Review

Mobile health applications for chronic diseases: A systematic review of features for lifestyle improvement

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ABSTRACT

Aims: To identify mobile health applications with features for improving the lifestyle of patients with chronic diseases.

Methods: We performed a systematic literature review between November 2017 and May 2018 on the Virtual Health Library's interface. A total of 816 records were identified. In the selection process, 24 studies met inclusion criteria for analysis. Study characteristics were extracted and synthesized.

Results: We identified applications with similar functionalities, such as the use of reminders and medical monitoring. Most of them addressed the treatment of conditions related to an already diagnosed chronic disease, including Diabetes Mellitus, Hypertension, Cardiovascular Diseases, Asthma, Neoplasms, and chronic conditions in general. The main lifestyle changes were the reduction of body weight, promotion of healthy eating, and adherence to the regular practice of physical exercises.

Conclusions: Technology can facilitate health care with simple messages and alerts that aid in adherence to treatment. Changes in lifestyle with the use of applications are remarkable. Benefits may be even greater if more applications address the importance of prevention and not just treatment.

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1. Introduction

The increasing incidence and prevalence of chronic non-communicable diseases (CNCD) represents a severe public health problem. CNCDs are associated with complications involving high costs with treatments, as well as compromising people's productivity and quality of life [1]. This increase reflects the growing life expectancy and the current demographic, epidemiological, and nutritional transition of the population [2].

The World Health Organization highlights as CNCDs cardiovascular diseases, neoplasms, chronic respiratory diseases, and diabetes mellitus (DM). Systemic Arterial Hypertension (SAH) and DM are the diseases with the highest incidence and with the highest mortality rates. Its leading causes are modifiable risk factors arising from lifestyle habits, such as smoking, alcohol consumption, physical inactivity, and unhealthy diet [3].

The adopted lifestyle determines the quality of human aging, since adequate food and time spent with personal, social, and physical activities influence the physical and mental functioning and personal engagement with life habits [4]. Lifestyle is related to aspects that reflect the attitudes, values, and opportunities in a person's life, and can be defined as a behavior pattern that affects, in some way, the human health [5].

Health-related mobile communication applications (m-Health) have been attracting increasing attention globally [6] because they have great potential to aid in behavior change encouraging healthy habits on a daily basis. These applications have a variety of features including medical information exchange, text messaging, educational content, web-based video and photo maintenance [7], which can reduce the disparity in health care, achieving high, medium and low-income savings, from the delivery of integrated information on the management of CNCD [8]. Furthermore, m-Health applications enable continuous monitoring of chronic diseases, improved quality of care and feedback, shorter hospital stays, increased medical capacity and reduced health costs [9] — resources that allow the patient to achieve better health outcomes [10].

The availability of m-Health applications to assist in the self-

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management of CNCD reveals a constant concern for improving people's lifestyle [11], but the evaluation of their quality, safety, and results shows some gaps [12]. There is a heterogeneity of functionalities available on these applications and a need to identify which can really contribute to a behavior change and disease self-management [13]. From this context, we systematically reviewed the literature to identify the functionalities of m-Health applications aimed at improving the lifestyle of patients with CNCDs.

2. Methods

Between November 2017 and May 2018, we performed a systematic literature review according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) report [14], also considering the recommendations by Kitchenham and Charters [15].

2.1. Key questions

This study had three key questions:

1. What are m-Health applications available for chronic non-communicable diseases?
2. What are the features of these m-Health applications?
3. What are the improvements in lifestyle perceived from using these m-Health applications?

2.2. Search strategy

We consulted synonyms in DeCS structured vocabulary service [16] to compose the search term according to the PICo strategy (population, interest, context). Table 1 details the search terms. The first column presents the top five chronic non-communicable diseases according to the Brazilian Ministry of Health, the second column specifies the m-Health applications, and the third column reports the synonyms of the term lifestyle.

We performed the search within databases grouped on the Virtual Health Library (BVsalud) website, including MEDLINE, LILACS, BDENF, IBECS, and MedCarib. The applied filter was for keywords, title, and abstract. We considered studies published until May 2018, when the searches ceased. There were no restrictions regarding language.

2.3. Eligibility criteria

As eligibility criteria, we considered studies (I) that described a change in the lifestyle of patients with any chronic disease; (II) that used mobile applications allowing user interaction or testing; (III) that addressed at least one routine or treatment task for monitoring chronic diseases; (IV) that described any application feature.

Table 1
Search terms defined with the PICo strategy.

Population or Problem (P)	Interest (I)	Context (Co)
Hypertension	Mobile app	Healthy style
High pressure	Mobile application	Healthy life styles
Chronic diseas0065	Application computer	Lifestyle
Cardiovascular diseases	Mobile app	Health habit
Diabetes	m-Health	
Lung diseases	Phone application	
Neoplasms	Smartphone application	

2.4. Studies selection process

The studies selection process was structured in three stages:

- Stage 1. Identification: search string executed on BVsalud website;
- Stage 2. Screening: publications title and abstract reviewed as a preliminary examination to determine if they contained information relevant to the key questions;
- Stage 3. Eligibility: studies evaluated with a full reading to settle their adequacy to the eligibility criteria, culminating in the included studies.

Two researchers simultaneously and independently performed the selection process, arranging the papers with Mendeley software (Mendeley Ltd). Evaluations with identical results were maintained, while divergent evaluations underwent a new analysis conducted jointly by the two researchers to reach the final consensus decision.

3. Results

The systematic review identified 816 papers in the surveyed databases. At first, 744 were excluded for not presenting affinity with the key questions in their titles, abstracts, and keywords. With an appraisal of the full-text papers against the eligibility criteria, 48 studies were excluded, resulting in 24 papers included in this study (Fig. 1).

We identified several m-Health applications that assist patients with CNCDs in their ongoing treatment. The leading applications are related to the Diabetes Mellitus (n = 8). We also identified applications for the treatment of hypertension (n = 6), cardiovascular diseases (n = 5), asthma (n = 1), and cancer (n = 1). In addition to applications for specific conditions, four applications addressed the treatment of CNCDs in general (n = 4). Table 2 details the summary of the reviewed studies.

The mean time to test with users ranged from 2 to 24 weeks. Some studies [9,17—23] conducted medical follow-up and with a
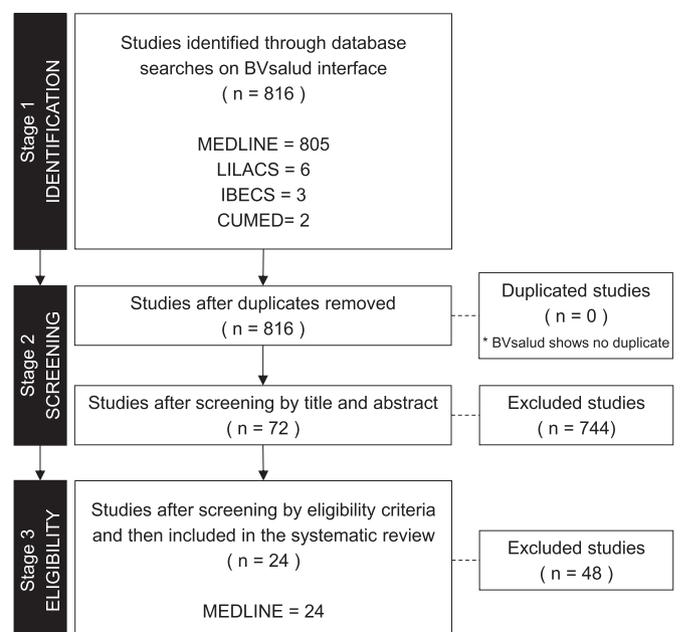

Fig. 1. Flow diagram of systematic review selection process.

Table 2
Taxonomy of studies included in the systematic review on m-Health applications for chronic diseases aimed at improving lifestyle.

Study	Year	Application's purpose	Sample size	Medical Monitoring	Follow-up of therapeutic goals	Alerting and goals	Blood glucose record	Registration of diet habits	Physical activity record	Smoking and alcoholism	Identification of exposure to ultraviolet radiation	Vaccine monitoring	Self-examination for cancer prevention	Identification of risk for respiratory problems	Step count	Assessment of symptoms of coronary disease	Stress level assessment	Blood pressure monitoring	Body weight control
Curran et al. [24]	2010	Adjusting the insulin level	6				✓												
Elias et al. [25]	2013	Managing asthma in children	200											✓					
Ribu et al. [26]	2013	Motivate self-management of diabetes	151			✓	✓	✓	✓										
Ribeiro et al. [27]	2017	Prevent cancer	53					✓	✓	✓	✓	✓	✓						
Klasnja et al. [28]	2009	Encourage the exercise practice	13												✓				
Zhang et al. [29]	2017	Prevent coronary heart disease	80					✓	✓	✓						✓	✓		
Pfaeffli Dale et al. [30]	2015	Educate patients about cardiovascular risk and support lifestyle changes	123			✓		✓	✓	✓					✓				
Smith et al. [31]	2015	Promote healthy health habits	14			✓													
Höchsmann et al. [32]	2017	Inducing a healthier lifestyle in the treatment of Type 2 Diabetes Mellitus	42						✓										
Yom-Tov et al. [33]	2017	Promote walking for patients with Diabetes	27			✓													
Toro-Ramos et al. [34]	2017	Improve blood pressure levels and quality of life	73			✓	✓	✓										✓	
Alonso-Domínguez [21]	2017	Decrease glycemic levels of patients with Diabetes	200	✓		✓	✓	✓	✓										
Balk-Møller et al. [35]	2017	Improve quality of life of workers with Diabetes	566		✓	✓		✓	✓									✓	
Gabrielli et al. [22]	2017	Reduce children's weight through dietary improvements	6	✓		✓	✓	✓											
Ashoorkhani et al. [36]	2016	Increase self-awareness and blood pressure control	132	✓	✓	✓												✓	✓
Mameli et al. [23]	2016	Reduce children's weight	43	✓	✓	✓	✓		✓										
Albini et al. [17]	2016	Managing hypertension	690	✓	✓	✓												✓	
De la Torre Diez et al. [37]	2017	Reduce body weight	45		✓	✓		✓	✓										
Seto et al. [18]	2012	Monitor heart failure	22	✓	✓	✓												✓	✓
Eagleson et al. [9]	2017	Interfere with the lifestyle of overweight children	Undefined	✓	✓	✓		✓	✓										
Toro-Ramos et al. [38]	2017	Decrease body weight and high blood pressure	63	✓	✓	✓		✓	✓									✓	✓
Haricharan et al. [39]	2017	Promoting health of deaf people with knowledge about hypertension and healthy habits	41			✓													
Plotnikoff et al. [40]	2017	Improve health and quality of life of adults with type 2 Diabetes	42				✓	✓	✓	✓									
Doocy et al. [20]	2017	Improve quality and continuity of care with hypertension and type 2 Diabetes	793	✓			✓												✓

multi-professional team to ensure better data reliability and greater adherence to treatment. The use of reminders in applications helped in motivating patients to register more data in applications. The features vary according to the disease addressed by the application, as presented in the following subsections.

3.1. Applications for diabetes mellitus

Curran et al. [24] developed an application that aims to adjust the insulin level. The authors tested their application with 6 patients. The main functionality is the use of a database of blood glucose. The patients reported improvement in glycemic control from the use of the application.

Ribu et al. [26] developed a motivational application for patients with Diabetes. The differential in its functionalities is the sending of alerts, besides the record of eating habits and physical activity. The application was tested by 151 patients who reported having better management of Diabetes.

Alonso-Domínguez [21] developed an application to decrease glucose levels. It has several functionalities, including medical monitoring, sending alerts, logs of blood glucose, eating habits, and physical activities. The application was tested by 200 patients who reported improvement in lifestyle, decrease in body weight, and increase in physical activity.

Balk-Møller et al. [35] and Höchsmann et al. [32] developed applications to improve the quality of life of patients with type 2 Diabetes. Its features are similar to the studies mentioned above. The study by Balk-Møller et al. [35] was conducted with 566 patients, who presented a reduction in body weight, percentage of body fat, and waist circumference. Höchsmann et al. [32] tested the application with 42 patients who reported increased cardiorespiratory fitness and leg strength, improved glucose metabolism and diabetes management, representing lower cardiovascular risk and improved quality of life.

Yom-Tov et al. [33] developed an application to encourage walking for patients with Diabetes. Plotnikoff et al. [40] developed an application to improve the health and quality of life of adults with type 2 Diabetes. Its functionalities included blood glucose logs, the record of eating habits and physical activity, and control of smoking and alcoholism. Patients who used the application showed improvement in clinical exams and physical fitness.

Doocy et al. [20] have developed an application to improve the quality and continuity of care, mobility of medical records, and health outcomes for patients with hypertension and type 2 Diabetes. It has functions such as medical monitoring, blood glucose logs, and weight control. Its main result was the improvement in adherence to the proposed guidelines and better quality of care.

3.2. Applications for arterial hypertension

Toro-Ramos et al. [34] developed an application to improve systemic blood pressure levels and increase the quality of life of patients with hypertension. Its functionalities included sending alerts, blood glucose database, records of eating habits, and monitoring of blood pressure. Tests with 73 people revealed a decrease in diastolic pressure and body weight. Ashoorkhani et al. [36] developed an application to increase the knowledge of individuals with hypertension and increase disease control. It has features similar to the application by Toro-Ramos et al. [34] and was tested with 132 people who demonstrated reduced levels of hypertension from lifestyle changes.

Albini et al. [17] and Toro-Ramos et al. [38] developed applications to reduce body weight and blood pressure. The features are practically the same and include therapeutic goals and medical follow-up, sending alerts, records of diet, physical activities, blood pressure, and body weight. The application by Albini et al. [17] was tested by 690 patients, who showed decreased levels of hypertension and better adherence to pharmacological treatment. The application by Toro-Ramos et al. [38] was tested by 63 people who demonstrated significant weight loss and decreased hypertension. The application by Doocy et al. [20], besides Diabetes (described in the previous subsection), also has functionalities for the treatment of hypertension. Haricharan et al. [39] developed an application to promote the health of deaf people through knowledge about hypertension and healthy habits. Its main functionality was to send alerts to patients, who had an improvement in their knowledge about health.

3.3. Cardiovascular disease

In order to facilitate the self-management of cardiovascular diseases, mobile applications are being developed to help monitor the symptoms and reduce spending on health services [41]. The use of applications to improve the lifestyle of people with cardiovascular disease was identified in three studies. Among them is the study of Zhang et al. [29], who developed an application for the prevention of coronary heart disease. Pfaeffli Dale et al. [30] developed an application to educate patients about cardiovascular risk factors and to support them in making lifestyle changes. Smith et al. [31] developed an application for the promotion of healthy habits and basic health information. All of these applications have common features that include the record of diet habits, physical activity, decreased smoking, and alcoholism. A differential was found in the study by Zhang et al. [29], which included changes in participants' behavior, such as stress and cholesterol levels.

Zhang et al. [29] assessed 80 participants who, after the intervention, presented greater awareness and knowledge of heart disease and changes in cholesterol behavior and control, as well as the reduction of stress. Pfaeffli Dale et al. [30] tested their application with 123 people, who had better adherence to healthy life behaviors. Smith et al. [31] tested their application with 14 participants, who reported improved health care due to reminders, contributing to the prevention and treatment of chronic diseases.

3.4. Applications for lung diseases

Pulmonary diseases, or chronic respiratory diseases, can affect the upper and lower respiratory tracts. The most common ones are asthma, allergic rhinitis, and chronic obstructive pulmonary disease. There are few studies using applications regarding chronic respiratory diseases. Only Elias et al. [25] developed an application to help manage asthma in children. Its functionality is to identify risks for respiratory problems, promoting improvements in breathing and consequently coughing. The application was tested with 200 children and adolescents, who reported a 95% decrease in cough from application use.

3.5. Applications for cancer

The use of applications for the follow-up of cancer patients still appears to be innovative. In this systematic review, only one application was found, which presents similar functionalities to the other ones. Ribeiro et al. [42] developed an application to prevent the development of cancer with the differential of an accompaniment of vaccines and preventive examinations. This application was tested with 53 patients, who showed better behavior concerning healthier choices, reducing the risk of cancer.

3.6. Applications for chronic diseases in general

Among the different chronic diseases, obesity and overweight are more frequent in the population. For these diseases, different m-Health applications were identified.

Klasnja et al. [28] presented applications to encourage the practice of physical activities through the step counting functionality. The tests were conducted with 13 participants, who showed an improvement in the level of weekly physical activity. Gabrielli et al. [22] have developed an application to encourage weight reduction in children through healthier eating habit. Its functionalities are medical monitoring, sending alerts, blood glucose database, and recording of eating habits. The application was tested with 6 children, who presented weight reduction and reeducation of family habits.

De-La-Torre-Diez et al. [37] developed an application to aid in the reduction of body weight with monitoring of therapeutic goals, alerts and reminders, records of eating habits and physical activity. They study with 180 people revealed an improvement in body weight, physical exercise, and consumption of a balanced diet.

4. Discussion

All m-Health applications were tested with patients with chronic diseases, through questionnaires before and after application use. The studies also used research tools with the analysis of the patient's diet and lifestyle based on data entered in the application itself, including blood pressure, blood glucose, weight, and exercise frequency. The results of the analyzes indicated improvements in lifestyle, healthier eating, weight loss, controlled blood pressure and glycemic levels, cough suppression, and treatment awareness.

Different studies addressed the use of applications for hypertension, aiming at improving blood pressure levels through simple changes in lifestyle, such as balanced diet and physical exercise, also contributing to weight loss. Regular checking and reminders were crucial factors for the studies presented, besides medical monitoring, which is imperative [43].

The m-Health applications comprise important features capable of improving the lifestyle of patients with CNCD and, consequently, their health condition. Among the perceived changes, the most relevant are those related to Diabetes treatment, with better control of insulin dosages, one of the main challenges of patients [24]. In summary, in the eight studies that addressed applications focused on DM treatment, the improvement of lifestyle was from functionalities to the adjustment of the insulin level [24], patient's motivation [26], reduction of the glycemic levels [21], boosting quality of life [32,35,40], encouraging exercise [33], and the mobility of health records [20].

In the application for the treatment of pulmonary diseases, it was identified the increase of the cardiorespiratory capacity, helping in the cough diminution [25]. In patients with arterial hypertension, an improvement in blood pressure levels was observed, concomitantly with a decrease in body weight, an essential factor for its control [17,19,20,36,39]. In its turn, the application for the care of cancer patients enabled more excellent knowledge of healthy choices [42].

Most of the applications concentrate on he modification of dietary habits and exercise practice as main targets in the treatment of chronic diseases, since these are the main risk factors for its development [21,26,27,32,35]. However, even after identifying some chronic disease, patients have difficulty adhering to a healthy lifestyle [44]. This is due to the fact that changing the usual food is challenging. However, this practice is essential for the treatment of CNCDs and maintenance of health. On the other hand, the regular performance of physical activities is a fundamental practice, as it helps in reducing body weight, blood pressure, and the risks of illnesses. In contrast, studies showed that patients were mostly sedentary [9,37,40]. Another perceived complication that contributes to the development of these conditions is the use of cigarettes and alcoholic beverages, harmful to health, but poorly addressed by the m-Health applications.

5. Conclusions

We identified 24 studies that used mobile applications to improve the lifestyle of patients with CNCDs. Some similar functionalities, such as the use of reminders and medical follow-up, are fundamental practices for patient treatment. Technology can facilitate health care with simple messages and alerts that aid in adherence to treatment. Changes in lifestyle with the use of applications are remarkable. The main ones are the adherence to the practice of regular exercise, healthy diet, and reduction of body weight. Another significant result is the decrease in blood pressure and glycemic levels. Even though alcohol consumption and tobacco use are risk factors for the development of CNCDs, no significant changes were related in these practices by the use of m-Health applications. Attention should also be given to disease prevention and the adoption of healthy practices in general, highlighting the application for cancer care. Benefits may be even better if more applications address the importance of prevention and not just treatment. The number of available m-Health applications is increasing every day, and there is still a need for further m-Health applications focusing on improving the lifestyle regarding CNCDs, especially to prevent these conditions.

Conflicts of interest

Authors declare no conflict of interest.

References

[1] Bahia LR, Araujo DV, Schaan BD, Dib SA, Negrato CA, Leão MPS, et al. The costs of type 2 diabetes mellitus outpatient care in the Brazilian public health system. Value Health 2011;14:S137–40. https://doi.org/10.1016/j.jval.2011.05.009.

[2] Azevedo PR de, Sousa MM de, Souza NF de, Oliveira SHS. Health education shares in the context of chronic diseases: integrative review/Ações de educação em saúde no contexto das doenças crônicas: revisão integrativa. Revista de Pesquisa: Cuidado é Fundamental Online 2018;10:260. https://doi.org/10.9789/2175-5361.2018.v10i1.260-267.

[3] Szerwieski LLD. Doenças crônicas não transmissíveis e a polifarmácia em idosos, vol. 27; 2018. Revista UNINGA Review, http://revista.uninga.br/index.php/uningareviews/article/view/1821.

[4] Oliveira S de FD, Duarte YA de O, Lebrão ML, Laurenti R. Demanda referida e auxílio recebido por idosos com declínio cognitivo no município de São Paulo. Saúde e Sociedade 2007;16:81–9. https://doi.org/10.1590/S0104-12902007000100008.

[5] Oliveira LS, Rabelo DF, Caires Queroz N. Life style, perceived control and quality of life: a study with the aged population of Patos de Minas-MG. Estudos e Pesquisas em Psicologia 2012;12:416–30.

[6] Nahar P, Kannuri NK, Mikkilineni S, Murthy GVS, Phillimore P. mHealth and the management of chronic conditions in rural areas: a note of caution from southern India. Anthropol Med 2017;24:1–16. https://doi.org/10.1080/

13648470.2016.1263824.

[7] Isaković M, Sedlar U, Volk M, Bešter J. Usability pitfalls of diabetes mHealth apps for the elderly. J Diabetes Res 2016;2016:1604609. https://doi.org/10.1155/2016/1604609.

[8] Slater H, Campbell JM, Stinson JN, Burley MM, Briggs AM. End user and implementer experiences of mHealth technologies for noncommunicable chronic disease management in young adults: systematic review. J Med Internet Res 2017;19:e406. https://doi.org/10.2196/jmir.8888.

[9] Eagleson R, Altamirano-Diaz L, McInnis A, Welisch E, De Jesus S, Prapavessis H, et al. Implementation of clinical research trials using web-based and mobile devices: challenges and solutions. BMC Med Res Methodol 2017;17:43. https://doi.org/10.1186/s12874-017-0324-6.

[10] Quaosar GMAA, Hoque MR, Bao Y. Investigating factors affecting elderly's intention to use m-health services: an empirical study. Telemed J e Health 2018;24:309–14. https://doi.org/10.1089/tmj.2017.0111.

[11] Chen J, Bauman A, Allman-Farinelli M. A study to determine the most popular lifestyle smartphone applications and willingness of the public to share their personal data for health research. Telemed J e Health 2016;22:655–65. https://doi.org/10.1089/tmj.2015.0159.

[12] Bellei EA, Biduski D, Cechetti NP, De Marchi ACB. Diabetes mellitus m-health applications: a systematic review of features and fundamentals. Telemed J e Health 2018;24:839–52. https://doi.org/10.1089/tmj.2017.0230.

[13] Sudhir PM. Advances in psychological interventions for lifestyle disorders. Curr Opin Psychiatr 2017;30:346–51. https://doi.org/10.1097/YCO.0000000000000348.

[14] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med 2009;6:e1000100. https://doi.org/10.1371/journal.pmed.1000100.

[15] Kitchenham B, Charters S. Guidelines for performing systematic literature reviews in software engineering. United Kingdom: Staffordshire; 2007.

[16] NLM Medical Subject Headings. DeCS - health sciences descriptors. Virtual Heal Libr 2018. http://decs.bvs.br/. [Accessed 31 May 2018].

[17] Albini F, Liu X, Torlasco C, Soranna D, Faini A, Ciminaghi R, et al. An ICT and mobile health integrated approach to optimize patients' education on hypertension and its management by physicians: the Patients Optimal Strategy of Treatment(POST) pilot study. In: 2016 38th annu. Int. Conf. IEEE eng. Med. Biol. Soc. IEEE; 2016. p. 517–20. https://doi.org/10.1109/EMBC.2016.7590753.

[18] Seto E, Leonard KJ, Cafazzo JA, Barnsley J, Masino C, Ross HJ. Perceptions and experiences of heart failure patients and clinicians on the use of mobile phone-based telemonitoring. J Med Internet Res 2012;14:e25. https://doi.org/10.2196/jmir.1912.

[19] Toro-Ramos T, Kim Y, Wood M, Rajda J, Niejadlik K, Honcz J, et al. Efficacy of a mobile hypertension prevention delivery platform with human coaching. J Hum Hypertens 2017;31:795–800. https://doi.org/10.1038/jhh.2017.69.

[20] Doocy S, Paik KE, Lyles E, Hei Tam H, Fahed Z, Winkler E, et al. Guidelines and mHealth to improve quality of hypertension and type 2 diabetes care for vulnerable populations in Lebanon: longitudinal cohort study. JMIR MHealth UHealth 2017;5:e158. https://doi.org/10.2196/mhealth.7745.

[21] Alonso-Domínguez R. Effectiveness of a multifactorial intervention based on an application for smartphones, heart-healthy walks and a nutritional workshop in patients with type 2 diabetes mellitus in primary care (EMID): study protocol for a randomised controlled trial. BMJ Open 2017;7. https://doi.org/10.1136/bmjopen-2017-016191.

[22] Gabrielli S, Dianti M, Maimone R, Betta M, Filippi L, Ghezzi M, et al. Design of a mobile app for nutrition education (TreC-LifeStyle) and formative evaluation with families of overweight children. JMIR MHealth UHealth 2017;5:e48. https://doi.org/10.2196/mhealth.7080.

[23] Mameli C, Brunetti D, Colombo V, Bedogni G, Schneider L, Penagini F, et al. Combined use of a wristband and a smartphone to reduce body weight in obese children: randomized controlled trial. Pediatr Obes 2016. https://doi.org/10.1111/ijpo.12201.

[24] Curran K, Nichols E, Xie E, Harper R. An intensive insulinotherapy mobile phone application built on artificial intelligence technology. J Diabetes Sci Technol 2010;4:209–20. https://doi.org/10.1177/193229681000400126.

[25] Elias P, Rajan NO, McArthur K, Dacso CC. InSpire to promote lung assessment in youth: evolving the self-management paradigms of young people with asthma. Med 2013;20. https://doi.org/10.2196/med20.2014. 2:e1.

[26] Ribu L, Holmen H, Torbjørnsen A, Wahl AK, Grøttland A, Småstuen MC, et al. Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: protocol for a randomized controlled trial. JMIR Res Protoc 2013;2:e34. https://doi.org/10.2196/resprot.2768.

[27] Ribeiro N, Moreira L, Almeida AMP, Santos-Silva F. Pilot study of a smartphone-based intervention to promote cancer prevention behaviours. Int

J Med Inform 2017;108:125–33. https://doi.org/10.1016/J.IJMEDINF.2017.10.013.

[28] Klasnja P, Consolvo S, McDonald DW, Landay JA, Pratt W. Using mobile & personal sensing technologies to support health behavior change in everyday life: lessons learned. AMIA. AMIA Annual Symposium Proceedings 2009;2009. 338–42.

[29] Zhang H, Jiang Y, Nguyen HD, Poo DCC, Wang W. The effect of a smartphone-based coronary heart disease prevention (SBCHDP) programme on awareness and knowledge of CHD, stress, and cardiac-related lifestyle behaviours among the working population in Singapore: a pilot randomised controlled trial. Health Qual Life Outcomes 2017;15:49. https://doi.org/10.1186/s12955-017-0623-y.

[30] Pfaeffli Dale L, Whittaker R, Jiang Y, Stewart R, Rolleston A, Maddison R. Text message and internet support for coronary heart disease self-management: results from the Text4Heart randomized controlled trial. J Med Internet Res 2015;17:e237. https://doi.org/10.2196/jmir.4944.

[31] Smith R, Menon J, Rajeev JG, Feinberg L, Kumar RK, Banerjee A. Potential for the use of mHealth in the management of cardiovascular disease in Kerala: a qualitative study. BMJ Open 2015;5:e009367. https://doi.org/10.1136/bmjopen-2015-009367.

[32] Höchsmann C, Walz SP, Schäfer J, Holopainen J, Hanssen H, Schmidt-Trucksäss A. Mobile Exergaming for Health—effects of a serious game application for smartphones on physical activity and exercise adherence in type 2 diabetes mellitus—study protocol for a randomized controlled trial. Trials 2017;18:103. https://doi.org/10.1186/s13063-017-1853-3.

[33] Yom-Tov E, Feraru G, Kozdoba M, Mannor S, Tennenholtz M, Hochberg I. Encouraging physical activity in patients with diabetes: intervention using a reinforcement learning system. J Med Internet Res 2017;19:e338. https://doi.org/10.2196/jmir.7994.

[34] Toro-Ramos T, Kim Y, Wood M, Rajda J, Niejadlik K, Honcz J, et al. Efficacy of a mobile hypertension prevention delivery platform with human coaching. J Hum Hypertens 2017;31:795–800. https://doi.org/10.1038/jhh.2017.69.

[35] Balk-Møller NC, Poulsen SK, Larsen TM. Effect of a nine-month web- and app-based workplace intervention to promote healthy lifestyle and weight loss for employees in the social welfare and health care sector: a randomized controlled trial. J Med Internet Res 2017;19:e108. https://doi.org/10.2196/jmir.6196.

[36] Ashoorkhani M, Bozorgi A, Majdzadeh R, Hosseini H, Yoonessi A, Ramezankhani A, et al. Comparing the effectiveness of the BPMAP (Blood Pressure Management Application) and usual care in self-management of primary hypertension and adherence to treatment in patients aged 30–60 years: study protocol for a randomized controlled trial. Trials 2016;17:511. https://doi.org/10.1186/s13063-016-1638-0.

[37] de la Torre Díez I, Garcia-Zapirain B, López-Coronado M, Rodrigues JJPC, del Pozo Vegas C. A new mHealth app for monitoring and awareness of healthy eating: development and user evaluation by Spanish users. J Med Syst 2017;41:109. https://doi.org/10.1007/s10916-017-0753-0.

[38] Toro-Ramos T, Lee D-H, Kim Y, Michaelides A, Oh TJ, Kim KM, et al. Effectiveness of a smartphone application for the management of metabolic syndrome components focusing on weight loss: a preliminary study. Metab Syndrome Relat Disord 2017;15:465–73. https://doi.org/10.1089/met.2017.0062.

[39] Haricharan HJ, Heap M, Hacking D, Lau YK. Health promotion via SMS improves hypertension knowledge for deaf South Africans. BMC Public Health 2017;17:663. https://doi.org/10.1186/s12889-017-4619-7.

[40] Plotnikoff RC, Wilczynska M, Cohen KE, Smith JJ, Lubans DR. Integrating smartphone technology, social support and the outdoor physical environment to improve fitness among adults at risk of, or diagnosed with, Type 2 Diabetes: findings from the 'eCoFit' randomized controlled trial. Prev Med 2017;105: 404–11. https://doi.org/10.1016/J.YPMED.2017.08.027.

[41] Portz JD, Vehovec A, Dolansky MA, Levin JB, Boxer R. The development and acceptability of a mobile application for tracking symptoms of heart failure among older adults. Telemed J e Health 2018;24:161–5. https://doi.org/10.1089/tmj.2017.0036.

[42] Ribeiro N, Moreira L, Almeida AMP, Santos-Silva F. Pilot study of a smartphone-based intervention to promote cancer prevention behaviours. Int J Med Inform 2017;108:125–33. https://doi.org/10.1016/J.IJMEDINF.2017.10.013.

[43] Cechetti NP, Bellei EA, Biduski D, Rodriguez JPM, Roman MK, De Marchi ACB. Developing and implementing a gamification method to improve user engagement: a case study with an m-Health application for hypertension monitoring. Telematics Inf 2019;41:126–38. https://doi.org/10.1016/j.tele.2019.04.007.

[44] Verplanken B, Wood W. Interventions to break and create consumer habits. J Public Policy Mark 2006;25:90–103. https://doi.org/10.1509/jppm.25.1.90.