






Persuasive Mobile Apps for Health and Wellness: A Comparative Systematic Review

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Abstract. While majority of previous research focus on reviewing mobile health (mHealth) apps targeting specific health domain, this paper provides a comparative systematic review of mHealth apps across multiple health domains with the aim of deconstructing the persuasive strategies employed and their implementation. Specifically, we targeted four health domains (i.e., *physical activity and fitness*, *diet*, *emotional and mental health*, and *health assessment and healthcare*). We retrieved a total of 639 apps from Google Play out of which 80 popular apps were extracted (20 apps in each category). Three expert reviewers coded the apps using 32 persuasive strategies (PSs) based on Persuasive System Design (PSD) Model and Cialdini's Principles of Persuasion. Overall, out of the 80 mHealth apps reviewed, *personalization* is the most commonly employed PS ($n = 77$), followed by *surface credibility* ($n = 69$), *trustworthiness* ($n = 66$) and *self-monitoring* ($n = 64$). How the apps are implemented varies depending on the domain. Based on our findings, we offer suggestions for designing mHealth apps to improve their persuasiveness.

Keywords: Health · Wellness · Mobile apps · Persuasive strategies · Behaviour change · Systematic review

1 Introduction

The proliferation of smartphones has made it possible to share millions of life-enriching mobile apps to billions of people worldwide [1]. Many of these apps are health-related and help in managing chronic or mild health conditions [2], supporting the adoption of a healthy lifestyle or promoting healthy behaviours [3]. Specifically, these mobile health (mHealth) apps are effective in promoting physical activity [3, 4], weight management [5], dietary interventions [3], disease management [2], mental well-being [6], and so on. However, for behaviour change to occur, developers of mHealth apps need to employ persuasive principles or strategies [7, 8].

While previous research has conducted literature review on the persuasiveness of mHealth apps [9, 10] or review apps targeting specific health domain [11–14], existing work has not conducted a comparative systematic review of mHealth apps (on Google Play or App Store) across multiple health domains (such as fitness, diet, mental health, etc.) at the same time to the best of our knowledge.

To fill this gap, we conduct a comparative systematic review of 80 mHealth apps across four different categories with each category having 20 popular apps. The categories include *physical activity and fitness*, *diet*, *emotional and mental health*, and *health assessment and healthcare*. The goal of this review is to identify and compare the persuasive strategies employed by the apps and how they were implemented. Three expert reviewers coded the apps using 32 persuasive strategies (PSs) based on the Persuasive System Design (PSD) Model [7] and Cialdini's Principles of Persuasion [8].

Our findings show that for the Physical Activity and Fitness category, *personalization* (n = 20) and *trustworthiness* (n = 20) PSs are the most commonly employed, followed by *self-monitoring* (n = 19). For the Diet category, *personalization* (n = 20), *commitment/consistency* (n = 20) and *suggestion* (n = 20) PSs emerged as the most commonly employed, followed by *reminders* (n = 19). Moreover, under the Emotional and Mental Health category, *personalization* (n = 19) and *surface credibility* (n = 19) PSs are the most commonly employed, followed by *liking* (n = 17). For the Health Assessment and Healthcare category, *personalization* (n = 18) is the most commonly employed PS, followed by *surface credibility* (n = 16), and *self-monitoring* (n = 15). Overall, out of the 80 mHealth apps reviewed, *personalization* emerged as the most commonly employed PS (n = 77), followed by *surface credibility* (n = 69), *trustworthiness* (n = 66), and *self-monitoring* (n = 64). Based on our findings, we offer suggestions for designing mHealth apps to improve their persuasiveness.

2 Related Work

Existing research has evaluated mobile health apps to determine the persuasive features they provide. For instance, Langrial et al. [15] conducted a review to identify the persuasive features in twelve mobile apps for personal well-being using the PSD model. Similarly, Chang et al. [6] evaluated twelve mobile apps for mental well-being using the 28 principles of the PSD model. They reviewed the apps based on user acceptance of mobile services, mobile intervention design, and persuasive design. Furthermore, Azar et al. [16] assessed the intervention strategies present in 23 weight management mobile apps using four behavioural theories or models, which are the health belief model, trans-theoretical model, theory of reasoned action/planned behaviour, and the social cognitive or social learning theory. They also assessed the persuasive nature of the applications using the Fogg Behavioural Model (FBM).

Rather than targeting a specific health domain, our work provides a comparative systematic review of 80 mHealth apps across multiple health domains using both the PSD model and Cialdini's Principles of Persuasion. Specifically, we targeted four health domains: *physical activity and fitness*, *diet*, *emotional and mental health*, and *health assessment and healthcare* to uncover new insights and enrich the literature.

3 Methodology

In this section, we discussed the app selection criteria and coding process.

3.1 Selection of MHealth Apps

We developed a Python script to automate the app selection process which involves two stages. First, we searched for health-related apps that are free or free with in-app purchases on Google Play using keywords appropriate for each category, as defined in Table 1. We filtered our search results by selecting apps that belong to at least one of the following relevant Google Play groups: health and fitness, medical, social, and lifestyle. Second, we selected 20 most popular apps after sorting the total apps in each category in descending order of number of installations, followed by average ratings and number of reviews. Table 2 shows the apps summary per category based on number of installations, average ratings and number of reviews. We ensure that none of the 20 apps in a category is repeated in another category. In other words, we selected 80 unique apps in total for coding and analysis. 92.5% of the 80 apps were updated in 2019.

Table 1. App Categories and Search Keywords, and the corresponding number of Unique Apps retrieved.

App Category	Description	Keywords	No. of Apps
Physical Activity and Fitness	Apps that promote any form of physical activity or exercises, such as walking, running, cycling, etc.	<i>fitness, physical activity, exercise, running, walking, cycling, etc.</i>	195
Diet	Apps targeted at healthy eating such as tracking diet or food intake, as well as water consumption	<i>diet, drink, food, nutrition, water, etc.</i>	120
Emotional and Mental Health	Apps for mental health and emotion regulations such as helping users control their feelings and thoughts, as well as anxiety, depression, stress and sleep disorders	<i>mental, emotion, anxiety, depression, sleep, stress, etc.</i>	167
Health Assessment and Healthcare	Apps that help with health assessment and/or diagnosis, as well as provide access to qualified healthcare professionals	<i>healthcare, health assessment, symptom, diagnosis, doctor, etc.</i>	157

Table 2. Summary of 20 Popular Apps in each Category based on the Number of Installations, Average Ratings, and Number of Reviews

App category	No. of installations (range)	Average ratings (range)	No. of reviews (range)
Physical Activity and Fitness	10000000–500000000	3.7–4.8	60788–930822
Diet	1000000–50000000	3.4–4.8	8699–2165194
Emotional and Mental Health	1000000–10000000	3.6–4.8	8686–298437
Health Assessment and Healthcare	500000–10000000	4.1–4.8	5133–303407

3.2 Coding and Analysis of Selected Apps

In the coding phase, we identified the persuasive strategies (PSs) employed in designing each of the 80 mHealth apps including how the strategies were implemented using the PSD model [7] and Cialdini's Principles of Persuasion [8]. Both frameworks have been widely used in deconstructing persuasive technologies over the years. From the PSD model, we used all the PSs under the primary task support, dialogue support, system credibility support and social support categories for coding purposes. From the Cialdini's Principles of Persuasion, we selected four out of the six available PSs since two strategies (i.e., *authority* and *liking*) already exist in the PSD model. Table 3 shows the 32 persuasive strategies and their categories.

Figure 1 describes the coding process. Three expert reviewers installed the apps on their Android smartphones and used the app features to perform various tasks while taking note of the PSs and how they were implemented in their coding sheets. Afterwards, the reviewers discussed the information captured on the coding sheets.

Table 3. Persuasive Frameworks, Categories and Descriptions, as well as the individual Persuasive Strategies

Framework	Category	Description	Persuasive strategies
PSD	Primary task support	Support users in performing their intended tasks	Reduction, Tunneling, Tailoring, Personalization, Self-monitoring, Simulation, Rehearsal

(continued)

Table 3. (continued)

Framework	Category	Description	Persuasive strategies
	Dialogue support	Provide feedback that moves users toward the target behaviour	Praise, Rewards, Reminders, Suggestion, Similarity, Liking, Social role
	System credibility support	Support the development of systems that are more credible	Trustworthiness, Expertise, Surface credibility, Real-world feel, Authority, Third-party endorsements, Verifiability
	Social support	Motivate users through social influence	Social learning, Social comparison, Normative influence, Social facilitation, Cooperation, Competition, Recognition
Cialdini’s Principles of Persuasion	–	Set of principles or strategies that influence people’s behaviour	Reciprocity, Scarcity, Social proof, and Commitment/consistency

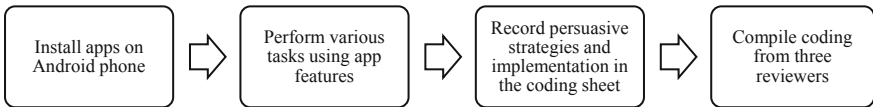


Fig. 1. The Process of Coding Apps

4 Results

In this section, we present the apps review results. We discussed the persuasive strategies identified in the apps and how they were implemented.

4.1 Persuasive Strategies Employed by Apps in Various Health Domains

Figure 2 shows the primary task support PSs employed by apps in the four health domains or categories (i.e., Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare). Of the seven primary task support PSs, *personalization* is the most commonly employed strategy in all four categories, followed by *self-monitoring*. Specifically, for Physical Activity and Fitness category, *personalization* is the most commonly employed strategy (n = 20), followed by *self-monitoring* (n = 19) and *reduction* (n = 18). For Diet category, *personalization* is the most commonly

employed strategy (n = 20), followed by *self-monitoring* (n = 19) and *reduction* (n = 19). However, for Emotional and Mental Health category, *personalization* is the most commonly implemented strategy (n = 19), followed by *self-monitoring* (n = 11) and *tunneling* (n = 11). For Health Assessment and Healthcare category, *personalization* is the most commonly implemented strategy (n = 18), followed by *self-monitoring* (n = 15) and *tunneling* (n = 11).

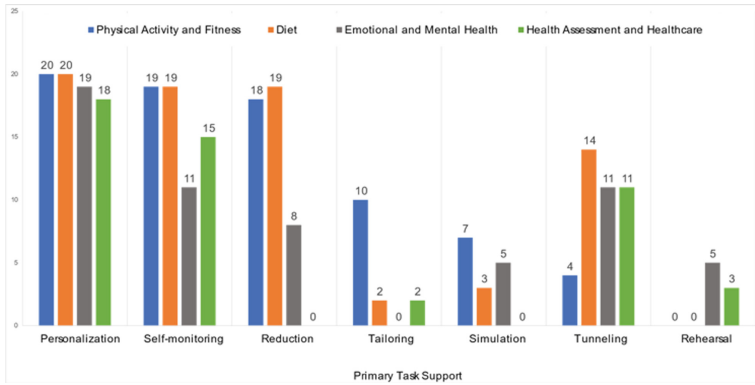


Fig. 2. Primary Task Support PSs employed in Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare categories

Furthermore, Fig. 3 shows the dialogue support PSs employed by apps in the four categories. For Physical Activity and Fitness category, *reminders* (n = 17) is the most commonly employed, followed by *suggestion* (n = 15) and *liking* (n = 12). However, for Diet category, *suggestion* (n = 20) is the most commonly employed, followed by *reminders* (n = 19) and *liking* (n = 10). For Emotional and Mental Health category, *liking* (n = 17) is the most commonly employed, followed by *reminders* (n = 14) and

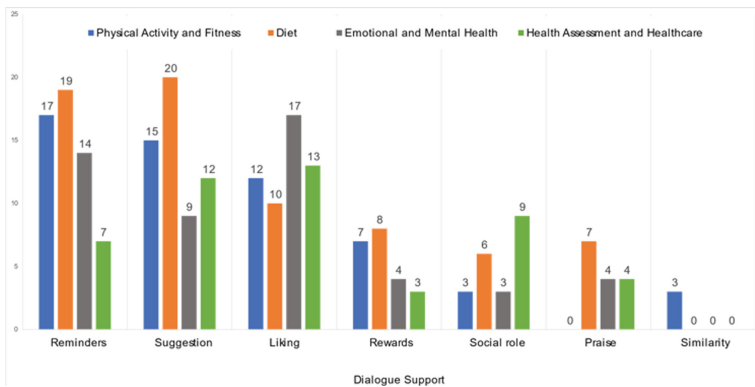


Fig. 3. Dialogue Support PSs employed in Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare categories

suggestion (n = 9). Finally, for Health Assessment and Healthcare category, *liking* (n = 13) is the most commonly employed, followed by *suggestion* (n = 12) and *social role* (n = 9).

Moreover, Fig. 4 revealed the system credibility PSs employed by apps in the four categories. For Physical Activity and Fitness category, *trustworthiness* (n = 20) is the most commonly employed PS, followed by *real-world feel* (n = 17), *surface credibility* (n = 16) and *expertise* (n = 16). For Diet category, *trustworthiness* (n = 19) and *expertise* (n = 19) are the most commonly employed PSs, followed by *surface credibility* (n = 18). For Emotional and Mental Health category, *surface credibility* (n = 19) is the most commonly employed, followed by *trustworthiness* (n = 13) and *real-world feel* (n = 12). Finally, for Health Assessment and Healthcare category, *surface credibility* (n = 16) is the most commonly employed, followed by *real-world feel* (n = 15) and *trustworthiness* (n = 14).

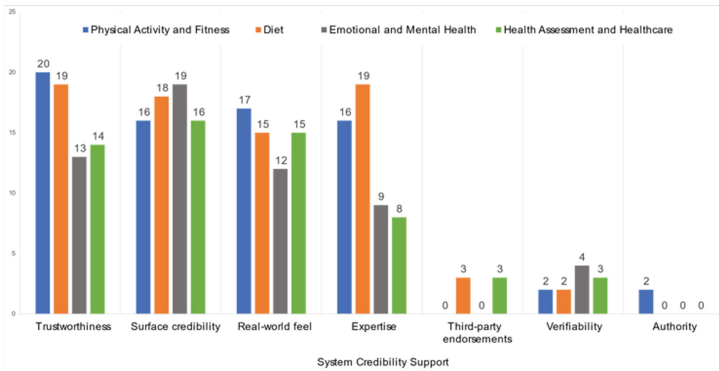


Fig. 4. System Credibility Support PSs employed in Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare categories

Furthermore, Fig. 5 shows the social support PSs employed by apps in the four categories. For Physical Activity and Fitness category, *competition* is most commonly employed (n = 10), followed by *social learning* (n = 5) and *recognition* (n = 5). For Diet category, *normative influence* is most commonly employed (n = 8), followed by *social learning* (n = 7) and *competition* (n = 7). For Emotional and Mental Health category, only *social facilitation* (n = 1) and *social learning* (n = 1) were employed. Interestingly, for Health Assessment and Healthcare category, none of the apps employed the social support PSs. Also, none of the four categories employed the *cooperation* PS.

Finally, Fig. 6 revealed the Cialdini’s Principles of Persuasion employed by apps in the four categories. For *commitment/consistency* (n = 18) is the most commonly employed, followed by *reciprocity* (n = 9) and *social proof* (n = 6). For Diet category, *commitment/consistency* (n = 20) is the most commonly employed, followed by *social*

proof (n = 10) and *scarcity* (n = 7). For Emotional and Mental Health category, *reciprocity* (n = 6) is the most commonly employed, followed by *commitment/consistency* (n = 5) and *social proof* (n = 3). Interestingly, for Health Assessment and Healthcare category, *commitment/consistency* (n = 4) is the only strategy employed.

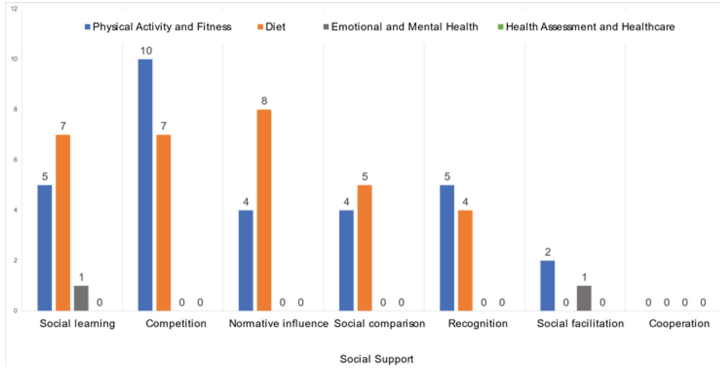


Fig. 5. Social Support PSs employed in Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare categories

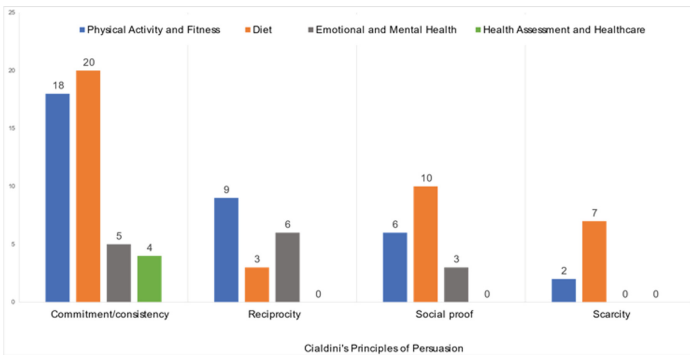


Fig. 6. Cialdini's Principles of Persuasion employed in Physical Activity and Fitness, Diet, Emotional and Mental Health, and Health Assessment and Healthcare categories

4.2 Persuasive Strategies Implementation in the Apps

Table 4 presents how the various persuasive strategies are implemented in the apps.

Table 4. Persuasive Strategies and how they are Implemented in the Apps

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Personalization	Personalized contents based on users' gender, age, weight and height; customizable language, sound, music, etc.	Personalized contents based on users' demographics, height, weight, location; customizable notification, sound and triggers, widgets, language, etc.	Personalized contents based on users' demographics; customizable theme, alarm, sound, music, language, etc.	Use personal information to assign doctors; customizable theme, font size and language
Self-monitoring	Graphs and texts that show users' progress, including current and past activities	Graphs and texts that show users' progress, including current and past activities	Graphs/charts showing sleep, mood, and emotion analysis	Heartrate analysis, symptom tracking, sugar-level analysis, doctors' report, self-assessment report, etc.
Reduction	Predetermined lists of exercise/sport types and training plans	List of popular restaurants and recipes with their respective calories; cup sizes for drinking water; barcode scanner for food logging	Meditation, sleep, relaxation and happiness goals are broken down into smaller achievable tasks	–
Tunneling	After question answering steps, suitable exercise, fitness or training plans are provided	After question answering steps, suitable exercise, fitness or training plans are provided	Step-by-step guides on proper meditation and emotional health	Guide users on addressing symptoms
Tailoring	Exercise plans are based on users' fitness level	Users can set dietary preferences and get matching recipes	–	Medical scenarios and learning contents are based on area of specialty

(continued)

Table 4. (continued)

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Simulation	Pictures show the before and after effects of performing various exercises	Uses fat and slim avatars reflect the impact of performing target behaviour	Animated images and avatars demonstrate transitions towards good sleeping habits	–
Rehearsal	–	–	Rehearse meditation and gratitude leading to happiness	Healthcare professionals can rehearse medical cases (such as surgery-related cases)
Reminders	Remind user to workout using push notifications with sound and text	Reminds users to track meals and water using push notifications with sound and text	Remind or notify users to meditate, sleep and wakeup, etc. using push notifications with sound and text	Remind users about finishing pills using push notifications with sound and text
Suggestion	Suggest number of calories to burn, fitness plan, daily steps, etc.	Suggest daily calories, ounce of water, nutrition values, food quantity, etc.	Provide tips on how to have better sleep and relaxation; suggest better meditation modes	Suggest solutions to skin diseases and certain health issues or symptoms
Praise	–	Offer praises using texts, symbols and images after users log food and drinks	Praise users for completing meditation audios and other activities	Healthcare professionals are praised for managing medical cases
Liking	Well-organized and attractive user interfaces with relevant pictures and videos	Well-organized, attractive, simple, and easy-to-use user interfaces	Attractive icons/avatars and illustrations, great animations and cool colours	Well-organized, attractive, simple, and easy-to-use user interfaces

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Table 4. (continued)

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Rewards	Virtual rewards in form of badges and trophies	Virtual rewards in form of points, stars, badges, etc.	Virtual rewards in the form of stickers, badges, and activity streaks	Scores awarded for completing medical cases
Similarity	Girl avatar with pink colours provide necessary information to female users	–	–	–
Social role	Forum supports conversations between users	Forum and chat features support conversation with other users	Virtual therapist and life coach to respond to users' queries or questions	Nurse, doctor and advisor's role to provide medical assistance
Trustworthiness	Contents are related to the target behaviour, with privacy policy statements to gain user trust	Contents are related to the target behaviour, with privacy policy statements and relevant health notices	Contents are related to the target behaviour, with privacy policy statements; user have control over data	Contents are related to the target behaviour, with privacy policy statements to gain user trust
Expertise	Exercise types, fitness plans and training contents reflect specialist knowledge	Meal plans, drink suggestions, recipes and calorie content reflect specialist knowledge	Audios and videos from experts (e.g., licensed therapists), etc.	Doctors are licensed experts
Surface credibility	Professional interface with limited or no ads	Professional interface with limited or no ads	Professional interface with limited or no ads	Professional interface with limited or no ads

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Table 4. (continued)

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Real-world feel	Contact names, email and mailing addresses, and phone numbers of people behind the apps are revealed	Contact names, email and mailing addresses, and phone numbers of people behind the apps are revealed	Contact names and email addresses of people behind the apps are revealed	Contact names, email and mailing addresses, and phone numbers of people behind the apps are revealed
Authority	World Health Organization and National Institutes of Health are referenced in app	–	–	–
Third-party endorsements	–	Endorsement by British Medical Journal and University of Sydney’s Medical Centre and other organizations	–	Endorsement/accreditation by URAC, TRUSTe Certified Privacy, HiTrust, ClearHealth Quality Institute, etc.
Verifiability	Links to external websites from training contents to provide further details	Links to external websites for supporting videos; links to websites for more recipes	Links to web resources to verify information	Links to web resources to verify information
Social learning	Forum for sharing success stories and experiences so other users can learn	Sharable food journal, community and newsfeed features allow users to share progress and experiences	Users can chat in groups to learn from one another	–

(continued)

Table 4. (continued)

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Social comparison	In a challenge, compare performance with that of participating users	Compare hydration and calorie levels with friends; compare progress with that of others during a challenge	–	–
Normative influence	Community, groups and clubs for users with similar goals or interests (e.g., running, walking, or cycling)	Groups and community for users with similar goals or targets	–	–
Social facilitation	Users can see friends running with them virtually	–	Users can see the number of people also meditating at the same time	–
Cooperation	–	–	–	–
Competition	Users compete in running, walking or cycling challenges	Users compete in food-related challenges (e.g., no chocolate, no fatty food, etc.) for specified duration	–	–
Recognition	Leaderboard reveals top runners for public recognition	Leaderboard reveals top performers for public recognition	–	–

(continued)

Table 4. (continued)

Persuasive Strategy	Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps
Commitment/consistency	Users commit to daily, weekly or monthly workout or exercise goals/plans	Users commit to daily, weekly or monthly water drinking and weight reduction goals	Users commit to daily and weekly sleep goals, as well as mood-based and meditation programs	Users commit to daily plans and health goals
Scarcity	65% discount on premium offers that expire in 24 h	Limited time, large discount offers for plan/subscription upgrade and premium features	–	–
Social proof	Each active challenge shows number of participants; groups/clubs show number of runners, cyclers, etc.	Number of users who joined an active challenge; number of group members; etc.	Shows the number of users currently meditating; shows number of members in a chat group	–
Reciprocity	7 days and 30 days free access to premium features	7 days and 30 days free access to premium features	7 days trial period for premium features	–

4.3 Persuasive Strategies and App Effectiveness

For each category, we performed a bivariate Pearson Correlation (using SPSS version 25) to determine whether a relationship exists between the number of persuasive strategies implemented in an app and the perceived app effectiveness (based on average ratings). We also performed the same computation for all apps combined. The results, as shown in Table 5, revealed that for each category, there is no correlation (though not significant) between the number of strategies employed and app effectiveness. Overall, no relationship exists between the number of persuasive strategies employed in an app and its effectiveness.

Table 5. Relationship between Number of Persuasive Strategies and App Effectiveness based on Pearson Correlation Coefficient (*r*)

Physical Activity and Fitness Apps	Diet Apps	Emotional and Mental Health Apps	Health Assessment and Healthcare Apps	Overall (all apps)
$r(20) = 0.188, p = 0.428$	$r(20) = -0.037, p = 0.877$	$r(20) = -0.126, p = 0.598$	$r(20) = 0.048, p = 0.841$	$r(80) = 0.044, p = 0.697$

5 Discussion

We conducted a comparative systematic review of 80 mHealth apps across four categories (see Table 1) with the aim of deconstructing the persuasive strategies employed and their implementation, and then provide suggestions on how the persuasiveness of mHealth apps can be further improved using the insights.

5.1 Persuasive Strategies Employed Overall

Out of the 80 mHealth apps reviewed, *personalization* emerged as the most commonly employed PS ($n = 77$), followed by *surface credibility* ($n = 69$), *trustworthiness* ($n = 66$), *self-monitoring* ($n = 64$), *real-world feel* ($n = 59$), *reminders* ($n = 57$), *suggestion* ($n = 56$), *liking* ($n = 52$), *expertise* ($n = 52$), *commitment/consistency* ($n = 47$), *reduction* ($n = 45$) and *tunneling* ($n = 40$). Other strategies were employed by less than 23 apps. Research has shown that the *personalization* strategy was effective in promoting health-related behaviours [9, 17] which, in turn, explains why 96% of the total apps implemented it.

5.2 Persuasive Strategies for Physical Activity

Based on our findings, all the reviewed apps under the physical activity and fitness category employed both the *personalization* and *trustworthiness* PSs. Moreover, 95% of the apps employed *self-monitoring*, 90% employed *commitment/consistency* and *reduction*, 85% employed *reminders* and *real-world feel*, 80% employed *surface credibility* and *expertise*, and 75% employed *suggestion*. 65% or less employed other strategies. Existing research supported our findings. For instance, *self-monitoring* and *reminders* were found to be commonly implemented in physical activity apps by [18, 19]. Another study found that users are more persuaded by physical activity apps that implement primary task support and dialogue support PSs [20], including goal-setting [21] which correlates well with the *commitment/consistency* strategy [22].

5.3 Persuasive Strategies for Healthy Eating

Our findings revealed that *personalization*, *commitment/consistency*, and *suggestion* PSs were implemented in all the reviewed apps under the Diet category. 95% of the apps employed *self-monitoring*, *reduction*, *reminders*, *expertise* and *trustworthiness* PSs, while 90% and 75% of the apps employed *surface credibility* and *real-world feel* respectively. This shows that most mHealth apps rely on a mix of these strategies to promote healthy diets among users.

5.4 Persuasive Strategies for Emotional and Mental Health

Our findings showed that 95% of the reviewed apps employed the *personalization* and *surface credibility* PSs under emotional and mental health category, while 85% and 70% implemented the *liking* and *reminders* strategies respectively. This outcome is corroborated by previous research on persuasive mental health apps which shows that primary task support PSs are the most commonly implemented, followed by system credibility and dialogue support strategies [6].

5.5 Persuasive Strategies for Health Assessment and Healthcare Delivery

In health assessment and healthcare category, 90% and 80% of the reviewed apps implemented the *personalization* and *surface credibility* PSs respectively. However, 75% of the apps implemented *real-world feel* and *self-monitoring*, while 70% implemented the *trustworthiness* PS. Only 60% and 45% of the apps employed *suggestions* and *social role* PSs which are equally important to provide medical advice and facilitate doctor-patient conversations.

5.6 Comparative Analysis

Table 6 shows the three most dominant persuasive strategies and the least dominant strategies for each of the four categories.

In a world where precision medicine has become prominent, personalization is unarguably critical to tailor healthcare (such as treatment and prevention of diseases or ailments) to individual patient. It is therefore not surprising personalization is the most dominant in mHealth apps. Surface credibility is important for emotional and mental health, as well as health assessment and healthcare delivery, due to the sensitive nature of these issues. Users tend to be skeptical and critical of apps in these areas and that makes it really necessary that the apps must be professionally looking, responsive, and with visually appealing interface to be adopted. Any app that lacks these attributes may be deemed incredible. Hence, surface credibility is a popular strategy in these domains. Furthermore, self-monitoring is dominant in physical activity and fitness apps since technological advancements in these areas have made it possible to automatically track movements (while walking, running, cycling, etc.) in real-time through various sensors on smartphones or wearable devices. Same applies to health assessment and healthcare delivery apps, where various sensors can be used to track vital signs, such as heart rate, blood pressure, temperature, etc. However, it is difficult to monitor food intake and dietary levels in diet apps unless users supply this information manually, and that explains why self-monitoring is not among the top in the domain of dieting.

5.7 Design Suggestions

Research has shown that social interaction can motivate individuals to achieve their target behaviours [18, 23, 24]. However, only 21% of the 80 mHealth apps employed at least one of the social support PSs. Designers of persuasive mHealth apps should consider implementing social support strategies in their apps by providing features allowing users

Table 6. Comparative Analysis of Persuasive Strategies across the four Categories

	Physical Activity and Fitness	Diet	Emotional and Mental Health	Health Assessment and Healthcare
Most Dominant Persuasive Strategies	Personalization Trustworthiness Self-monitoring	Personalization Suggestion Commitment/consistency	Personalization Surface credibility Liking	Personalization Surface credibility Self-monitoring
Least Dominant Persuasive Strategies	Rehearsal, Praise, Third-party endorsements, Cooperation	Rehearsal, Similarity, Authority, Cooperation, Social facilitation	Tailoring, Similarity, Third-party endorsements, Authority, Cooperation, Social comparison, Competition, Normative influence, Recognition, Scarcity	Reduction, Simulation, Similarity, Authority, Competition, Cooperation, Social comparison, Social learning, Normative influence, Social facilitation, Recognition, Scarcity Social proof, Reciprocity

to: (1) invite their friends to perform the target behaviour together, (2) compare their performance with others performing the same activities, (3) be publicly recognized after achieving important milestones that move them closer to their health goals, (4) learn from other users’ experiences or success stories, (5) team up with (or join) other users in performing a common healthy activity.

Designers should also introduce *praise* in their apps such that users are praised or appreciated for every milestone achieved even if it seems small or trivial.

Finally, the relationship between the number of persuasive strategies employed in persuasive app design and their effectiveness is an open area of research. Although many existing persuasive apps employ multiple strategies, this analysis suggests that there is no relationship between the number of strategies employed in persuasive app for health design and app effectiveness as operationalized by the app rating. Hence, persuasive app developers could employ fewer strategies and still be effective. This will reduce the app complexity and reduce overall cognitive load on the user. This is in line with Orji et al. [25] which shows that persuasive apps employing a single strategy can be effective.

6 Conclusion and Future Work

We conducted a comparative systematic review of 80 mHealth apps across four categories with each category having 20 popular apps. The categories include physical activity and

fitness, diet, emotional and mental health, and health assessment and healthcare. The goal of this review is to identify and compare the PSs employed and how they were implemented, and then offer design suggestions to improve persuasiveness of mHealth apps.

Our future work will be a broader review involving additional mHealth apps from both Google Play and App Store, spanning more health domains. In addition to PSs in PSD and Cialdini's Principles of Persuasion frameworks, others such as *punishment* would be considered. We also plan to investigate the effectiveness of apps employing multiple strategies in comparison to those employing a single strategy in actual app.

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