Reports on Global Health Research
Lieneck C, et al. Rep Glob Health Res 7: 203.
https://www.doi.org/10.29011/2690-9480.100203
www.gavinpublishers.com

GAVIN PUBLISHERS

Review Article

Assessing Use of mHealth Applications Since 2022: A Systematic Review

Lieneck C[1*], Carr E[2], Voss M[3], Smith D[3], Townsend D[3], Washington C[3], Wallace A[3]

[1]School of Health Administration, Texas State University, San Marcos, TX 78666, USA

[2]McCoy College of Business, Texas State University, San Marcos, TX 78666, USA

[3]School of Health Sciences, Southern Illinois University-Carbondale, Carbondale, IL 62901, USA

***Corresponding author:** Lieneck C, School of Health Administration, Texas State University, San Marcos, TX 78666, USA.

Citation: Lieneck C, Carr E, Voss M, Smith D, Townsend D, et al. (2024) Assessing Use of mHealth Applications Since 2022: A Systematic Review. Rep GlobHealth Res 7: 203. DOI: 10.29011/2690-9480.100203.

Received Date: 12 June, 2024; **Accepted Date:** 19 June, 2024; **Published Date:** 24 June, 2024

Abstract

The surge in the utilization of mobile health (mHealth) apps for monitoring and improving physical fitness continues to occur beyond levels initially experienced during the COVID-19 global pandemic. This systematic review aims to assess the various mobile health apps available for tracking and enhancing physical fitness levels between January 1, 2022 through June 2023. A comprehensive search of electronic databases was conducted to identify relevant studies published to identify most recent trends in the mHealth industry sector. The inclusion criteria involved mHealth apps designed for assessing and promoting physical fitness among individuals. The review analyzed app features, usability, effectiveness, integration of fitness tracking technologies, and overall impact on physical fitness. Additionally, the review considered user satisfaction, adherence, and any barriers encountered in using these apps. The synthesis of the findings will provide valuable insights into the effectiveness and appropriateness of mHealth apps as tools for promoting physical fitness during the COVID-19 global pandemic and beyond, aiding in the development of informed strategies to optimize the use of technology for enhancing public health and well-being.

Keywords: Mobile Health Applications; mHealth; Physical Fitness;Exercise.

Introduction

Background

The rapid proliferation of mobile technology has revolutionized various sectors, including healthcare, where mobile health (mHealth) applications have emerged as potent tools to bridge gaps in healthcare access, monitoring, and delivery. mHealth, defined as the practice of medicine and public health supported by mobile devices, offers opportunities to enhance patient-clinician communication, improve health outcomes, and reduce healthcare costs. These applications range from simple medication reminders to sophisticated remote patient monitoring systems, showing potential to transform the patient experience and redefine healthcare in the digital age.

The global mHealth market has seen exponential growth, driven by increasing smartphone penetration, high speed data connectivity, and a rising inclination towards personalized healthcare. Patients and healthcare professionals alike have recognized the benefits of real time health monitoring, disease management, and preventive care that mHealth applications offer. However, as the adoption rate continues to climb, it becomes imperative to critically assess the efficacy, security, and overall impact of these applications on patient outcomes and the broader healthcare ecosystem.

While there are numerous anecdotes and qualitative reviews praising the advantages of mHealth, rigorous empirical research remains limited. This study aims to investigate the effectiveness of mHealth applications, scrutinize their strengths and weaknesses, and understand the broader implications of their integration into contemporary healthcare. Through a multifaceted approach, this research will provide insights into the real world applications, challenges, and the future trajectory of mHealth in the global healthcare landscape.

Purpose

As the world emerges from the shadow of the pandemic, mHealth apps have gained unprecedented traction in promoting physical fitness amidst lockdowns and restricted outdoor activities. Investigating the use of these apps is crucial for understanding the facilitators and barriers influencing individuals' physical fitness levels during such challenging times. An in-depth analysis can reveal how features, user interface, or even social integration within these apps enhance or impede regular physical activity. Furthermore, understanding these dynamics can provide insights into designing better digital interventions, ensuring that populations remain active and healthy even in the face of future crises or restrictions. This knowledge is not only pertinent for individual well being but also has broader societal implications, considering the links between physical fitness, overall health, and healthcare expenditures.

Materials and Methods

Overview and Inclusion Criteria

This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The research team's overall intent was to investigate published literature surrounding the use of mhealth apps in recent literature/publications, building upon prior mHealth reviews and industry observations (therefore, 2022 to-date research articles). Literature for this review was obtained from three separate databases: Academic Search Complete, Business Source Ultimate, via Ebson B. Stephens Company (EBSCO host) and PubMed (which queries MEDLINE) at Southern Illinois University-Carbondale. These databases were utilized to ensure a broad search of the research topic, as initial investigations demonstrated limited publications in other research databases.

Focusing specifically on 'mhealth' and related publications, the Medical Subject Headings (MeSH) controlled vocabulary thesaurus (National Library of Medicine) was utilized to capture exploding terms for this topic, as well as 'physical fitness' and related terminology. Additional research team queries on the EBSCO host website were conducted to ensure the highest number of published articles germane to the research topic were identified using the most amiable Boolean search operators to identify the following search string for the study:

[(mobile health applications") OR ("mhealth") OR ("mobile apps")] AND [("physical activity") OR ("exercise") OR ("fitness") OR ("physical exercise")]

Articles included in the review had to be published between 1 January 2022 through 2024 on the research databases, with the actual database queries occurring between May 1 – June 10, 2023 by the research team. The 2024 ending search date range was auto populated by the EBSCO host website, therefore delineating the most up-to-date publications during the review team's search period (note: often, the next year's pre-populated to also capture articles published with future journal dates, etc). Full-text only, English-only were required search parameters on the EBSCO host platform, and editorials, government re-ports, letters to editors, or other non-peer reviewed studies were not included in the review. The research team was able to access and/or locate all the article citations identified in the search in full-text format to permit follow-on literature review.

Studies in the review had to focus on or address the use of mhealth applications, either as the primary research topic, or at least be included as part of the research process or observations in the studies. The research team conducted a search for the most recent, relevant literature to simply assess the use of such technology to identify underlying themes (constructs) in the literature regarding mhealth apps during a declining pandemic phenomenon. The study's information did not include human subjects (secondary data sources), with all of the literature published and publicly available. If studies identified by the research team focused on any individual research subject(s), they were unidentifiable. As a result, this systematic review qualifies under the "exempt" status in 45 Code of Federal Regulations (CFR) 46. Further, an institutional review board (IRB) was not required and no consent was necessary.

Exclusion Process

Figure 1 demonstrates the article exclusion process for the review, starting with the initial research database results and ending with a final literature sample (n = 25). Initially, 13,525 articles were identified as meeting the primary search criteria – addressing both mhealth and physical fitness review criteria. Because three research databases were used in the review, a high number of duplicate articles were observed in the initial search (5,623 total duplicates). The EBSCO host search engine options were then used to only include full-text, English-only, peer reviewed articles in the review, published within the 1 January 2022 through 2024 timeframe. This further reduced the number of articles included in the initial database search. The research team conducted an abstract screening process (abstracts located on the EBSCO host website for each article) of the remaining 702 articles in the search, further excluding articles that did not include both mhealth and physical fitness-related research topics (-664 additional articles).

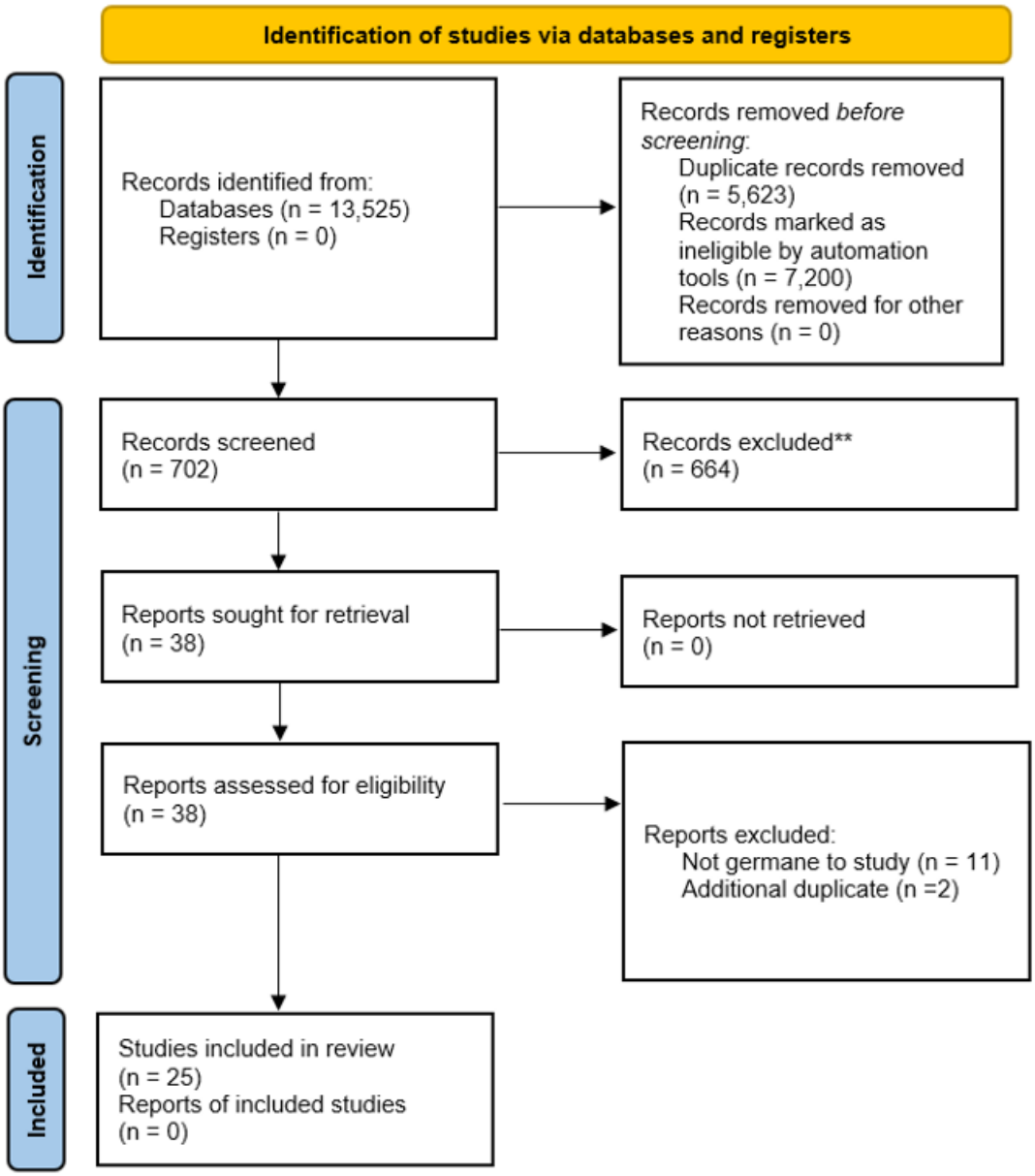

Figure 1: Preferred reporting items for systematic reviews and meta-analysis (PRISMA) figure that demonstrates the study selection process.

The research team sought 38 articles for retrieval in full-text format for official full-text review per PRISMA guidelines, with each identified publication being reviewed by at least two members of the research team. Table 1 shows the delineation of review articles assigned to the research team members.

Article Assignment	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Reviewer 5	Reviewer 6	Reviewer 7
Articles 1–8	X	X	X	X	X	X	X
Articles 9–16			X	X		X	X
Articles 17–25					X	X	X

Table 1: Reviewer assignment of the initial database search findings (full article review).

The research team's full text review for eligibility resulted in 38 remaining publications remaining in the review. 13 articles were removed from the review by the research team as follows:

- 11 articles were deemed not germane to the research topic. Either erroneously added by the initial database search, or somehow mentioning "mhealth," yet not related to "physical fitness" (or related exploded MeSH terminology for both topics.
- Two articles were removed as additional duplicates.

The research team collaborated online via webinars to address any potential article bias or conflict with the application of the selection criteria for the review. Several consensus meetings resulted in no disagreement among the research team members in this regard.

Results

Study Characteristics

The team's full-text review of the 25 articles identified underlying constructs (characteristics) associated with surprise billing (perceptions and/or challenges) within the US healthcare system. A summary of review findings for each article is provided in a modi-fied PICOS table (patient, intervention, control, and outcome) to fit the purpose of this review (Table 2).

Article Number and Title	Population	Intervention	Outcome
		[Use/purpose of mHealth application]	[Physical fitness assessment/observation]
[1] SMART STEP – SMARTphone-driven exercise and pedometer-based STEP intervention to promote physical activity among desk-based employees: Study protocol for a three-arm cluster randomized controlled trial	Desk-based employees aged between 30 and 50 years from various administrative offices of a multifaceted university in India. Total participants: 159.	• The main purpose of the article is to investigate how physical activity, technology based, or education based, affects the performance, productivity, and cardiometabolic risk associated with employees that are desk-based. • The method used in this study was the three-arm cluster randomized trial. The subjects in the study will be conducted with various employees from the age of 30-50 in different administrative offices.	• The study was separated into two groups. The SMART group and the TRADE and CONTROL group. The SMART group showed significantly better outcomes than the TRADE and CONTROL group. These results will aid in developing recommendations as to how to improve the physical activity of these desk-based employees. • Accelerometer-measured sitting time and PA levels.
[2] Adapted exercises versus general exercise recommendations on chronic low back pain in industrial workers: A randomized control pilot study	Assembly line workers with chronic low back pain (LBP).	• Adapted exercises tailored to the characteristics of the workplace plus general exercise recommendations. The exercise program is delivered through a mobile application (APP). • The main purpose of this article is to determine if an exercise program that is formed in the workplace can supplement general exercise recommendations given to employees, specifically industrial workers, with lower back pain.	• Industrial workers were randomly assigned to both group adapted exercises as well as general exercise recommendations and control groups exercise recommendations to determine the most effective method. • This study concluded that an adapted exercise program plus the general recommendations for industrial workers suffering from lower back pain could be an effective treatment.

[3] Promoting Optimal Sexual and Reproductive Health with Mobile Health Tools for Black Women: Combining Technology, Culture and Context	Black women in the U.S. with disparities in sexual and reproductive health outcomes.	• Use of mobile health (mHealth) tools. Comparison: without the use of mHealth tools or traditional health communication methods. • The main purpose of this article is to use mobile technology and mobile health interventions to provide sexual education and to sustain the outcome to specific populations. • The method used to gather data for this study was to use a multimedia platform that encourages user engagement. An example of this provided is the app "Girl Talk". This app allows users to be specific to their individual and cultural needs.	• Reduction in disparities of sexual and reproductive health outcomes. • This study was proven to be successful in improving the reproductive health outcomes as well as alleviate health disparities among this specific population.
[4] Effects of vehicular whole-body vibration on focus measured by a mobile app for brain training: A pilot study on the influence of gender and Attention Deficit Hyperactivity Disorder	Students and other professional drivers, both genders, with and without Attention Deficit Hyperactivity Disorder (ADHD).	• Exposure to whole-body vibration (WBV) while travelling on a stone paved route. Control: Not exposed to WBV during the journey. • The main purpose of this article is to investigate the effects of whole-body vibration exposure on focus. This study was conducted to compare the effects in both genders as well as individuals with ADHD. • The method used to conduct this study was to use a focus game available through a brain training app. The individuals participating in the study were either exposed or not exposed to whole body vibration. This method was also used to determine difficulty evaluations and comfort.	• Performance in a focus game measured by the score at the end of each game. • The results of the study determined that whole body vibration had a negative effect on focus performance. • However, three minutes into exposure, it proved to have positive effects on the test subjects. Difficulty was not different based on gender, but females did present an average of higher scores.
[5] Impact of COVID-19 on rehabilitation experiences of physiotherapists	Physiotherapists who were practicing during the COVID-19 pandemic.	• Physiotherapy services during the COVID-19 pandemic (including both face-to-face practice and telerehabilitation methods). Control: Physiotherapists who suspended their services due to the pandemic versus those who did not. • The main purpose of this article is to determine the effects the COVID-19 pandemic had on physiotherapists, the interruptions of their services during this time, and the adaptations these professionals had to make in the services they offered face-to-face.	• Number and percentage of physiotherapists who suspended their services. • The method used for this article was a descriptive, cross-sectional study of 558 physiotherapists that was completed through an online survey to collect and evaluate data. • The results of this study concluded that these professionals were interrupted during their practices face-to-face, but continued to treat all patients, despite any medical risk.

[6] A Qualitative Cultural Sensitivity Assessment of the Breathe Easier Mobile Application for Lung Cancer Survivors and Their Families	African American lung cancer survivors and their families.	• Breathe Easier mobile health application designed to teach strategies to combat symptoms related to lung cancer. • Comparison: cultural sensitivity and relevance of the Breathe Easier mobile app content compared to the specific needs and preferences of African American lung cancer survivors and their families. • The main purpose of this article is to evaluate the application Breathe Easier and its effects on a specific population, African American lung cancer survivors and their families.	• Culturally relevant themes related to content literacy, inclusiveness, and acceptability of the mobile application. • The methods used in this study were cultural sensitivity tools and cultural sensitivity checklists. In-depth interviews were performed on 12 survivors and their family members. • The results of this concluded with multiple benefits and concerns. Overall, these subjects were more concerned with the information given via the application.
[7] What nursing interventions and healthcare practices facilitate type 1 diabetes self-management in young adults? An integrative review	Young adults aged 16-25 years with type 1 diabetes (T1D).	• Current nursing and healthcare practices designed to facilitate effective T1D self-management. • Traditional nursing and healthcare practices that were not designed specifically for the 16-25 age group or not considering the advances in technology and social platforms. • The purpose of this article is to determine effective ways that current nursing and healthcare practices can help facilitate self-management of type 1 diabetes in individuals ages 16-25.	• Effectiveness of digital information systems, glucose monitoring and insulin devices, group and peer education and support, and diabetes care delivery style in improving T1D self-management. • The method used in this study was an integrative review that was performed to fully understand what works and engages these patients with managing their type 1 diabetes. • The results of this study conclude that there are 4 effective ways found that these professionals could do to positively promote self-management in these patients.
[8] A Point-of-care app for chronic oedema management	Health professionals using mobile devices for patient care and patients/ carers assuming greater control and responsibility over their health, particularly those with chronic oedema and lymphoedema.	• se of the mobile app “Juzo Care” designed for the management of chronic oedema and lymphoedema in mobile working settings. • Comparison: traditional methods of managing chronic oedema and lymphoedema without the use of mobile applications or point-of-care technology. • The main purpose of the article is to introduce a new app called the Juzo Care App, a new Point-of-Care technology that has four main elements: the clinical pathway, education, training, and information.	• Enhanced management of chronic oedema and lymphoedema; patient empowerment to assume more control and responsibility for their health; better support and education for patients and their carers; improved and rapid clinical decision-making by health professionals. • It was found that the COVID-19 Pandemic changed the way we delivered healthcare in American, sparking the idea for this app. • Mobile devices like Juzo Care are an ideal tool for patients to use in today’s world. The Juzo Care app involves nurses, carers, and patients, in identifying pathologies of lower-limb conditions related to the symptom of oedema. • Although there are other apps out there like Juzo Care, this one is different because it supports health practitioners’ decision-making.

[9] Development of an iPad-based assessment tool for measuring attention and validation in older employees	Elderly individuals aged between 65–85 years who are working or may be potential candidates for working environments.	• The use of the iPad-based attention assessment tool, "Shih-Hsu Test of Attention" (SHTA). • The main purpose of this article is to measure attention performance in the older population still in the working field, to ensure that this generation is still safe to use modern day technology. • The first part of this study used an iPad-based attention assessment tool with auditory stimuli, while the second part of the study examined the criterion related validity.	• Criterion-related validity and test-retest reliability of the SHTA to determine its efficacy and reliability in assessing the work attention of the elderly. • No critical evidence was found during this study and more research is needed to determine if an older individual is in fact not safe to use a specific technology.
[10] Experiences with Technology Amongst an International Sample of Older Adults: Results from a Qualitative Interpretive Meta-Synthesis	Older adults aging in the community, potentially experiencing social exclusion or isolation.	• Training older adults to use information and communications technology (ICT) to mitigate social isolation impacts. • The main purpose of this article is to show that information and communication technology (ICT) use can assist in preventing the negative effects of isolation amongst the elderly population and benefits of improving physical and mental health.	• Three overarching themes describing older adults' experiences with technology: 'desire for empowerment', 'connection', and 'aging well'. Also, an understanding of the benefits of technology use among older adults aging in Methods used were Qualitative Interpretative Meta-Synthesis (QIMS) that utilized data from different authors of publications on the subject merging their data together to develop a more holistic understanding of the elderly use ICT. Some other authors utilized focus groups, interviews (group and individual) and observations of a diverse group of people across the world. • The finding showed that older people's use of ICT improved community and social engagement. Although using technology cannot replace face to face social interaction, ICT since COVID has shown benefits in reaching the elderly populations enhancing social connectivity, physical health, and psychological wellbeing. Some limitations might occur with those that elderly people

[11] Clinician Perspectives on Ethics and COVID-19: Minding the gap in Sexual Reproductive Health	Individuals in the U.S. seeking sexual and reproductive health (SRH) services.	• Implementation of policies and practices such as social distancing, sheltering in place, shifting to telemedicine, and limiting care to essential procedures due to COVID-19. • The purpose of this article is to give a clinician's viewpoint on the disparities in services and outcomes between marginalized and privileged populations and offer suggestions for reducing these differences in the present and the future. • Identifying and tracking gaps will allow barriers to be addressed. In the end, it was suggested that as COVID-19 lessens, decision makers/providers/ advocates should take inventory of the damages that covid caused and create ways to restore services to better than they were. Expanding access through new policies and programs (partnerships with communities).	• Wider gaps in SRH outcomes and decreased access to SRH education, abortion, and contraceptives. • Observational/descriptive study. The study design isn't explicitly mentioned but it's implied that the article is describing observed effects based on enacted policies.
[12] Harnessing Technology for the Social Good: Empowering Consumers with Immediate Feedback and Self-Directed Means of Care to Address Affordability, Access, and Stigma in Mental Health	Individuals in the U.S. facing health disparities, particularly in mental health care due to lack of access and high costs.	• Use of technology to provide affordable, easy access to mental health care, including transformative technological tools and experiential medicine. • The purpose of this article is to highlight how technology can create a means of Increasing consumer participation and treatment effectiveness while providing consumers with fast, inexpensive access to care. It is stated that "technology alone is not enough to address these complex issues, but harnessing technological innovation has implications that may prove beneficial". • This is through tech tools creating greater flexibility in service delivery, as well as improved self-regulation (patient accountability).	• Improved mental health care access, increased consumer empowerment, affordability of care, and increased treatment effectiveness. • It was found that to create and test interventions that tackle the root causes of societal problems, more research is required in transformational technology.
[13] Women with Congenital Adrenal Hyperplasia: Promoting Cardiovascular Health Across the Lifespan	Women with Congenital Adrenal Hyperplasia (CAH).	• Targeted, patient-centered, and interdisciplinary supports to mitigate and prevent cardiometabolic risks associated with CAH. • This article looks at promoting cardiovascular health across the lifespan, because Women with CAH are more vulnerable to poor outcomes due to existing gender disparities that impact cardiovascular disease outcomes and recognition.	• Improved cardiovascular health, reduced cardiometabolic risks, better patient outcomes, and enhanced health-related quality of life for women with CAH. • An intervention mentioned for CAH/ CVD care was health education/ coaching interventions that promote heart health across the lifespan to improve health of women with CAH.

[14] Using mobile health applications to enhance physical activity in Saudi Arabia: a cross-sectional study on users' perceptions.	Users in Saudi Arabia who are >15 years of age and use mobile health (mHealth) applications to promote physical activity.	• Use of mobile health applications to promote physical activity. • Quantitative cross-sectional study.	• Users' perceptions on the usability and quality of mobile health applications, including aspects like perceived usefulness, ease of use, attitudes, user experience, and subjective quality.
[15] Effectiveness of a Smartphone App (MINISTOP 2.0) integrated in primary child health care to promote healthy diet and physical activity behaviors and prevent obesity in preschool-aged children: randomized controlled trial.	Parents (n = 552) of 2.5-to-3-year-old children recruited from 19 child health care centers across Sweden.	• 6-month mHealth intervention using the MINISTOP 2.0 app to promote healthy lifestyle behaviors in children. The app was translated into English, Somali, and Arabic. • Hybrid type 1 effectiveness-implementation design with a two-arm, individually randomized controlled trial.	• Primary Outcomes: Children's intake of fruits, vegetables, sweet and savory treats, sweet drinks, moderate-to-vigorous physical activity, and screen time. Secondary Outcomes: Parental self-efficacy (PSE) for promoting healthy lifestyle behaviors and children's body mass index (BMI).
[16] The effects of a physical activity intervention based on a fatness and fitness smartphone app for University students.	100 Spanish university students (After applying exclusion criteria: intervention group n = 35 and control group n = 31). Cluster-randomized trial.	• A 9-week physical activity intervention designed to promote a healthy physical activity pattern using a smartphone app. The mHealth approach contained five Behavior Change Techniques (BCTs). • Control group without the smartphone app intervention.	• Primary Outcomes: Changes in physical fitness and self-reported physical fitness. • Secondary Outcome: Changes in body fatness composition.
[17] The Effects of Adopting Mobile Health and Fitness Apps on Hospital Visits: Quasi-Experimental Study.	267,651 Chinese mobile phone users who provided data on health and fitness app use and hospital-related geolocation from January to December 2019. Difference-in-differences and difference-in-difference-in-differences design, with sensitivity analysis and heterogeneity analyses.	• Adoption of health and fitness apps. • Mobile phone users before the adoption of health and fitness apps vs. after the adoption.	• Primary Outcome: Decrease in hospital visits following the adoption of health and fitness apps. • Other outcomes: The varying effect based on users' socioeconomic status and digital literacy.

[18] Challenges of Implementing an mHealth Application for Personalized Physical Activity Counselling in Primary Health Care: A Qualitative Study	Primary health care (PHC) providers participating in the study. A qualitative study using a descriptive phenomenology approach with data collected through focus group discussions (FGDs) and analyzed using a deductive thematic approach.	• Implementation of the mHealth application (PAC app) for personalized PA counselling in PHC settings. • Control: primary health care settings without the use of the PAC app for PA counselling.	• Primary Outcome: Feasibility and challenges of implementing the PAC app in PHC settings. • Secondary Outcomes: Themes related to the use, barriers, patient involvement, and impact on PHC services.
[19] Predicting Physical Exercise Adherence in Fitness Apps Using a Deep Learning Approach	Users of the Mammoth Hunters Fitness app (n = 246). A data analysis study employing pre-processing, clustering, and regression modeling on user data to predict adherence.	• Automatic classification of users into adherent and non-adherent based on their training behavior in the first three months using an ensemble of regression models.	• Primary Outcome: Prediction of user training behavior (adherence) during the fourth month. • Secondary Outcomes: Accuracy and F1 score of the prediction model.
[20] Profile of adults users of smartphone applications for monitoring the level of physical activity and associated factors: A cross-sectional study	Asymptomatic Brazilian adults: 176 men and 178 women (43 ± 12 years; 27 ± 5 kg/m2). Cross-sectional study design, involving assessments and comparisons between APP users and non-users.	• Use of a smartphone APP to monitor the physical activity level (PAL) that contains functionalities such as exercise session logs and/or step counts. • Control: App users vs. non-users in terms of demographic, socioeconomic, clinical, physiological, and functional characteristics.	• Primary Outcome: Profile of APP users in terms of demographic, socioeconomic, clinical, physiological, and functional characteristics. • Secondary Outcomes: Associations with variables like VO2 max, socioeconomic status, quality of life, and others.
[21] The effects of a lifestyle intervention supported by the InterWalk smartphone app on increasing physical activity among persons with type 2 diabetes: Parallel-group, randomized trial	Individuals with type 2 diabetes (T2D) referred to municipality-based lifestyle programs. Parallel-group, randomized trial with a 52 weeks' intervention and a subsequent follow-up for effectiveness (52 weeks from baseline).	• App-based (InterWalk) approach in municipality-based rehabilitation which includes standard care + InterWalk app–based interval walking training (IWT). Half of the IWT group also received additional motivational support for up to 52-week follow-up.	• Primary Outcome: Change in objectively measured MVPA time (minutes/day) from baseline to 52-week follow-up. • Key Secondary Outcomes: Changes in self-rated physical and mental HRQoL, physical fitness, weight, and waist circumference.

[22] Determinants of fitness app usage and moderating impacts of education-, motivation-, and gamification-related app features on physical activity intentions: Cross-sectional survey study	839 US residents who reported having used at least one smartphone fitness app.	• Usage of smartphone fitness apps with features related to education, motivation, and gamification. • Control: non-users of smartphone fitness apps or usage without specific features.	• User's behavioral intention to use fitness apps. • Intentions of being physically active. • Moderating effects of different smartphone fitness app features and individual differences on these intentions.
[23] Commercial app use linked with sustained physical activity in two Canadian provinces: A 12-month quasi-experimental study	39,113 participants from two Canadian provinces. 12-month quasi-experimental study with a two-week baseline period followed by a period where participants earned digital incentives upon reaching their daily step goals. Mixed-effects models were used to estimate changes in physical activity levels based on engagement and baseline activity status.	• Use of a multi-component commercial app that rewards users with digital incentives ($0.04 CAD/day) for achieving a personalized daily step goal. • Control: physical activity levels during a two-week baseline period prior to the introduction of digital incentives.	• Changes in weekly mean daily step count between the baseline period and the last two recorded weeks. • Step count increases for various sub-groups based on engagement and baseline physical activity status.
[24] MINISTOP 2.0: a smartphone app integrated in primary child health care to promote healthy diet and physical activity behaviours and prevent obesity in preschool-aged children: protocol for a hybrid design effectiveness-implementation study	Families (n = 500) who attend routine visits to one of the 15-20 primary child health care centres throughout Sweden when their child is 2.5 years old.	• A 6-month parent-oriented smartphone intervention aimed at improving the dietary and activity behaviours of preschool-aged children using the MINISTOP 2.0 app.	• Primary outcomes: Changes in dietary habits, physical activity, and screen time. Secondary outcomes: Body weight and height changes in children, and parental self-efficacy. • Implementation outcomes: Perceived acceptability, appropriateness, and feasibility among primary child health care nurses and parents.
[25] User-centered development of a smartphone application (Fit2Thrive) to promote physical activity in breast cancer survivors	Breast cancer survivors. Three independent groups of participants: Group 1 (n=8), Group 2 (n=14), and Group 3 (n=15). User-centered, iterative design process involving field tests of the app across three groups of participants.	• Fit2Thrive, an app designed to promote MVPA in breast cancer survivors.	• Usability and quality of the app assessed by the Post-Study System Usability Questionnaire (PSSUQ) and the User Version Mobile Application Rating Scale (uMARS). Qualitative feedback on app functionality and content, including app notifications.

Table 2: Summary of Findings (n = 25).

Identification of Underlying Constructs

The review team identified four primary themes were identified in the literature, supporting the research topic of the use of mhealth applications as related to physical fitness during the search date range (Figure 2).

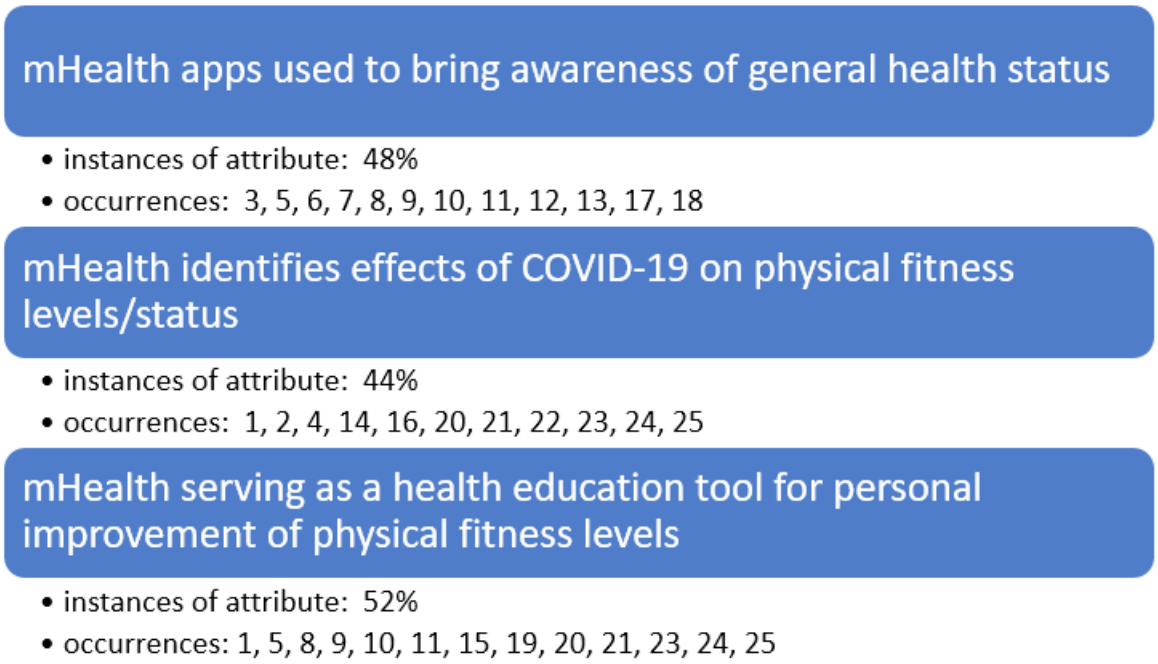

Figure 2: Primary occurrences of mhealth and physical fitness underlying themes (constructs) identified in the literature and related metadata.

Discussion

mHealth apps used to bring awareness of general health status

Upon systematic review, one common goal accompanying the introduction of mHealth apps was to bring more awareness of general health status to its users. mHealth apps helped bring awareness of a range of general health concerns, from common everyday health concerns to more commonplace diseases. This technology introduced aware-ness both through information and education. For example, mobile technology and mobile health interventions provided sexual education and provided information on sexual and reproductive health and was able to improve reproductive health outcomes and alleviate health disparities among minority populations [3,11].

MHealth technology also aided awareness in type I diabetes management, general patient care, social isolation, and cardiovascular health [7,8,10,13]. Not only did mHealth apps help with awareness in diseases and health concerns, but they also brought awareness of healthcare affordability and access [12]. Technology can be used to create a means of increasing consumer participation and treatment effectiveness while providing consumers with fast, inexpensive access to care. Finally, the apps were able to measure more personal features, including focus and attention span [4] amongst ADHD students and attention and validation amongst elderly working individuals [4,9]. Using mHealth apps as a way of measuring mental health and not just physical quantitative variables can help transform healthcare awareness and tracking in the future.

mHealth identifies ongoing effects of COVID-19 on physical fitness levels/status

During the COVID-19 pandemic, health and fitness was at an all-time low while many services and medical interventions were canceled. One type of intervention that was canceled during the COVID-19 pandemic was physiotherapy. One study conducted by Ciddi and Bayrum regarding this type of intervention, was to determine the status of physiotherapists who interrupted their services due to the pandemic and investigate procedures adopted by physiotherapists during face-to-face practice. Of the physiotherapists, 351 (62.9%) suspended their services due to pandemic, while 207 (37%) of all participants worked without suspending their services since the beginning of the process [5].

Another type of service that was affected by the COVID-19 pandemic was regarding the sexual and reproductive health of the population, along with the gaps in the services that were being provided. The study discusses the disparities in services and outcomes between marginalized and privileged populations, and also offers suggestions for reduc-ing these differences in the present and the future. The pandemic showed the current gaps within these services and how to improve them. It was suggested in the study that as the spreading of the pandemic declines, decision makers/providers/advocates should take inventory of the damages that were caused as well as create ways to improve services [11].

One of the largest benefits seen in healthcare from the COVID-19 pandemic was the new and innovative ways to use technology. Technology has become valuable and wide-spread, as well as supporting health care professionals in patient care. This technology also has the ability to educate patients, which will allow them more control over their care. This topic was researched to introduce a new app called the Juzo Care App, a new Point-of-Care technology that has four main elements: the clinical pathway, education, training, and information [8].

mHealth serving as a health education tool for personal improvement of physical fitness levels

A global shift in lifestyle continues, pushing many individuals to take measures for not only personal fitness, but continuance of physical distancing at times, or other related public health prevention measures since COVID-19. Traditional venues of physical activity like gyms, parks, and recreation centers were either temporarily closed or had restricted access. Within this backdrop, mHealth (mobile health) apps and platforms emerged as invaluable tools to educate and motivate individuals on maintaining and even enhancing their physical fitness [5, 23, 25]. The interactivity, accessibility, and flexibility of mHealth apps offered personalized workout regimens [9, 10], tracking features [1, 25], and informational resources that catered to varied fitness levels and needs [1, 5, 8, 11]. Users could access these tools anytime, anywhere, eliminating the barriers imposed by the pandemic.

In addition to providing exercise routines, mHealth platforms have delivered holistic health education, encompassing nutrition advice, sleep hygiene tips, and mental well-being resources [15, 20]. This comprehensive approach encouraged users to under-stand the intricate relationship between different aspects of health, allowing for an informed and well-rounded personal improvement journey. As the pandemic heightened stress and uncertainty, the mental health components, combined with physical fitness guidance, played a crucial role in assisting individuals in staying resilient [15, 20, 24]. The widespread adoption and reliance on mHealth apps during the COVID-19 era underscore their potential not only as fitness aids but as holistic health educators and motivators for personal growth.

Finally, it is important to also note the ongoing/additional research from other countries focusing on mHealth applications and related developments to further individual health. The COVID-19 pandemic has highlighted the importance of the virtual world in providing solutions to everyday challenges, leading to increased reliance on modern technology for communication across all sectors of society [26]. In particular, one study assesses the impact of such technologies on individual personalities, utilizing textual analysis to explore both the benefits and drawbacks of this shift towards virtual interaction. Concluding that technological devices offer significant advantages for personal development, their integration into our lives also poses potential risks to personal and family relationships, such research underscores the need for a balanced approach to their use [26]. Additionally, future research may even involve furthering a study which explores the relationship between social evaluation and personal well-being [27]. Concluding that personal well-being is significantly influenced by social acceptance and self-acceptance, diminishing psychological health as related to physical health and the use of mHealth applications will require continued assessment for outcomes, both physically and psychologically [27].

Conclusion

This systematic literature review on mHealth since 2022 and the global pandemic has unveiled several salient themes and underscored the transformative potential of mobile health solutions in the face of global health crises. Notably, mHealth applications have demonstrated a unique aptitude for enhancing accessibility to health information, facilitating remote patient monitoring, and fostering patient engagement, while also serving as vital conduits for disseminating public health advisories and gathering epidemiological data. Another emergent theme is the adaptive nature of mHealth platforms, which have evolved rapidly in response to the dynamic needs presented by the pandemic, from contact tracing capabilities to mental health support modules.

As a transition to a post-pandemic world continues, there is a pressing need to further scrutinize the long-term viability, scalability, and ethical implications of mHealth tools. Future research should investigate the sustainability of behavioral changes instigated by mHealth interventions and evaluate their impact in real-world, non-pandemic settings. Moreover, it would be instructive to explore how mHealth can be integrated more seamlessly into traditional healthcare infrastructures and the potential for these tools to foster global health collaboration, transcending geographical and institutional boundaries. As the dust settles on the pandemic, the lessons derived from this review should guide the next wave of mHealth innovations, ensuring they are more inclusive, effective, and responsive to the multifaceted needs of global populations.

Author Contributions: All authors contributed to this review in accordance with ICMJE standards. C.L., E.C., M.V., D.S., D.T., C.W., and A.W. contributed to investigation into the research topic, participation in the method, and drafting of the manuscript. In addition to screening and assistance with construct identification, E.C. also assisted with discussion/analysis and overall editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Chandrasekaran B, Rao CR, Davis F, Arumugam A (2021) SMART STEP – SMARTphone-driven exercise and pedometer-based STEP intervention to promote physical activity among desk-based employees: Study protocol for a three-arm cluster randomized controlled trial. Work 69:1229-1245.
2. Cimarras-Otal C, Marcen-Cinca N, Rabal-Pelay J, Lacrcel-Tejero B, Alczar-Crevilln A, et al. (2020) Adapted exercises versus general exercise recommendations on chronic low back pain in industrial workers: A randomized control pilot study. Work 67:733-740.
3. Chandler R, Guillaume D, Parker AG, Carter S, Hernandez ND (2020) Promoting Optimal Sexual and Repro-ductive Health with Mobile Health Tools for Black Women: Combining Technology, Culture and Context. Perspectives on Sexual & Reproductive Health 52: 205–209.
4. Duarte MLM, Costal GZ, Martinelli SF, Neves JLB (2020) Effects of vehicular whole-body vibration on focus measured by a mobile app for brain training: A pilot study on the influence of gender and Attention Deficit Hyperactivity Disorder. Work 67: 641–654.
5. Ciddi PK, Bayram GA (2022) Impact of COVID-19 on rehabilitation experiences of physiotherapists. Work 71: 31–39.
6. Owens OL, Smith KN, Beer JM, Gallerani DG, McDonnell KK (2020) A Qualitative Cultural Sensitivity Assessment of the Breathe Easier Mobile Application for Lung Cancer Survivors and Their Families. Oncology Nursing Forum 47: 331–341.
7. Phiri T, Mowat R, Cook CM (2022) What nursing interventions and healthcare practices facilitate type 1 diabetes self-management in young adults? An integrative review. Nursing Praxis in Aotearoa New Zealand 38: 32–43.
8. Collett M (2020) A point-of-care app for chronic oedema management. Br J Community Nurs 25:S12-S16.
9. Shih YN, Hsu JL, Wu CC, Hsiao JH (2020) Development of an iPad-based assessment tool for measuring at-tention and validation in older employees. Work 67: 811–815.
10. Miller V, Murphy ER, Fields N, Cronley C (2021) Experiences with Technology Amongst an International Sample of Older Adults: Results from a Qualitative Interpretive Meta-Synthesis. British Journal of Social Work 51:1332–1353.
11. Ott MA, Bernard C, Wilkinson TA, Edmonds BT (2020) Clinician Perspectives on Ethics and COVID-19: Minding the Gap in Sexual and Reproductive Health. Perspectives on Sexual & Reproductive Health 52:145–149
12. Ross M (2020) Harnessing Technology for the Social Good: Empowering Consumers with Immediate Feedback and Self-Directed Means of Care to Address Affordability, Access, and Stigma in Mental Health. Health Soc Work 45:135–137.
13. Davina B, Joanne H, NinaC, Shayna D, Nicole T, et al. (2020) Women with congenital Adrenal Hyperplasia: Promoting cardiovascular Health Across the lifespan. Canadian Journal of Cardiovascular Nursing 30:4–9.
14. Ansari FSA, Alfayez A, Alsalman D, Alanezi F, AlhodaibH, et al. (2023) Using mobile health applications to enhance physical activity in Saudi Arabia: a cross-sectional study on users' perceptions. Int Health 15:47-55.
15. Alexandrou C, Henriksson H, Henström M, Henriksson P, Nyström CD, et al. (2023) Effectiveness of a Smartphone App (MINISTOP 2.0) integrated in primary child health care to promote healthy diet and physical activity behaviors and prevent obesity in preschool-aged children: randomized con-trolled trial. Int J Behav Nutr Phys Act 20:22.
16. Muntaner-Mas A, Sanchez-Azanza VA, Ortega FB, Vidal-Conti J, Borràs PA, et al. (2021) The effects of a physical activity intervention based on a fatness and fitness smartphone app for University students. Health Informatics Journal 27:1–14.
17. Bo y, Liu QB, Tong y (2023) The Effects of Adopting Mobile Health and Fitness Apps on Hospital Visits: Qua-si-Experimental Study. J Med Internet Res 25:e45681.
18. Wattanapisit A, Amaek W, Wattanapisit ST, Tuangratananon T, Wongsiri S, et al. (2021) Challenges of Implementing an mHealth Application for Personalized Physical Activity Counselling in Primary Health Care: A Qual-itative Study. International Journal of General Medicine 14:3821-3831.
19. Jossa-Bastidas O, Zahia S, Fuente-Vidal A, Férez NS, Noguera OR, et al. (2021) Predicting Physical Exercise Adherence in Fitness Apps Using a Deep Learning Approach. Int J Environ Res Public Health 18:10769.
20. Vieira WDO, Ostolin TLVDP, Simões MDSMP, Proença NL, Dourado VZ (2022) Profile of adults users of smartphone applications for monitoring the level of physical activity and associated factors: A cross-sectional study. Front Public Health 10:966470.
21. Yang IK, Valentiner Y, Glümer LS, Karstoft C, Brønd K, et al. (2022) The effects of a lifestyle intervention supported by the InterWalk smartphone app on increasing physical activity among persons with type 2 diabetes: Paral-lel-group, randomized trial. JMIR MHealth and UHealth 10:1–18.
22. Yang Y, Koenigstorfer J (2021) Determinants of fitness app usage and moderating impacts of education-,motivation-, and gamification-related app features on physical activity intentions: Cross-sectional survey study. J Med Internet Res 23:e26063.
23. Mitchell M, Lau E, White L, Faulkner G (2020) Commercial app use linked with sustained physical activity in two Canadian provinces: A 12-month quasi-experimental study. Int J Behav Nutr Phys Act 17:24.
24. Henriksson H, Alexandrou C, Henriksson P, Henström M, Bendtsen M, et al. (2020) MINISTOP 2.0: a smartphone app integrated in

primary child health care to promote healthy diet and physical activity behaviours and prevent obesity in preschool-aged children: protocol for a hybrid design effective-ness-implementation study. BMC Public Health 20:1756.

25. Welch WA, Solk P, Auster-Gussman L, Gavin KL, Whitaker M, et al. (2022) User-centered development of a smartphone application (Fit2Thrive) to promote physical activity in breast cancer survivors. Transl Behav Med 12:203-213.

26. Budayová Z, Pavliková M, Al-Adwan AS, Klasnja K (2022) The Impact of Modern Technologies on Life in a Pandemic Situation. Journal of Education Culture & Society 13:213–224.

27. Danylchenko T (2021) Correlation between the Individual's Experience of Well-Being and Social Evaluation. Journal of Education Culture & Society 12:179–189.