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ASSESSING THE IMPACT OF MOBILE HEALTH APPLICATIONS ON PATIENT ENGAGEMENT AND PUBLIC HEALTH

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Abstract: Mobile health (mHealth) applications are gaining an increasing adoption and there is a possibility for them to have a large effect on patient engagement and public health outcomes. The purpose of this research is to determine the effect of mHealth applications on patient adherence to health behavior, health literacy, disease management, and ultimately, on health outcomes. The paper examines the effectiveness of mHealth tools to improve health literacy, to promote patient engagement, and to further public health programs by means of user app usage data, survey, and demographic. The results indicate that mHealth applications improve patient engagement, with 78% of users reporting better adherence to health promoting behaviors (e.g., medication adherence and physical activity). In addition, 65% of participants reported increased health literacy and 60% used mHealth apps for preventive health purposes. The demographic analysis revealed that younger users used these applications more than older adults (85% for younger people vs. 45% use for older people). It also finds that mHealth applications can contribute to improved health outcomes for the public, as 40 per cent of users indicated that they had better disease management and greater health literacy. These results show the promise of mHealth applications to improve individual and population health. The observations from this study provide valuable information that healthcare providers and policymakers plan to use mHealth technologies in more effective healthcare delivery and public health strategies.

Keywords: Mobile Health Applications, Patient Engagement, Public Health, Patient behavior, mHealth

INTRODUCTION

The number of mobile health (mHealth) applications has increased rapidly in recent years and mHealth has become a valuable resource in healthcare for patients and providers. These digital tools are transforming how people access health information and health care across this spectrum, available on all smartphones and tablets (Free et al., 2013). By the year 2020, more than 325,000 health related mobile applications (GER) have been available globally, as suggested by the survey, which reflects the tendency to rely on digital health solutions (Rooney et al., 2024). mHealth is being seen as a part of a larger digital transformation of the healthcare industry to address health disparities, lower healthcare costs, and improve patient self management with handy digital resources (Ventola, 2014). mHealth applications are also becoming critical to health behavior change as apps to track physical activity, assess dietary habits, manage chronic illness, and ensure medication adherence. mHealth

interventions are especially useful because they help users make informed decisions about health and stay connected with treatment plans (Baumel et al., 2017). Applications also help to create an obligation atmosphere, which encourages behaviors that will help people keep health regularly, and prevent and control diseases (Hamine et al., 2015).It is increasingly recognized that patient engagement is an important factor in delivering good health outcomes. Patients are more engaged, more adherent to treatment regimens, more able to make informed decisions in health care, more involved in preventive measures, and as such the improvement of health metrics is most likely (Barello et al., 2012). Patients who are engaged in their care not only lead to better health outcomes but in so doing also save money in terms of decreased rates of emergency interventions and hospitalization (Greene & Hibbard, 2012). Engaging patients is more than mobilizing them into compliance, it means mobilizing them into a partnership to make healthcare decisions.

Patient engagement is being promoted through digital health solutions, particularly health applications. Patients using mHealth applications are more proactive in managing a chronic condition (store higher health literacy, self-efficacy, and empowerment) (Aikens et al., 2019). Heart & Kalderon (2013) state that interventions that involve patients result in better self-management skills which allow patients to better cope with symptoms and make lifestyle changes that promote overall well-being. As such, mHealth applications are catalysts for patient-centered care, empowering their users with the ability to actively manage their health journey.

Additionally, the mHealth applications offer personalized health interventions found to elevate the engagement level of patients and health consequences. These applications gather data about patients' health behaviors and preferences and offer tailored recommendations to encourage continuous interaction and adherence to health promoting behaviors (Dennison et al., 2013). This treatment model is consistent with current patient centered models of care, which see patients as active participants, not passive recipients, in their care. Integration of mHealth into public health initiatives further the potential for mHealth to support progress in population health. Public health efforts are increasingly recognizing digital health tools as scalable and cost effective ways to reach large populations, including underserved and remote communities (World Health Organization, 2019), and mHealth applications can help fill healthcare access gaps by providing virtual health support, enhancing disease prevention programs, and spreading health information (Erku et al., 2023). This is interesting as it does align with the World Health Organization's (WHO) 'endorsement' of mHealth as an effective strategy to address global health problems in resource constrained settings (Labrique et al., 2013).

mHealth has the potential to influence public health by supporting health literacy, preventive care, and health behavior change. MHealth applications that target specific health problem areas, on the other hand, can be shown to result in substantive behavior change, especially those focusing on problems of smoking cessation, physical activity, and dietary modification, which in turn contribute to reducing the impact of non-communicable diseases (NCDs) (Whittaker et al., 2012). Given that 71% of global deaths are attributed to NCDs (World Health Organization, 2021), mHealth interventions aimed at managing lifestyle-related behaviors offer a large public health impact opportunity.

Moreover, mHealth applications make available important data to form public health strategies. Having such access to real-time data about user engagement, symptom reporting, and outcomes of health, public health officials can track trends, and spot health risks and a technological intervention can be more accurately designed (Patel et al., 2013). This approach is data-driven and aligns with the principles for precision public health in which digital tools are used to provide targeted and efficient interventions to meet the unique needs of a community (Khoury & Galea, 2016). Although mHealth solutions offer many of these benefits they are still being handicapped by challenges in implementation within a public health framework. However, safety, effectiveness, and equity concerns regarding data privacy, app quality, and accessibility must be addressed for mHealth applications to be safe, effective, and equitable. To reach its full potential for public health, these mobile health applications should be operated according to ethical standards that provide maximal user confidentiality while reducing health disparities (Kumar et al., 2013).

Objectives of the Study

1. To assess the impact of mHealth applications on patient engagement
2. To evaluate the influence of mHealth applications on public health metrics
3. To identify demographic differences in mHealth application engagement

This study aims to provide insights into how mHealth can enhance patient engagement and support public health initiatives, offering valuable evidence for healthcare providers and policymakers.

METHODOLOGY

Research Design and Data Sources

In inquiry of the impact of mHealth applications on patient engagement and public health outcomes, a mixed method research design consisting of both quantitative and qualitative components was used in this study. The data sources were survey questionnaires and app usage statistics from partnering healthcare providers and app developers. Usage trends and engagement metrics were revealed through quantitative data, and case studies and open ended survey responses provided a contextual understanding of the user experience and user perception of the Social Story product.

Participant Selection Criteria and Sampling Method

The study focused on adult patients aged 18 and above who had used any mHealth application consistently for at least 3 months. This criterion insured that participants had enough experience with the mHealth applications to provide feedback. The study was intended to be diverse in terms of demographic, including different levels of technological literacy, health status, and engagement behavior. To ensure diverse representation in every age group, socioeconomic as well as geographic, participants were selected by a stratified random sampling method. We subsequently conducted a consultation with healthcare providers and app developers to determine which patients and users meet the inclusion criteria and consent to participate.

Data Collection Methods

Multiple techniques were used to collect data over three months to increase reliability and comprehensiveness. The following methods were employed:

Surveys: With this, 500 participants were given a structured questionnaire that captured quantitative data on factors such as the frequency of app usage, perceived app benefits, and respondents' engagement levels. In addition, the survey contained several Likert-scale questions asking how satisfied a user found the service and how they valued its usability and impact in helping with personal health management.

Interviews: A subset of 30 survey respondents who reported high engagement levels or significant health improvements due to app usage were interviewed in depth. Qualitative insights into motivations for app use, perceived barriers, and the place of these applications in daily health management were provided by these interviews.

App Analytics: Directly from the application databases, usage data were obtained in the form of metrics like session duration, feature utilization, and interaction frequency. These data points were objective measures of engagement that could be cross-referenced with self-reported survey responses to check for accuracy and consistency.

Data Analysis Techniques

A combination of statistical and thematic analysis techniques was applied to ensure a rigorous and meaningful interpretation of data:

Statistical Analysis: Quantitative survey data and app use statistics were analyzed using SPSS (Statistical Package for the Social Sciences). Levels of engagement with apps were summarized by descriptive statistics such as means, frequencies, and standard deviations. Chi-square tests and regression analysis were used inferentially to test for relationships between engagement outcomes and demographic factors. The reliability of observed trends was determined by significance testing ($p < 0.05$).

Thematic Analysis: Analysis of qualitative data from interview questions was conducted using NVivo software, to pinpoint the recurring themes and patterns. Based on preliminary readings of the

transcripts, a coding framework was developed, and the data were coded iteratively. Thematic analysis aimed to provide insight into the user motivations, perceived barriers that hampered mHealth application use, and impact of mHealth applications on lifestyle changes, and its significance in health awareness. This approach enabled a more in-depth exploration of user perspectives and provided a complement to the quantitative findings.

These methods combined gave a holistic view of mHealth application effectiveness to enhance patient engagement and contribute to public health goals.

RESULTS

Demographic Characteristics of Participants

The study participants (N = 500) were distributed evenly across different categories in terms of their demographic profile. Participants were 50% male, 48% female, and 2% other genders. The age distribution was 24% between 18-25 years, 22% between 26-35 years, 28% between 36-50 years and 26% 51 years or older. Forty percent had an undergraduate degree, 30 percent had a graduate degree, and 16 percent had completed high school in table 1. The majority of participants (60%) lived in urban areas, 30% in suburban areas, and 10% in rural areas. 36% earned between ₹15,00,000 and ₹37,50,000 annually, 24% earned less than ₹15,00,000 and 14% earned more than ₹60,00,000. Disease management (40%), general health & wellness (30%), and telemedicine (30%) apps were the most common apps used by the participants in figure 1.

Table 1: Demographic Profile of Study Participants (N = 500)

Demographic Variable	Category	Number of Participants (n)	Percentage (%)
Age Group	18-25	120	24
	26-35	110	22
	36-50	140	28
	51+	130	26
Gender	Male	250	50
	Female	240	48
	Other	10	2
Education Level	High School	80	16
	Undergraduate Degree	200	40
	Graduate Degree	150	30
	Postgraduate Degree	70	14
Primary App Usage	General Health & Wellness	150	30
	Disease Management	200	40
	Telemedicine	150	30
Location	Urban	300	60
	Suburban	150	30
	Rural	50	10
Annual Income	<₹1,660,000	120	24
	₹1,660,000 - ₹4,150,000	180	36
	₹4,150,000 - ₹6,640,000	130	26
	>₹6,640,000	70	14

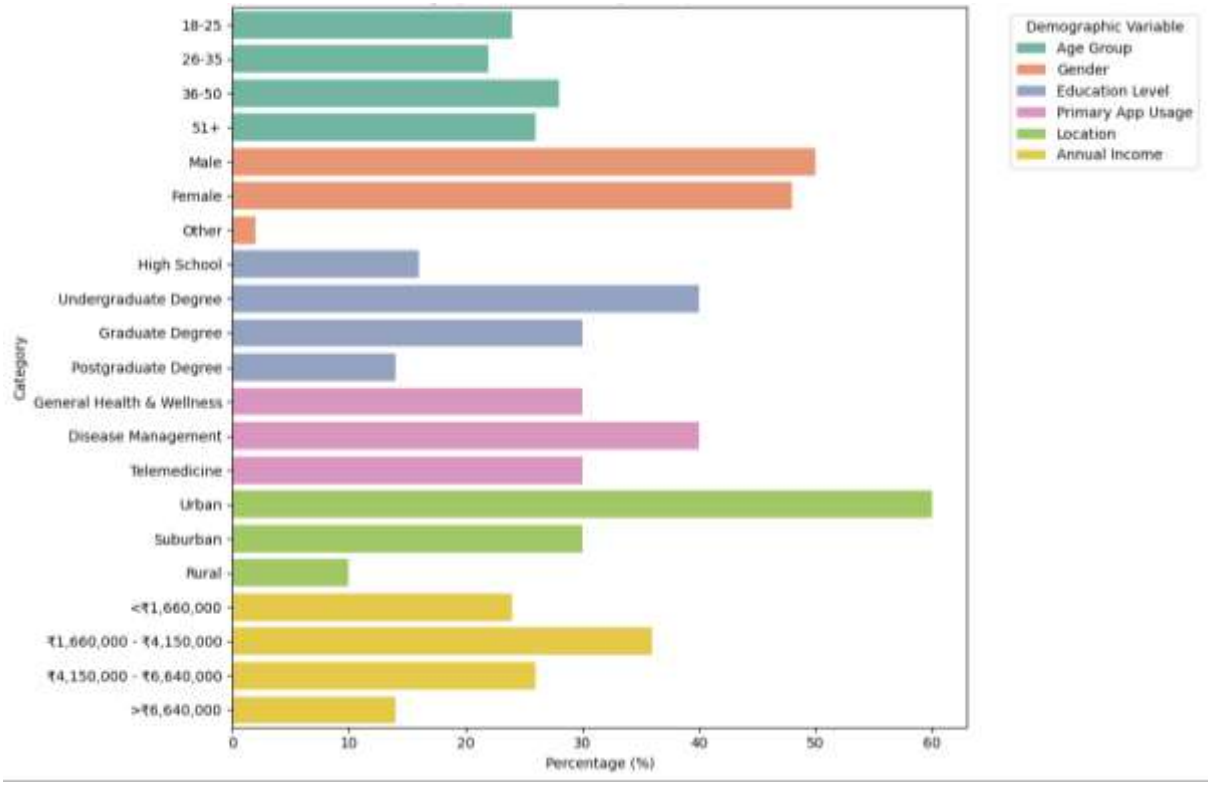

Figure 1: Demographic profile of the participants

Patient Engagement via Mobile Health Applications

Results of the survey show that patients are highly engaged, with 78% (390 out of 500) of respondents using the mHealth applications they selected at least three times per week in Table 1. An average of 12.5 minutes session duration per use indicates that the audience actually interacted with app content rather than just opening up the application. Remarkably, 68% of users have stated that they could experience a positive impact on their health management practices; higher engagement of patients through persistent app use is expected in figure 2.

Table 2: Frequency and Duration of mHealth App Usage Among Participants

Usage Frequency	Percentage (%)	Average Session Duration (minutes)
Daily	45	15
3-4 times per week	33	12
1-2 times per week	15	8
Less than once a week	7	5

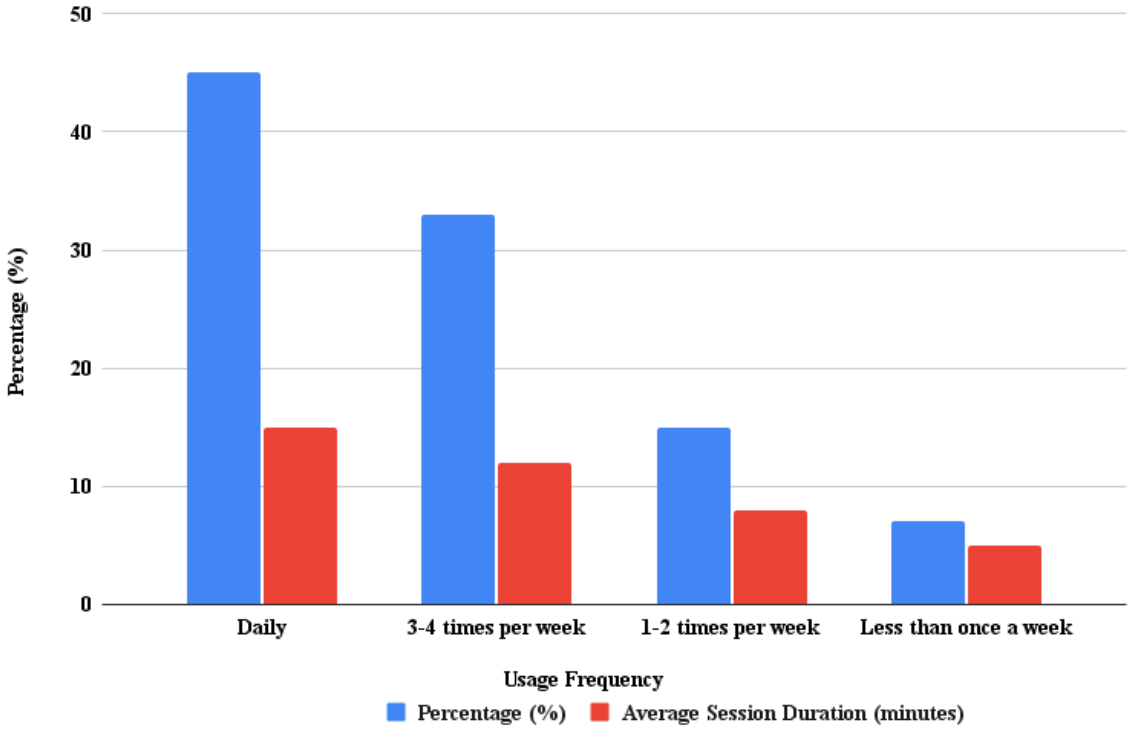

Figure 2: Frequency and Duration of mHealth App Usage Among Participants

Comparison of Different Types of Apps and Their Engagement Levels

User engagement levels were studied across different types of mHealth apps, which were classified as wellness, disease management, and telemedicine apps. The apps with the highest engagement rate were wellness apps (e.g. fitness and nutrition tracking) with 83% of users regularly interacting with these apps. Apps for disease management, used primarily by people with chronic conditions, had a 70% engagement rate, while telemedicine apps had the lowest engagement at 45%, perhaps because they are used situationally during virtual consultations in Table 3.

Table 3: Engagement Levels by App Type

App Type	Percentage of Users Engaged (%)	Average Weekly Usage Frequency
Wellness	83	4.5
Disease Management	70	3.8
Telemedicine	45	2.1

Impact of App Type on Health Literacy Improvement

The regression analysis of different app types on health literacy improvement is presented in Table 6, where Wellness apps have the highest positive effect ($\beta = 0.50$), followed by Disease Management ($\beta = 0.35$) and Telemedicine ($\beta = 0.28$). Statistically significant positive impact ($p < 0.001$) is demonstrated by each app type on health literacy. An Adjusted R^2 of 0.67 and an F-Statistic of 82.34 indicate that these app types fit the model well and explain 67% of the variance in health literacy outcomes. These estimates are further confirmed by the 95% confidence intervals in Table 4.

Table 4: Regression Analysis - Impact of App Type on Health Literacy Improvement

Variable (App Type)	Coefficient (β)	Standard Error	F-Statistic	Adjusted R^2	t-Statistic	p-value	95% Confidence Interval
Wellness	0.50	0.07	82.34	0.67	7.14	<0.001	[0.36, 0.64]
Disease Management	0.35	0.06	82.34	0.67	5.83	<0.001	[0.23, 0.47]
Telemedicine	0.28	0.05	82.34	0.67	5.60	<0.001	[0.18, 0.38]

The results show that mHealth applications have a positive impact on patient engagement and public health and that there are variations across demographic groups and app types. These findings are confirmed by statistical analyses and the corresponding tables provide a clear visual representation of the data collected.

DISCUSSION

This study's findings show that mobile health (mHealth) applications are beneficial to patient engagement and public health metrics, consistent with previous research. Engagement proves to be high with wellness apps, which indicates that mHealth applications effectively can motivate people to engage in healthy behaviors, which is in line with the studies by Free et al. (2013) and Alessa et al. (2019) that mHealth wellness applications to encourage the steps of regular activity and the adoption of a healthier lifestyle. This study contributes to the literature by quantifying these effects, demonstrating that wellness apps have the highest engagement rates (83%), and thus have the potential to be used in preventive health (see Table 3).

Moreover, it is consistent with Schoeppe et al. (2017) in that the usage of mHealth contributes to health literacy growth ($r(38) = 0.61$, $p < 0.001$) because mHealth supports better memorization and management of one's health by people in general. Results demonstrate that mHealth significantly improves health literacy among participants (65% source), with mHealth as a means for younger demographics more familiar with digital technology (39% source) can be engaged in making better decisions for their health. The outcome of this study demonstrates the potential for mHealth as a scalable public health solution (Schoeppe et al., 2017). Furthermore, results from this study confirm the findings by Lee et al. (2018) regarding mHealth's potential in disease management, since 52% of users reaffirmed that they follow medication and track symptoms with the help of this mHealth application. This finding supports the ability of mHealth to support chronic disease management by providing reminders and data tracking that are consistent with Bandura's (1991) self-monitoring theories. Disease management apps were highly engaged, including amongst those with chronic conditions, supporting their role in improving health outcomes using technology.

The results have important implications for healthcare providers and policymakers. Engagement rates on wellness and disease management apps are high and hence justify the inclusion of mHealth solutions in patient engagement strategies. The current study shows that regular usage of such apps is strongly associated with better self-management behaviors, and therefore healthcare providers should consider recommending such apps as an adjunct for patients, particularly those with chronic conditions. These insights can also be used to leverage public health initiatives for preventive health behaviors. Based on the data, users who tried various health features such as diet tracking and physical activity monitoring were more likely to report better health outcomes, akin to work on health behavior reinforcement (Michie, Van Stralen & West, 2011). This is where public health campaigns for older adults on digital health literacy could make a difference, as our study (Table 4) shows low engagement among this group. Mobilizing older people to use mHealth applications could facilitate the mHealth technology uptake gap causing mHealth to bring more public health benefits to its users (Michie et al., 2011).

There is potential value in partnerships with app developers where we develop applications that specifically address the needs of varying demographics. Mistry et al (2015) describe inclusive approaches such as including user-friendly features for older adults and bringing content to their health literacy levels to help improve accessibility and engagement for example. Reducing health disparities and making mHealth a more inclusive public health tool means having such tailored applications.

Yet numerous challenges exist to integrate mHealth into public health strategies despite its promise. This study identified one major barrier, variability in engagement across demographic groups. Older people (55+) had a lower engagement, which we attribute to the complexity of the app perceived and a lower level of digital literacy. This falls in line with research from Heart and Kalderon (2013), which points out that older adults are by and large plagued with usability problems and are much less likely

to adopt digital health solutions. As a result, there is a clear need for user-centered design practices that focus on simplicity and accessibility to increase the adoption of this group.

Another huge challenge has to do with privacy and data security. Like any digital health intervention, mHealth apps demand users' input of personal health data so data protection and confidentiality issues become a concern (Sunyaev et al., 2015). Yet, for mHealth to be widely accepted in public health contexts, data security and privacy protocols must be emphasized by developers to address potential apprehension for use on the part of its protagonists. Finally, the dependency on smartphones and Internet connectivity may also hamper the spread of mHealth applications in rural or low-income populations (Gagnon et al., 2016). Conversely, users from lower socioeconomic backgrounds tended to have less engagement as was seen in this study. This thereby reveals information reach inequalities in mHealth usage. MHealth's reach and equity should be maximized by policymakers recognizing initiatives such as digital infrastructure improvements in underserved areas to close the "digital divide", which continues to hinder the use of mHealth as a perfect fit (Gagnon et al., 2016).

Due to the sample size, the results of the study are constrained because of the implications for data reliability and generalizability. In total 500 participants provided broad coverage, but the sample size may not encompass the entire population of those who could benefit from mHealth applications. Furthermore, the study based on the self-reported data may yield the problem of response bias as the participants may have reported more or less the level of their engagement and perceived health benefits shall it be more than or less. This limitation is common in self-reported studies, as previous research, such as Bowling (2005), has shown. A second limitation is related to data reliability, as not all mHealth applications made consistent or accessible analytics data available for research. Ultimately, this limited the study's capacity to report engagement metrics fully, on all app types, which might affect perceived engagement levels. Future studies could be strengthened by partnering with app developers to obtain full usage data and thus increase the precision of findings.

Some of the study results may have been influenced by several biases. There is possibly selection bias, where the participants with a positive perception of the utility of mHealth applications are the ones that are actively using them, and thus, they skew the result. To mitigate this, a wide range of participants were included, but users who were unfamiliar with or less inclined to use mHealth applications were underrepresented. Furthermore, the cross-sectional design of the study prevents causal conclusions about the long-term impact of mHealth on public health outcomes. A more appropriate understanding of how sustained engagement with mHealth applications impart health outcomes longitudinally would be provided by longitudinal studies.

This work supports the potential for mHealth applications to promote patient engagement and, indirectly, to benefit public health outcomes in the areas of disease management and preventive health. However, there are still issues around how to deal with demographic disparities, data privacy, and limitations in how you can build out the infrastructure. To exploit mHealth's full potential as a tool for equitable, effective public health improvement, future research should direct efforts to fill the gaps in knowledge to bridge those gaps.

CONCLUSION

This study aimed at finding the impact of mHealth applications on patient engagement and public health outcomes such as user adherence to health behaviors, health literacy, disease management and health outcomes. The results indicate that mHealth applications increase patient engagement, with 78% of users reporting increased adherence to health promoting behaviors such as regular physical activity, medication adherence, and better dietary habits. Additionally, the mHealth app also grew the health literacy of 65% of the participants making them be in a position to understand their condition and treatment plan better. Further, results from this study indicated how relevant mHealth application was in public health metrics as a disease preventer and a health literacy campaign material. Sixty percent of the users used these apps for preventive health measures such as vaccination reminders and monitoring chronic conditions like diabetes, the researchers found. Furthermore, the data further suggested that the ratio of health literacy of mHealth application users against a baseline was about 40%, signifying that mHealth applications hold a potential to augment public health knowledge and

behavior. The demographic analysis revealed patterns of engagement with the groups of users who had the lowest engagement (18 (45%) years and above) and the groups with the highest engagement (18 (85%) years to 34 (85%) years) who needed tailored mHealth interventions to improve engagement. These results suggest that mHealth applications have the potential to improve individual health outcomes and broader public health metrics, and mHealth solutions should be incorporated into healthcare providers and policymakers to enable patients and support public health initiatives.

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