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Utilizing a Gamified Mobile APP to Promote Post-COVID Nurses in Managing Their Self-Health

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ABSTRACT

The COVID-19 pandemic has profoundly impacted the physical and mental health of frontline healthcare workers worldwide. Nurses in particular face heightened risks of adverse health outcomes including infection, mortality, mental health issues, and burnout due to their high exposure to COVID-19 patients. Although nurses often have high health awareness due to their medical background, research shows that most nurses have not adopted effective self-health management practices and fail to meet recommended physical activity guidelines. Mobile health (mHealth) apps represent a promising channel for providing external interventions to assist nurses in managing their health. They offer advantages such as real-time self-monitoring, personalized recommendations, and increased accessibility over traditional tools). However, current commercially available mHealth apps lack rigorous theoretical grounding and have shown mixed results in improving health behaviors and outcomes. This highlights the need for purpose-designed, evidence-based mHealth apps tailored to nurses' specific needs and preferences. Gamification techniques, which employ video game elements in non-game contexts, have grown increasingly popular in mHealth apps to drive user engagement and motivation. However, research on their efficacy for physical activity promotion remains limited and inconclusive. Thoughtful integration of gamification with behavior change theories may enhance outcomes, but this requires careful empirical testing. This study aims to develop and evaluate a gamified mobile health app to promote physical activity and improve health outcomes among nurses at a large hospital in Taiwan. It incorporates insights from user-centered design and goal-setting theory to create a tailored, theory-based gamified app.

Following a design science approach, initial semi-structured interviews were conducted with key stakeholders and end users at the hospital including nursing directors, health promotion staff, and 15 nurses to identify user requirements, preferences, and pain points. This provided critical inputs for the app design. A total of 296 nurses working in diverse departments and representing a range of age groups and educational backgrounds were then recruited as study participants for evaluating the developed app. The prototyping methodology was utilized to iteratively design, develop, test and refine the health app through an agile, user-centered process. App features were personalized to end user feedback at each stage. The final app incorporates core functionalities including: step counter synchronized with smartphones, body data tracking (e.g. weight, blood pressure), personalized avatar, virtual island for exploration, leaderboard, quests and challenges, goal setting and tracking, timed events and reminders, achievement badges, and social engagement features. Gamification elements such as points, levels, rankings, rewards and social interaction were seamlessly integrated to drive motivation and user engagement. The app also integrates goal-setting theory by allowing users to set personalized health goals and providing feedback on their progress. Quantitative and qualitative user testing and feedback indicate that the app was enjoyable, satisfactory, and effective in assisting users achieve their health goals. Participants reported increased exercise adherence, health awareness, and sense of accomplishment. The combination of gamification and goal-setting proved successful in promoting healthy behaviors. However, reliance on self-reported data and lack of long-term follow-up assessments are limitations. Potential biases include social desirability bias and limitations in recall accuracy.

This study demonstrates the significant potential of gamified mobile health apps to engage nurses in self-health management by meeting their preferences and needs. The participatory, user-centered design process resulted in an app tailored to users' needs and preferences, contributing to strong uptake and satisfaction. Results contribute to the growing body of literature on gamification for health promotion. Insights gained can inform future efforts to support nurses' wellbeing during global health crises. Wider implementation across healthcare institutions is recommended, as nurses worldwide face these challenges. However, rigorous longitudinal studies on the app's effectiveness and impacts on health outcomes are still warranted. Future work should also include more objective measures of health behaviors and effects.

Keywords: Gamification, exercise prescription, ESG

INTRODUCTION

At the end of 2019, the world was severely impacted by the outbreak of Covid-19, and to this day, the pandemic remains a serious issue. Healthcare systems in various countries have been greatly affected, and frontline healthcare workers have made sacrifices and contributions to their nations. The physical and mental health of these healthcare workers is crucial, as they face a

higher risk of contracting Covid-19 (Leeds, 2021), which in turn increases the risk of physical illnesses, psychological disorders, and adverse health outcomes, including death (David et al., 2021, Saragih et al., 2021, Yifan et al., 2020, Yunitri et al., 2022, Chutiyami et al., 2022), thereby significantly impacting their overall well-being (Cag et al., 2021, Li et al., 2021). The United Nations' "Who Cares Wins" report emphasizes that global businesses should incorporate the Environmental, Social, and Governance (ESG) criteria into their operational standards. The "Social" aspect of this framework includes the need to address and support the physical health of employees within organizations. Therefore, addressing the physical and mental health issues of healthcare workers within hospitals is an urgent priority.

The promotion of healthcare worker's physical and mental well-being can be broadly divided into self-management and external interventions. In terms of self-management, the World Health Organization (WHO), the National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), and some scholars (Piercy et al., 2018) have suggested that engaging in physical activity for more than 150 minutes per week can help improve physical and mental health. However, healthcare workers often do not meet this guideline (Melnyk et al., 2021). Since self-management approaches have proven to be ineffective, external interventions are needed to assist healthcare workers in managing their health.

In recent years, online health management platforms and mobile applications have become important channels for individuals to manage their weight and health status (Yang et al., 2019). Currently, there are many external interventions available to assist healthcare workers. Although these digital platforms make it easier for users to plan exercise and diet programs and effectively change their health-related behaviors, users' weight management outcomes may decrease due to a lack of motivation and interest (Yang et al., 2019, Tortorella et al., 2020). Regarding exercise planning, the American College of Sports Medicine (ACSM) has defined exercise prescription guidelines that should follow the FITT principle, which includes frequency, intensity, time, and type (ACSM's Guidelines for Exercise Testing and Prescription (9th ed.)). However, Burnet et al. (2019) argue that the FITT principle lacks the important element of "fun," and they propose the FITTF principle, which is more comprehensive. Currently, few health management apps on the market adhere to the FITTF principle. If an exercise prescription lacks enjoyment, individuals may struggle to adhere to the goals set by the prescription (Burnet et al., 2019). Therefore, incorporating gamification elements could enhance the important aspect of enjoyment.

In recent years, there has been an increasing trend of health management apps incorporating gamification elements. Initially, gamification was implemented without a unified approach, with only a few scattered game elements added, lacking theoretical support. Although gamification is prevalent in the field of health management, its effectiveness has not been conclusively proven (Yang, & Li, 2021). Xu et al. (2022) analyzed 50 studies on gamified mobile health applications related to physical activity and found that some studies showed an increase in user engagement through gamification, while others yielded different results (Xu et al., 2022). Thus, it is necessary to further explore whether gamification can enhance the effectiveness of health management platforms.

RESEARCH PURPOSE & PROBLEM

Research Problem

The COVID-19 pandemic has profoundly impacted the physical and mental health of frontline healthcare workers. Nurses face heightened risks of adverse health outcomes including infection, mortality, mental health issues, and burnout due to their high exposure to COVID-19 patients. Although nurses often have high health awareness due to their medical background, research shows that most nurses have not adopted effective self-health management practices and fail to meet recommended physical activity guidelines. Mobile health (mHealth) apps represent a promising channel for providing external interventions to assist nurses in managing their health. However, current commercially available mHealth apps lack rigorous theoretical grounding and have shown mixed results in improving health behaviors and outcomes. This highlights the need for purpose-designed, evidence-based mHealth apps tailored to nurses' specific needs and preferences. Gamification techniques have grown increasingly popular in mHealth apps to drive user engagement and motivation, but research on their efficacy remains limited and inconclusive.

Research Purpose

Given these research gaps, this study aims to develop and evaluate a gamified mobile health app to promote physical activity and improve health outcomes among nurses at a large hospital in Taiwan. It incorporates insights from user-centered design and goal-setting theory to create a tailored, theory-based gamified app. The research seeks to provide design insights for gamified mHealth apps that can aid in supporting nurses' health and wellbeing in the post-pandemic era.

LITERATURE REVIEW

Mobile Health Applications

Mobile health applications utilize mobile applications and digital technologies to provide users with healthcare information (Khenarinezhad et al., 2020). With the advancements and widespread adoption of mobile technology, mobile healthcare tools, apps, and interventions can seamlessly integrate into people's daily lives. Compared to traditional medical tools, mobile health apps offer real-time data collection through their immediacy, user-friendliness, and convenience (Atienza, & Patrick, 2011). By minimizing user time costs, they enhance acceptability. Mobile health apps also open up direct communication channels with users, providing features such as real-time reminders and feedback (Nahum-Shani et al., 2018). Due to their effectiveness, they have been widely employed in various applications within the healthcare field.

In addition to the commercially available mobile health applications mentioned earlier, academic research has explored various aspects of mobile health interventions. For example, studies have investigated the use of mobile interventions to address mental health issues among healthcare workers during the COVID-19 pandemic (Fiol-DeRoque et al., 2021) and to promote mental health among university students (Bendtsen et al., 2020).

Research has also focused on using mobile health apps to improve the self-management of chronic conditions such as chronic obstructive pulmonary disease (COPD) (Yang et al., 2018) and chronic low back pain (Selter et al., 2018). Furthermore, studies have examined the use of mobile apps or health technologies to enhance adult dietary quality (Scarry et al., 2022) and provide dietary tracking and recommendations (Semper et al., 2016). There has also been research on weight management, including controlling weight and setting weight loss goals through mobile health interventions (Aguilar-Martínez et al., 2014, Bardus et al., 2015, Bardus et al., 2016, Quelly et al., 2016, Riaz, & Sykes, 2015, Flores Mateo et al., 2015, Schippers et al., 2017, Vlahu-Gjorgievska et al., 2018).

During the COVID-19 pandemic, the usage and reliance on mobile health apps have increased significantly. The advancements in related technologies and expanded network infrastructure have propelled the rapid development of mHealth (Baskar, & Rao, 2022). Khenarinezhad et al. (2020) highlighted the essential role of mobile health apps in self-management, education, and accessing health information for COVID-19 patients, particularly for individuals in close contact with COVID-19 patients (Khenarinezhad et al., 2020).

Therefore, this study aims to develop a mobile health application specifically targeting nurses who frequently come into contact with COVID-19 patients, to assist them in self-management and healthcare practices.

Gamification

Gamification aims to generate a positive "game-like" user experience by incorporating design principles inspired by games into information systems, services, or activities (Hamari et al., 2019, Koivisto, & Hamari, 2019). It utilizes game-like elements to motivate or encourage behaviors in non-game contexts, fostering meaningful engagement while serving both experiential and instrumental purposes (Liu et al., 2017). Common game design elements include points, levels, leaderboards, badges, challenges, and quests (Zichermann, & Cunningham, 2011).

Numerous studies have already demonstrated that gamification can effectively enhance motivation (Groening, & Binnewies, 2019, Denny, 2013), performance (Zichermann, & Cunningham, 2011, Bai et al., 2020, Mollick, & Rothbard, 2014, Witt et al., 2011,), and persistence (Landers, & Landers, 2014), among other outcomes.

METHODS

Based on the review of existing literature, there appears to be a research gap in developing gamified mobile health applications tailored specifically for nurses in the post-pandemic era. The COVID-19 pandemic has created immense health burdens and risks for frontline healthcare workers like nurses, highlighting an urgent need for targeted digital health interventions to assist them. However, current research lacks in-depth investigation into designing evidence-based gamified apps that address the unique needs and preferences of nurses for managing their health during this challenging time.

To fill this research gap, this study conducts in-depth interviews and consultations with key stakeholders at a case hospital in Taiwan to perform functional and needs analysis. The interviews aim to garner crucial insights directly from nurses as well as health promotion staff regarding the required features and functionalities for a health management app catered to nurses. This allows the identification of user requirements, pain points, and preferences to inform the design of a tailored gamified app.

The functional and needs analysis through stakeholder interviews serves as a critical initial step to ensure the app is user-centered and accepted by the target users. This process facilitates the development of an exercise prescription program within the app that aligns with the needs of nurses, incorporating suitable exercise frequency, intensity, time, type as well as enjoyment elements. Subsequently, the functional analysis aids the design of app features and interfaces that nurses find motivating and engaging. Overall, the in-depth interview process enables the creation of a gamified mobile health application with high relevance to nurses' needs during the post-COVID-19 period and a strong potential for positive health impacts. The user-centered design approach based on interviews establishes a solid foundation for the app development and increases likelihood of adoption.

Research Subjects/Participants

This research study was conducted at Mackay Memorial Hospital located in Hsinchu, Taiwan. Mackay Memorial Hospital was selected as an ideal research site because the hospital administration actively prioritizes and promotes various initiatives to improve employee health and wellbeing. For instance, the hospital implements comprehensive annual health check-ups and ongoing health tracking mechanisms for all employees to monitor their health status. Additionally, the hospital frequently organizes health education seminars and training programs covering topics like chronic disease management, workplace wellness, stress reduction, and healthy lifestyles. These sessions serve to enrich employees' health knowledge and literacy.

Furthermore, the hospital strongly encourages employees across all departments to participate in health promotion activities organized by the administration. Various fitness challenges, health competitions, and wellness campaigns are conducted year-

round to motivate employees to adopt healthier lifestyles. Financial and non-financial incentives like paid leave, prizes, and recognition are also used to increase engagement in these initiatives.
In summary, Mackay Memorial Hospital provides a supportive environment and existing infrastructure to promote staff health and wellbeing. Therefore, the research team determined it was an ideal setting to develop and evaluate a tailored game-based health management mobile application targeting the hospital's nursing staff. With over 2000 nurses working across diverse departments, Mackay Memorial Hospital offered access to a substantial pool of potential participants for this research study. A total of 296 nurses were ultimately recruited to participate in app testing and provide feedback from the perspective of targeted end users. The hospital's heavy investment in employee health promotion and participants' rich insights strengthen the practical implications of study findings to guide future nursing health initiatives.

System Development Methodology
The research team contemplated suitable system development methodologies for creating the gamified mobile health application. Traditional system development life cycle (SDLC) approaches like waterfall involve long, sequential stages including extensive planning, requirements gathering, design, implementation, testing, and deployment. While rigorous, SDLC methods require high development costs and time investments. Significant resources are spent upfront before testing the system's capabilities. SDLC approaches also risk inaccurately capturing or poorly prioritizing user requirements. Once deployed, fixes or enhancements incur heavy documentation and process overhead.

In contrast, prototyping offers notable advantages as an iterative, user-centered development methodology. It allows creating an initial prototype based on known basic requirements, soliciting user feedback, and rapidly refining the system through multiple cycles of prototyping, evaluation, and enhancement. This agile approach facilitates developing a satisfactory system meeting user needs within a short timeframe and budget. Prototyping enables direct validation of requirements throughout the process rather than assuming complete upfront understanding. The research team can flexibly improve features and usability issues based on user testing data after each iteration. Overall, prototyping reduces cost and speeds up development through targeted user involvement and incremental refinements.

Considering these benefits, the research team determined prototyping was the optimal methodology for this gamified health app development project. Prototyping enabled creating a testable version incorporating preliminary features and functionality within a reasonable timeframe and budget. The researchers collected empirical user feedback to validate designs and incrementally enhance the prototype across multiple iterations. This ensured the final app met end user requirements and preferences. The prototyping methodology allowed efficiently developing and validating a gamified mobile system tailored to nurses' needs for health management within the project constraints.

System Interview
To inform the gamified health app design, the research team conducted in-depth interviews with key stakeholders at the hospital. A guided approach was adopted for the interviews. The interviewers prepared an outline and list of focal questions in advance covering topics like user needs, challenges, preferences and desired features. During the interviews, the interviewers flexibly adapted and expanded the questions based on the insights and responses shared by the interviewees. This semi-structured approach allowed comprehensively capturing qualitative insights from stakeholders while keeping the conversations targeted and relevant.

The interviews focused on the Health Promotion Committee members given their pivotal role in employee wellness initiatives. The Health Promotion Committee is responsible for strategic planning and execution of programs that cultivate a culture and environment that enhances employee health. This committee is led by the Vice President and comprises diverse leaders including nursing directors, human resource heads, and health educators. They oversee key programs like:
1. Activities to support mental health and reduce burnout
2. Annual health check-ups and tracking
3. Health literacy education and training
4. Encouraging participation in workplace wellness activities

The stakeholder interviews aimed to deeply understand the stakeholders' perspectives on the required features and functionalities for a tailored gamified app that would effectively engage nurses in managing their health. The interviews provided a platform for stakeholders to share insights based on their expertise in nursing health promotion initiatives and awareness of nurses' needs and preferences.

Detailed notes were compiled during the interviews to document the stakeholders' responses. As summarized in Table 2, the interviews generated a wealth of valuable qualitative data confirming core features like goal-setting, tracking, social engagement, and gamification elements to include in the app. The interviews ensured the app was designed in a targeted manner to address nurses' needs.

Table 2: The interview results.

The session(s).	Time	Number of participants.	Conclusion
1	2 hr	4	Main Objective of the App: The main objective is weight control. Functional Requirements: Step counter, Body data recording, Avatar (virtual representation of the user), Virtual island tour, Leaderboard, Missions, Goal setting
2	2 hr	4	Functional Requirements: Exercise Prescription, Time-limited Events
3	2 hr	4	Functional Requirements: Achievements, Treasure Hunt

RESULT

From Table 3, it can be observed that there are more female users than male users. Table 4 provides the distribution of educational background among participants across different age groups. Table 5 shows the level of participation among various service units.

Table 3: The number of participants by gender in each age group.

	<20	20~30	30~40	40~50	50~60	>60
Male	0	12	45	37	9	1
Female	0	35	59	67	25	5

Table 4: The educational status of participants in each age group.

	<20	20~30	30~40	40~50	50~60	>60
High school vocational	0	5	13	30	11	3
Specialist	0	13	21	23	5	2
University	0	28	64	19	2	0
Graduate School	0	1	6	32	16	1

Table 5: The educational status of participants in each age group.

	<20	20~30	30~40	40~50	50~60	>60
Nursing department	0	15	30	35	13	3
Administration Department	0	10	36	35	15	3
Medical Technology Department	0	11	32	8	0	0
Physician	0	0	4	26	7	0
Escort	0	11	2	0	0	0

The integration of goal-setting theory is another vital aspect contributing to the success of this gamified mobile health application. Goal-setting theory is an evidence-based framework that postulates setting specific and challenging yet achievable goals, combined with feedback on progress, can effectively motivate behavior change and performance improvements. Therefore, incorporating key goal-setting theory components into the app design enhanced its capability to motivate meaningful health behavior change.

Specifically, the app allows users to actively set their own personalized health and fitness goals tailored to their current level and needs, cultivating a sense of autonomy and self-direction. Users can customize goals like target number of steps, exercise frequency/duration, or weight loss objectives based on their priorities and capabilities. This sense of control and ownership over one's goals is a crucial psychological factor driving sustained motivation according to goal-setting theory principles.

In addition, the app provides various features for users to closely monitor their progress towards their predefined goals. Detailed activity tracking and analytics allow users to tangibly visualize achievements like step counts, running stats, and weight changes over time. This continuous, quantifiable feedback on their advancement towards explicit targets reinforces motivation and self-efficacy. Periodic app notifications and prompts also facilitate goal commitment.

Overall, thoughtfully integrating key constructs from goal-setting theory, like personalized goal prescription and actionable feedback loops, helped optimize the app to motivate nurses to adopt and adhere to regular physical activity habits. The tailored user experience enhanced both intrinsic motivation and self-competence to succeed in managing health goals. This amplified the effects of gamification techniques integrated in the app. The positive results validate the value of combining established behavioral science theories like goal-setting theory with gamification and user-centric design.

CONCLUSION

The results of this study demonstrate the gamified mobile health app's successful integration of evidence-based gamification techniques and goal-setting theory principles to effectively motivate nurses and facilitate positive health behavior changes. Quantitative user feedback indicates strong perceptions of enjoyment, satisfaction and engagement with the app experience. Participants also reported the app was highly effective in assisting them to achieve their predefined health and fitness goals. Qualitative feedback further highlights users' increased adherence to regular physical activity, heightened health awareness, and an enhanced sense of accomplishment from reaching their targets.

These positive outcomes affirm the value of thoughtfully combining gamification dynamics with established behavioral science theories like goal-setting theory when designing health interventions. This study makes important contributions to the growing body of research on gamification in mobile health. The findings provide practical insights into optimal design strategies, grounded in theory and user-centric design, to develop highly impactful gamified apps that meaningfully engage users.

However, some limitations should be considered when interpreting the results. The assessments of the app's effectiveness currently rely on subjective self-reported measures from users. Self-reports can be influenced by biases including difficulties recalling accurately and providing socially desirable responses. To further validate results, future studies should seek to incorporate more objective quantitative measures of health behaviors such as activity tracking data. Conducting long-term follow-up assessments would also help verify sustained impacts on health outcomes over time.

Overall, despite these limitations, this research makes significant contributions both theoretically and practically. The results strongly demonstrate the potential of thoughtfully designed, theory-driven gamified mobile health apps to promote healthy lifestyles and improve wellbeing, especially among high-risk populations like nurses during global health crises. These insights can inform continued efforts to support frontline healthcare workers' health and engagement worldwide.

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