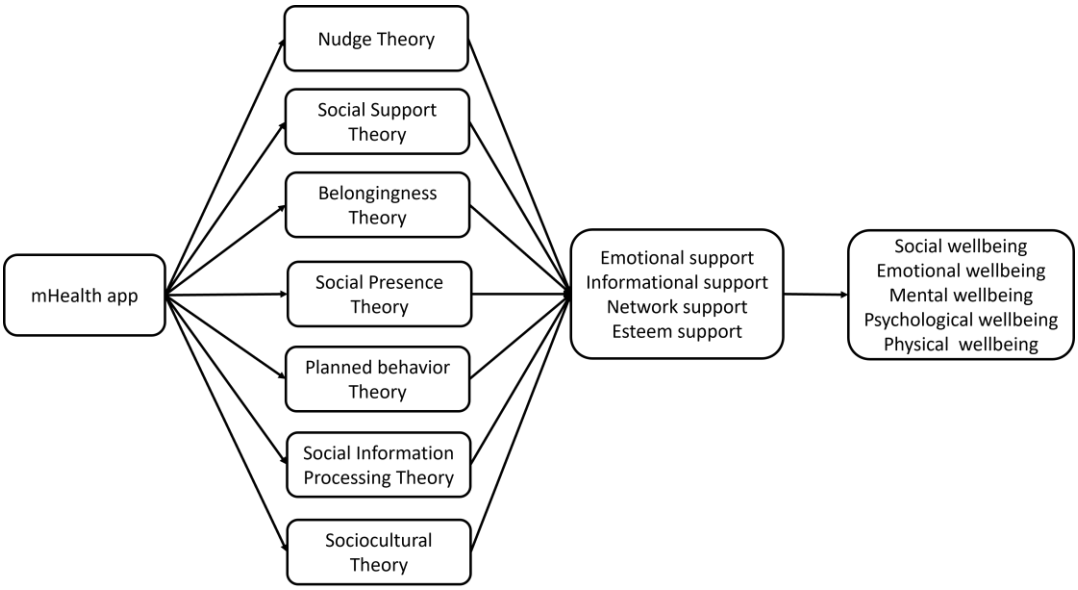

Figure 1. Theoretical Model of mHealth App use and Psychological Well-being of university students

3.1.1 Nudge Theory

The nudge theory, which was initially developed from behavioral economics and social psychology, is at the foundation of persuasive technology (Thaler and Sunstein 2009). To influence people's views and/or actions, persuasive technologies have been widely employed in different fields such as marketing, game design, and healthcare (Karppinen, et al. 2016). In order to improve clinical efficacy and user engagement, mental health persuasive technologies are frequently built to nudge people into changing their behavior (Oinas-Kukkonen and Harjumaa, 2009). Reduction, tunneling, customizing, suggestion, and self-monitoring are some of the theory-driven persuasive tactics used in the creation and assessment of such technologies (Orji, et al. 2017). Daily reminders and gamification aspects in the applications encourage users to keep track of their progress. This type of self-tracking is known as "pushed self-tracking," and it is commonly done in reaction to external stimulation (Munson and Consolvo, 2012).

3.1.2 Social Support Theory

Social support is defined as "the exchange of resources between two persons that the provider or receiver believes is intended to improve the recipient's health result" (Cutrona and Suhr 1992). There are several forms of social support, including esteem support, emotional support, network support, and informational assistance. Support seekers' demonstrations of good communication behaviors are referred to as "esteem support". Caring, compassion, listening, understanding, empathy, and encouragement are all examples of emotional support. Companionship and connectedness are examples of network assistance. Guidance, advice, facts, personal experience tales, views, and references to other sources of data and information that try to remove or solve assistance seekers' issues or assist in assessing circumstances are all examples of informational support. Enhancing informational support, emotional support, establishing network support, and boosting esteem support are all examples of how social support may help people feel better (Noronha and Mekoth 2013).

3.1.3 Belonging Theory

Belongingness theory is a helpful theoretical lens for investigating the role of social ties in the formation of social connectedness and, as a result, improved health outcomes (Grieve, et al. 2013). Emotional connectivity and a sense of belonging between an individual and other individuals are defined as social connectedness (Lee and Robbins 1995). According to BT, people form meaningful relationships to have

a feeling of belonging, which leads to improved psychological well-being and mental health. Other research has identified social connection as a strong, positive predictor of health and happiness (Galloway, and Henry 2014). Online Social Networks (OSNs) have been shown to improve helpful relationships, according to research (Lin, et al. 2015). As a result, belongingness theory helps explain OSNs' potential to establish supportive connections and increase youngster's psychological well-being.

3.1.4 Social Presence Theory

Shen and Khalifa (2008) describe social presence as "the sensation of understanding communications in a community," or "the degree to which a medium allows users to perceive others presence in a social context" (Xu, et al. 2012). SPT argues that communication is effective if the medium provides the proper social presence necessary for the amount of interpersonal participation required for a task, as stated by Short et al. (1976). SPT argues that communication is effective if the medium provides the proper social presence necessary for the amount of interpersonal participation required for a task. Researchers have shown a correlation between having a positive social presence and increasing user happiness and pleasant sentiments (Xu, et al. 2015). Positive health outcomes are associated with the social presence in online contexts (Kumar and Benbasat 2002).

3.1.5 Theory of Planned Behavior

The difficulty of obtaining mental health care was connected to the Theory of Planned Behavior (TPB), which is a model that utilizes attitude, social norms, perceived behavioral control (perception of obstacles), and intention to analyze and predict behavior. According to the idea of planned behavior, an individual's behavioral intentions and behaviors are shaped by their intention towards attitude, topic norms, and perceived behavioral control. The TPB claims that a person's attitudes towards a behavior, such as seeking mental health services, as well as his or her subjective beliefs about what others think about this behavior and the degree to which perceived barriers exist, all impact a person's desire to seek mental health services (Ajzen and Fishbein 1980).

3.1.6 Social Information Processing Theory

According to SIPT, participants in mobile-mediated communication (MMC) build individual perceptions of others based on collected messages and interactions, and as a result, textual or spoken signals may be used to form connections (Walther and Burgoon 1992). Individuals can modify verbal and paralinguistic actions to communicate in MMC settings by accumulating messages. MMC group members can adjust their vocally conveyed or typed communications to communicate social information over time, according to this idea. Members of the online community do not just accept technology passively; rather, they change their behavior to reap the benefits of the technology. SIPT contrasts between the intrinsic structures of sophisticated information technologies, which designers expect, and the structures that develop as people engage with such systems (Abedin, et al. 2011).

3.1.7 Sociocultural Theory

The focus of Sociocultural Theory is on learning as a social process. The term "regulation" refers to how learners advance from different forms of regulation to self-regulation. Successful learning, according to SCT, entails shifting from an object and other regulation to self-regulation. Learners' behaviors are determined by the objects they meet in the environment during the object regulation stage, and they begin to learn through observation in the social environment. Another level of regulation occurs when learners receive assistance and criticism from peers or mentors in a social setting (Lantolf 1994). When the learner is skilled enough to operate autonomously, he or she enters the self-regulation stage. Abedini et al. (2021) discuss adult learning in the context of Online Communities of Practice (OCOPs) and several factors which determine the level of engagement in such online settings.

3.2 Research Methods

3.2.1 Structured Interview

While the scoping research resulted in the proposal of an initial theoretical framework for app design, the theoretical framework was modified based on expert and user feedback. It's crucial to have a thorough grasp of the stakeholders' context. We intentionally assembled a team with the expertise, abilities, and resources to execute mHealth solutions, as well as the ability to speak to the unique needs of kids to enhance their wellbeing. We formed an advising development committee made up of technology specialists, healthcare professionals, and end-users who were all involved in the design process. The theoretical framework derived from the literature study was co-designed and refined with our advisory team through expert interviews and focus groups.

3.2.2 Content Validity

Expert interviews, according to Libakova and Sertakova (2015), are a form of a semi-structured interview that may be conducted between an interviewer and respondents who are experts in the topic of the questions. Interviewees should have studies, experiences, and profound scientific or experimental expertise in the field of the study objectives for this sort of interview. Interviewers acquire accurate and trustworthy information regarding their research aims by speaking with topic experts who undertake a professional and serious examination of the results.

For testing the validity of suggested modules of the first conceptual framework, we utilized Lynn's (1986) recommendations for conducting expert interviews, which indicate 10 or more participants. As a result, professionals with various backgrounds and professional skills were asked to take part. Psychologists, psychiatrists, social workers, software developers, and IT professionals with publications in the psychological well-being and health-related tools literature were among our participants.

By January 2021, we had issued invitations to 30 experts, and 9 (30%) had accepted to participate in an interview. We evaluated the proposed framework's content validity in two steps: the first was an assessment of features needed for a students' social support smartphone-based mental health intervention designed to improve university students' psychosocial well-being, and the second was an assessment of being culturally appropriate to the young generation. The percentage of experts agreeing on the characteristic of the intervention and recommending additional modules that can help to improve the psychological well-being of university students were the outcomes of these phases. The second author conducted online or face-to-face interviews between February and May 2021. Interviews took an average of one hour. We provided the experts with an early version of our proposed framework and asked if they agreed with each aspect, if not, what revisions were needed and why, and if they had any additional suggestions about the proposed conceptual framework. The percentage of experts agreeing on the features of the intervention and recommending additional modules that may help to enhance wellness management were the outcomes of these phases.

Lynn (1986) recommends a minimum of 75% or higher endorsements for each item in a group of nine participants. Our initial feature allocations were widely approved (78%) by experts, although several feature allocations were advised to be changed. The experts identified several new potential features. Figure 2 represents the confirmed framework for the mHealth app designed to improve students' social, emotional, mental, psychological, and physical wellness.

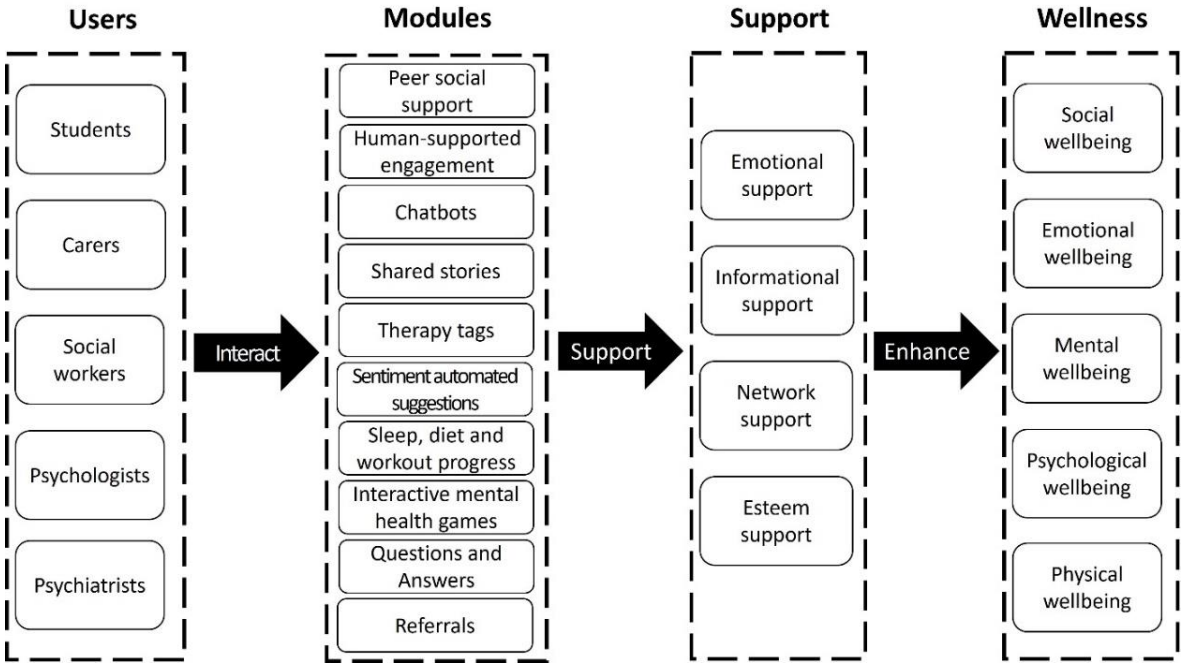

Figure 2. Proposed smartphone-based mental health app for improving students' wellness

4 Modules of Smartphone-Based Intervention Mental Health App

We developed a framework for a smartphone app to measure mental health support for university students. This user-centered app includes a self-monitoring feature (daily user condition: appetite,

exercise, sleep, and mood), as well as a self-screening feature (14 mental disorders), sentiment analysis (various ML techniques screen social interaction of the user on other apps) and a referral function that referred the users to caregivers, community volunteers, NGOs, psychiatrists, or other consultation services. In addition, we evaluate the app's impact on the youngsters' mental health.

The app's ultimate goal is to assist the youngsters in improving their mental health and overall quality of life by asking them to answer a structured questionnaire at first then the app uses AI for sentiment analysis of a participant's social interaction. The app incorporates aspects of the Internet of Things (IoT) by gathering real-time data about the user's behavior in real-world environments, identifying risk situations, and providing momentary interventions and assessments. In addition, the app collects data from wearable sensors (skin conductance, skin temperature, three-axis acceleration, activity levels, and sleep/wake patterns), a smartphone app (location, receivers, senders, and timings of calls and SMS text messages, the screen's on/off durations, and phone app usage), and electronic diaries day.

Then the app recommends random peers registered on the app to chat with to increase the participant's social interactions. If there is no peer available, a chatbot is used to have a conversation with the participant. In case of significant loneliness, the app connects the participant with caregivers, community volunteers, NGOs, and if necessary, health professionals. Psychologists could also volunteer to be connected with random users who are in need or users could connect with a specific psychologist that they know. In addition, the app sends periodic notifications to the participant including positive statements based on his or her sentiment.

The app uses several scales that assess the user's thoughts, emotions, and present mental state including "Goldberg Depression and Anxiety scale", "Wrapy Thoughts Quiz", "Pleasant Event Schedule", "Life Whacks Questionnaire", and "Measure of parenting Style". Since the app is vital for users' mental health, the app ensures that the service is reliable, and user's data is secured and private.

4.1 Peer Social Support

The first function is communication where users can connect and communicate with other users who share the same sentiment. They receive peer support from users who share the same feelings and went through a similar experience, so they understand the language and emotions of each other which helps them to recover. This module allows students to improve their social and mental well-being by providing knowledge, emotional support, and networking opportunities. They will be able to manage and maintain peer relationships, develop supportive interactions, express emotional responses and caring, share personal experience and provide advice to one another, feel a sense of belonging and connection, explore healthy lifestyle strategies, and, as a result, experience improved social and mental well-being.

4.2 Human-Supported Engagement

This module includes moderators who are mental health experts that may choose what material to recommend to people, because positive user motivation is boosted by accountable and trusted experts who monitor site activity, staff moderation has proved critical to increasing adherence (Mohr et al., 2011). Moderators not only ensure user safety by avoiding system abuse, but they also promote and improve user experience by serving as role models.

4.3 Chatbots

There is a chatbot that is used when there is no one online or no other user is sharing the same sentiment. A chatbot imitates the real conversation and reduces the user's loneliness as the chatbot has a conversation based on the sentiment analysis of the user and uses the appropriate words and shows compassion.

4.4 Shared Stories

Users share their stories and experiences so users can relate to these stories and how they overcame such feelings and trauma. Learning from other people's experiences and knowing that a tough situation is not the end of the world and success stories help young people to overcome their negative feelings.

4.5 Mental Health Therapy Tags

There are therapy tags to establish meaningful categories based on therapeutic material that targets certain groups of symptoms (e.g., anxiety) or skills (e.g., writing, social abilities). These therapy tags allow users to access information that is specifically customized to them based on their emotional state and requirements at the time based on the sentiment analysis of their social posts.

4.6 Sentiment Automated Suggestions

There is a self-screening mood feature (14 mental disorders), sentiment analysis (various ML techniques screen social interaction of the user on other apps) to suggest other uses with similar moods to communicate with, and relevant therapy tags.

4.7 Sleep, Diet, and Workout Progress

This user-centered app includes a self-monitoring feature (daily user condition: appetite, exercise, sleep, and mood). Through informative support, this module seeks to promote students' physical well-being. It will make it easier for kids to participate in a variety of recognized physical activities and will provide them access to healthy food recipes and diet plans. To guarantee that the suggested programs advance in a safe and attainable manner, health specialists will collaborate with fitness experts and nutritionists to develop them.

4.8 Interactive Mental Health Games

There are games that users could play with each other that help them to reveal their feelings and positively deal with them. This module will assist users in gaining network and esteem assistance to improve their social and mental well-being. For students, a series of online group-based games will be developed. Users will be able to have more good sentiments about themselves as a result of the games, as well as sensations of being connected, having a sense of purpose, and feeling less lonely. Students' confidence and self-efficacy will increase as a result of the games. Self-efficacy relates to people's assessments of their capacity to do specific tasks (Bandura and Adams 1977).

4.9 Questions and Answers

There are questions and answers of the most common topics the young people ask and enquire about.

4.10 Referrals

There is a referral function that refers users to caregivers, community volunteers, NGOs, psychologists, psychiatrists, or other consultation services. Also, it shows the contact details of various mental health support as well as access to support programs.

5 Future Phase: Developing A Mental Health App

Based on our suggested theoretical framework, a prototype of the mHealth app will be built and pilot-tested. We will test the app's usability before releasing it to the public by gathering input from target users using a usability questionnaire. To this aim, we will use Zhou et al. (2019) mHealth App Usability Questionnaire (MAUQ). To select university students, a non-probability approach called convenience sampling will be utilized. A total of 20 people under the age of 25 who can speak with the investigators acceptably will be chosen. We will ask university students to use the app for 4 weeks. We will interview users about their app usage experiences to assess the app's usability and efficacy, and we'll make changes depending on their input. In addition, we will see how effectively a mHealth app can help with wellness management, and we will use the Ryff Scales' psychometric characteristics to do so. We will assess its performance when it's launched to the public in terms of app downloads and more informal comments via an online survey embedded within the app. Furthermore, we will measure the efficacy of biofeedback in addressing mental health issues in the pilot group.

6 Conclusion

Smartphone applications might be a potential alternative for improving the mental health of university students, given the mental health burden that young adults face. We developed a framework for a smartphone-based intervention mental health app for the youth to reduce loneliness and social isolation among them. We propose a ‘preempt and prevent’ approach over a reactive approach in terms of coverage for 14 mental disorders and use biofeedback as an evidence-based therapy. This app includes self-monitoring and peer support functions to enhance mental health among young people. The main function of our app includes connecting users based on their present sentiment so they could express their feelings and thoughts in a friendly environment and get the required peer support from another user who shares the same sentiment. In addition, we have a self-monitoring system (daily appetite, exercise, sleep, and mood), and social interaction that’s used by AI tools to analyze the sentiment of the user and propose a certain therapy tag or a game or a chatbot.

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