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Luiza Siqueira do Prado, MSc; Camille Carpentier, MSc; Marie Preau, PhD; Anne-Marie Schott, MD, PhD; Alexandra Dima, PhD

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Abstract

Background: Quality of life of people living with chronic conditions is highly dependent on self-management behaviours. Mobile health applications (mHealth apps) could facilitate self-management and thus help improve population health. To achieve their potential, apps need to target specific behaviours with appropriate techniques that support change and do so in a way that allows users to understand and act upon the content they interact with.

Objective: To identify chronic conditions self-management apps available in France and examined what target behaviours (TBs) and behaviour change techniques (BCTs) they include, what is their level of understandability and actionability, and the associations between these characteristics.

Methods: We extracted data on Google Play store "TOP" apps in the "Medicine" category or found through 12 popular terms (keywords) for the four most common chronic conditions groups (cardiovascular diseases, cancer, respiratory diseases and diabetes), along with apps identified through literature search. We selected and downloaded native Android apps available in French for the self-management of any chronic condition in one of the four groups and extracted background characteristics (e.g. stars, number of ratings), coded presence of TBs, BCTs using the Behaviour Change Taxonomy v1 (BCTv1), and understandability and actionability using the Patient Education Material Assessment Tool for audiovisual materials (PEMAT-A/V). We performed descriptive statistics and bivariate statistical tests.

Results: Forty-four distinct native apps were available for download in France and in French, 39 (88.6%) found via Google Play store and 5 (11.4%) via literature search. Nineteen (43.2%) apps were for diabetes, 10 for cardiovascular diseases (22.72%), 8 for more than one condition in the 4 groups (18.8%), 6 for respiratory diseases (13.63%), and 1 for cancer. Median number of TBs per app was 2 (range 0 - 7) and of BCTs per app was 3 (range 0 - 12). Most common BCT was "Self-monitoring of outcome(s) of behaviour" (31 apps), while most common TB was "Tracking symptoms" (30 apps). Median level of understandability was 42% and actionability 0%. Apps with more TBs and more BCTs were also more understandable (rho?= 0.31, P = .041; rho?= 0.35, P = .021), but not significantly more actionable (rho?= 0.24, P = .123; rho?= 0.29, P = .054).

Conclusions: These apps target few behaviours and include few BCTs, limiting their potential for behavior change. While content is moderately understandable, clear instructions on when and how to act are uncommon. Developers need to work closely with health professionals, users and behavior change experts to improve content and format to better support patients to cope with chronic conditions. Developers may use these criteria for assessing content and format to guide app development and evaluation of app performance.

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Review

Behaviour change content, understandability and actionability of chronic condition self-management apps available in France: a systematic review

Abstract

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Conclusions: These apps target few behaviours and include few BCTs, limiting their potential for behavior change. While content is moderately understandable, clear instructions on when and how to act are uncommon. Developers need to work closely with health professionals, users and behavior change experts to improve content and format to better support patients to cope with chronic conditions. Developers may use these criteria for assessing content and format to guide app development and evaluation of app performance.

Registration: PROSPERO CRD42018094012
Keywords: mHealth; smartphone; app; self-management; chronic conditions; target behaviours; behaviour change techniques; understandability; actionability.

Introduction

Chronic conditions are the main cause of disability and premature death worldwide, representing the highest number of disability-adjusted life years (DALYs) in the Global Burden of Diseases [1]. More specifically, four groups of diseases (cardiovascular diseases, cancers, respiratory diseases and diabetes, respectively) cause 80% of premature deaths related to chronic conditions [2]. The rise in prevalence of such conditions, while being determined by multiple causes, is highly related to unhealthy lifestyles and population ageing. Treatment requires a long-term and multidisciplinary approach, including therapeutic education and lifestyle changes, to prevent further aggravation and/or premature death, focusing on modifiable behavioural risk factors, such as insufficient physical activity or inadequate diet [2]. Achieving and maintaining satisfactory quality of life is strongly dependent on the patient's ability to reduce behavioural risks and perform regularly specific self-care activities defined together with health care providers (self-management behaviours). This process of active engagement in obtaining skills and taking part in health-related decisions, also called patient empowerment [3], may be mediated by technology that facilitates self-awareness and understanding how and when to take action regarding measured physiological parameters, to prevent or react to deterioration in health status.

Currently, mobile health smartphone applications (mHealth apps) can support patients in performing behaviours such as symptom monitoring and medication intake, among others [4], and have therefore the potential to help improve population health and reduce healthcare costs. By the end of 2017, mobile broadband subscriptions were expected to reach 4.3 billion worldwide [5]. In 2012, one in five smartphone users had at least one health-related mobile app on his/her phone [6]; in 2015, over half of that population had downloaded at least once a health-related app [7], and numbers of mHealth apps downloaded are similar between individuals with and without chronic conditions [8]. The availability of mHealth apps and people's tendency to carry their devices with them at all times mean they can be also used for delivering behavioural interventions to large populations [9]. Yet, despite the increasing number of studies and reviews on the use of such apps on health outcomes, evidence for effectiveness is still unclear [10,11]. Furthermore, in the fast-paced technology culture, few mHealth interventions are designed in collaboration with patients, clinicians or behavioural scientists or are subject to rigorous testing [4,12]. The result is a wide and heterogeneous range of offerings that differ in their objective, content and user experience [13].

To assess the potential of self-management apps to improve individual and population health, it is useful to consider them as technology-mediated health behaviour change interventions. For such interventions to be effective, they need to intervene on the causal behavioural pathways relevant to the health of their user group, i.e. to target specific behaviours (TBs) causally linked to the desired outcomes. Moreover, from a psychological perspective, they need to include behaviour change techniques (BCTs), which are the "active ingredients" of behaviour change interventions – reproductible and irreducible components of these interventions that can trigger change in the psychological determinants of these behaviours, and consequently improve health [14]. In recent years, health behaviour theorists and intervention developers have been building consensus on methods to identify BCTs present in existing interventions, which resulted in a 93-BCT taxonomy currently used as a shared framework for intervention evaluation and development [15].The presence of behavioural change content has been shown to increase the effectiveness of mHealth and internet-based interventions [16,17]. Examining the mHealth app offer in terms of occurrence of TBs and BCTs can be informative regarding the current state-of-the-art on behaviour change, and highlight opportunities for improvement [18], for example by studying links between usage patterns of individual behaviour change content and changes in health outcomes.

The presence of relevant behaviour change content does not by itself guarantee that users will be able to interact with it, and potentially change their behaviours. These tools need to present information in an accurate, comprehensible and actionable way and must consider different communication competencies, styles and health literacy levels to optimize their reach and enhance health decision making [19]. Evidence shows most education materials are too complex for patients with low health literacy [20]. To assess the suitability of mHealth apps for diverse audiences it is useful to consider them as health-related materials. The Patient Education Material Assessment Tool for audiovisual materials (PEMAT-A/V) is a commonly-used method in this domain, which evaluates the extent to which health-related materials are understandable (understandability) and give clear instructions regarding actions that users may take to apply the information presented (actionability) [20]. Presenting relevant behaviour change content in a suitable manner is therefore important for ensuring that the intended users achieve the goals the app is supposed to facilitate. Apps with richer behavioural content may also present it in a more understandable and actionable way, and this can be seen as indicator of app quality and of the level of expertise of the developing team. Yet, to our knowledge, no examination of both content and suitability of apps was performed to date. Understanding the links between content and format in the current app offer in a specific territory may provide insights into the rapidly evolving app development phenomenon and recommendations for improvement.

As mHealth develops worldwide, evaluations of app content and format are increasingly common and necessary to inform policy discussions on achieving the potential of mHealth to improve public health [21]. For example, BCTs were shown not to be widely implemented in top-ranked physical activity apps in the United States [22]. In New Zealand, in physical activity and dietary apps, BCTs associated with increased effectiveness in modifying these behaviours were more common in paid apps [23]. In Canada, theory-based cognitive-behavioural content was found to be present in only 10% of apps for depression [24]. Although app use is a global phenomenon, research is normally limited to apps in English, while the available offer in commercial marketplaces is restricted to geographical regions. The French Health National Strategy 2018-2022 has forecasted a generalization of digital services in healthcare and put special interest in promoting favourable health behaviours and fighting social inequities in access to healthcare [25]. It is thus important to assess the current mHealth app offer in France and in French, especially for self-management of chronic conditions. To our knowledge, no review with these characteristics has been published to date worldwide and the potential of these tools to support behaviour change for self-management of chronic conditions has not been fully examined yet. Such evaluation is instrumental for orienting the development of this expanding field in a way that best serves the interests of all stakeholders, including patients, healthcare professionals, app developers, payers and the healthcare system.

Therefore, this systematic review of mHealth apps for chronic conditions self-management in France aimed to answer the following questions: (1) what behaviours are targeted in these apps, and by which BCTs?; (2) what levels of understandability and actionability characterize these apps?; and (3) are apps with more behavioural change content also easier to understand and act upon?

Methods

We developed a systematic review protocol based on PRISMA-P guidelines, an evidence-based minimum set of items for reporting systematic reviews [26], and registered it with PROSPERO, an international database of prospectively registered systematic reviews (registration number CRD42018094012). PRISMA checklist is available in Multimedia Appendix 1.

Apps were identified through two different approaches: a search of peer-reviewed articles reporting on development or validation of mHealth apps for self-management of chronic conditions, and a search in the Android commercial marketplace for smartphones. We used Android marketplace Google Play store as it detains 88% of the global mobile phone market [27] and most apps are developed for both operating systems (Android and iOS).

A systematic search of PubMed (MEDLINE), IEEE and Web of Science electronic bibliographic databases was conducted (all search terms are available in Multimedia Appendix 2). All peer-reviewed articles and conference papers published between 2012 and 2018 concerning mHealth self-management interventions in the previously stated chronic conditions reporting empirical research of the development or validation of mHealth tools, pilot studies, randomized controlled trials (both protocols and reports of study results) were assessed independently by two investigators based on title and abstract, followed by full-text examination to identify available apps in France, in French and for Android at the Google Play store.

Subsequently, a list of the first 500 free apps labelled as “Top” in Google Play store in the “Medicine” category and the 55 paid apps available in the same category was extracted (n = 555). The number of paid apps was limited by the marketplace. Another search was performed using 12 keywords in French related to the 4 groups of diseases: cardiovascular diseases, cancers, respiratory diseases and diabetes (“maladie cardiaque”, “maladie coeur”, “AVC accident vascular cérébral”, “infarctus”, “maladie pulmon”, “asthme”, “BPCO”, “maladie respiratoire”, “cancer”, “diabète”, “diabète type 1”, “diabète type 2”). For each keyword, the 20 first apps shown in the marketplace (n = 240) were extracted. The complete list (n = 795) was assessed independently by two investigators. After screening, selected apps were divided into 5 groups: 4 according to the condition they targeted (‘Cancer’, ‘Diabetes’, ‘Respiratory diseases’, ‘Cardiovascular diseases’) and one generic group (‘Other’), comprising apps targeting behaviours like medication adherence and physical activity irrespective of medical condition.

All searches, data extraction and coding were done between March and April 2018. Second coding by a different investigator, along with inter-rater reliability, reconciliation and coding review were performed in October 2018. A smartphone Samsung J7 with Android version 6.0.1 was used for downloading and evaluating all selected apps.

Eligibility

All native apps available for download in France and in French at Google Play Store designed for patients for the self-management of cardiovascular diseases, cancers, respiratory diseases and diabetes were eligible. There was no restriction considering price or source of for-/not-for-profit funding. Were excluded apps that were clearly not for chronic conditions (apps that did not state their main purpose, or were designed for other users or purposes, such as training health professionals or students, hospitals or medical laboratories, making medical appointments, reaching emergency services, or geographical localization of defibrillators or pharmacies), apps for chronic conditions other than those in the 4 groups studied in this work, apps for chronic conditions in the 4 groups but not for self-management (offering general health information or risk assessment), apps that required additional hardware like special glucometers, apps with description in French but content in English or with different names and same content, and finally apps that were no longer available in October 2018.

Eligible apps may describe their objective as chronic disease self-management, or target only specific behaviors relevant for these conditions, such as medication adherence, trigger management, exacerbation management, physical activity, dietary behaviors, archiving health information. Apps that targeted only preventive behaviors, such as physical activity and diet, with no reference to chronic condition management were also excluded.

Screening and selection

Reference management software (Zotero) was used to identify/remove duplicate records in the literature search. Titles and abstracts of remaining records were screened by two independent reviewers to establish eligibility. If at least one reviewer recommended study or app inclusion, the full text or app availability was sourced for review and appraisal, and/or to reaching consensus of study eligibility. If reviewer discordance persisted, consensus was reached through discussion and arbitration with a third investigator.

Data extraction and analysis

The following app characteristics were extracted from Google Play store: information on the presence of sales on app (paid app; free app with/without paid features), number of downloads (from 10+ to 10 000 000+), user ranking (from 1 to 5 stars), number of ratings, version, last update and developer information were extracted from the marketplace along with app's name and available description. Developers were then categorized in three groups, "Private company", comprising single app developers and dedicated app developing companies, "Non-private", comprising NGO, public institutions or European projects, and "Pharmaceutical/Medical Devices companies", comprising bigger players in the market such as pharmaceutical laboratories and other medical technology companies.

Target behaviours and behaviour change content

TBs were coded following detailed examination of app content and further functions, like sending notifications to users to perform tasks such as drinking water, exercising, etc. Each TB present was coded once per app; one app may contain several TBs. Behaviour change content was coded by a trained investigator using the BCT taxonomy [15]. This taxonomy represents a consensus of hierarchically structured techniques developed to specify behavioural interventions. Each BCT present was coded once for each app; one app may contain multiple BCTs. A second trained coder evaluated a subset of 8 selected apps (18.2%) and inter-rater reliability was computed with bias-adjusted kappa (PABAK).

Understandability and actionability assessment

A material is understandable and actionable when users of different health literacy levels can "process and explain key messages" and "identify what they can do based on the information presented" [20]. Understandability and actionability levels were evaluated using the PEMAT-A/V [20], which is a systematic method to evaluate understandability and actionability of patient education materials. It includes 13 items in five topics (Content, Word Choice & Style, Organization, Layout & Design and Use of Visual Aids) to evaluate understandability (e.g., "The material makes its purpose completely evident", "The material uses common, everyday language", etc) and 4 items for actionability (e.g., "The material clearly identifies at least one action the user can take"). Each item was rated with 0 (If Disagree) or 1 (If Agree), while not applicable items received N/A. Item scores were added and divided by the maximum score possible (excluding N/A items) and the result multiplied by 100 to get a percentage score. A second coder assessed understandability and actionability scores for the same subset of apps used for BCT coding; inter-rater reliability was computed using the intraclass correlation coefficient (ICC).

Data analysis

Coding was done using Microsoft Excel and all statistical analyses were performed using RStudio version 1.1.383. We examined app characteristics, behavioural content and PEMAT scores via descriptive statistics. We performed nonparametric tests to compare groups and to investigate the correlation between the variables of interest, given their distribution properties. Associations between behavioural content and PEMAT scores were investigated via bivariate correlations (Spearman's rank correlation coefficient, ρ). Additional exploratory analyses regarding relationships between app characteristics and these content and format properties are reported in Multimedia Appendixes 3 and 4 for interested readers.

Results

Search

Of the total 704 unique apps identified in Google Play store, 167 (23.72%) had descriptions in languages other than French; 104 apps (14.77%) were considered as targeting chronic conditions in general and 50 apps (7.10%) focused on chronic conditions in the 4 groups of diseases included in this review. Other chronic conditions (not considered in this work) were back pain, migraine and headache, sleeping apnea, depression, among others. For app selection, agreement between reviewers was substantial (kappa = 0.62). Reconciliation was done by a third reviewer when agreement was not reached after discussion between the first two. Fifty apps met inclusion criteria. Nonetheless, 3 of the selected apps required other connected objects (e.g., connected glucometer or blood glucose sensor, smart watch), 3 had descriptions in French but app content was entirely in English, and 2 pairs of apps had different names but same content (1 app of each pair was removed; total n excluded = 8). When second coding of BCT content and understandability and actionability scores was performed in October 2018 for calculation of inter-rater reliability and score revision, 3 apps were no longer available on the marketplace and were removed from the analysis.

The literature search yielded 1344 abstracts, and 234 manuscripts were assessed based on full-text. Inter-rater reliability was 0.33 (fair agreement), and a third reviewer did reconciliation by checking all records disagreed on by the first two. Many of the manuscripts found through literature search were reviews, and reviews of reviews (n = 282). No peer-reviewed or conference papers from French institutions was selected for full-text screening. Seven [28–34] out of 234 manuscripts selected mentioned at least one native app for Android available in France and in French and were included in our review. Of the 7 apps, one was present in two different articles and one required a glucometer connected to the smartphone, which prevented app use. This resulted in 5 distinct apps downloaded from Google Play store. Apps found through literature search were not present in the list of apps extracted previously from Google Play store. Finally, we analyzed a list of 44 unique native apps (5 from literature search and 39 from marketplace search) (Figure 1).

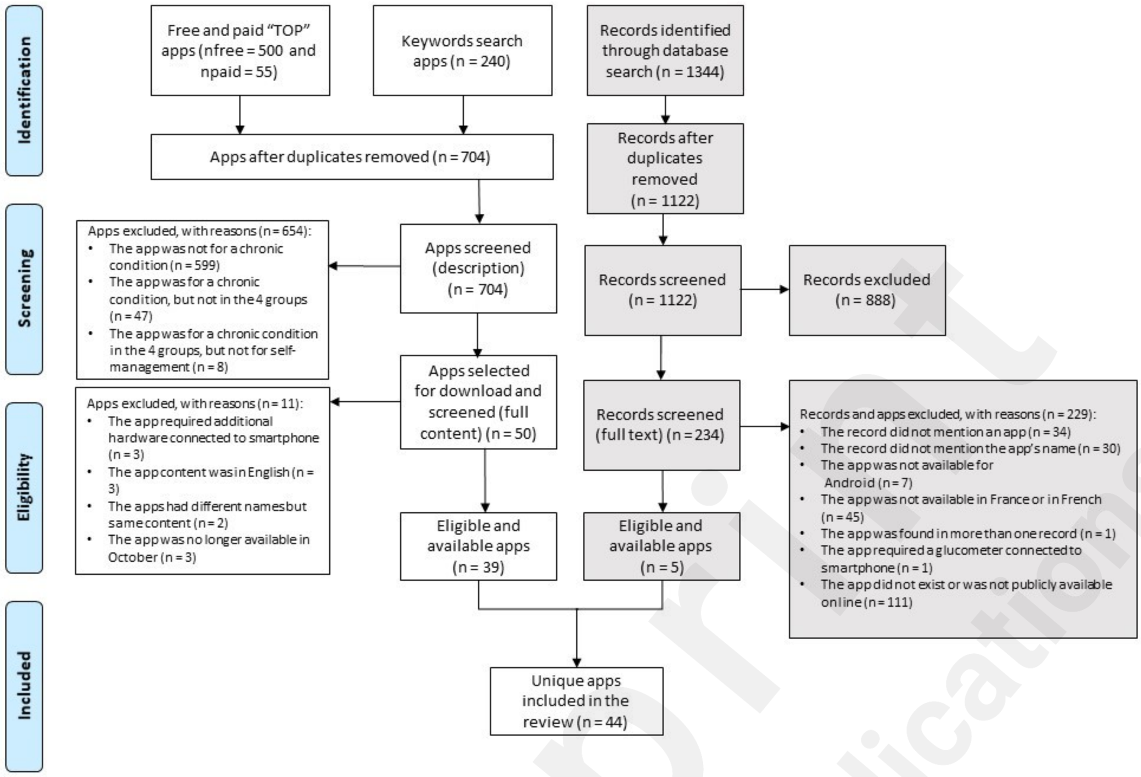


Figure 1 – Flowchart of screening process. Modified from: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

App characteristics

Forty-four apps were downloaded and analyzed, most of them targeting diabetes (n = 19). The least represented category was cancer (1 app). Table 1 shows the main characteristics of the apps analyzed.

Table 1. Sample characteristics

	Characteristics	**Apps (n = 44)**
Categories		
	Cancer	1 (2.27%)
	Respiratory diseases	6 (13.63%)
	Cardiovascular diseases	10 (22.72%)
	Diabetes	19 (43.18%)
	Other	8 (18.18%)
Stars		
	Mean (SD)	4.18 (0.48)
	Min - Max	3 - 5
Number of user ratings		

	Mean (SD)	16 140.1 (61 401.6)
	Min - Max	2 - 374 462
Downloads		
	50+	1 (2.27%)
	100+	3 (6.81%)
	500+	4 (9.10%)
	1000+	4 (9.10%)
	5000+	4 (9.10%)
	10000+	6 (13.63%)
	50000+	3 (6.82%)
	100000+	10 (22.72%)
	500000+	3 (6.82%)
	1000000+	3 (6.82%)
	5000000+	2 (4.54%)
	10000000+	1 (2.27%)
Gratuity		
	Paid app	1 (2.27%)
	With paid features	14 (31.82%)
	Without paid features	29 (65.91%)
Developer		
	Non-private[a]	4 (9.10%)
	Pharma/MedTech company	13 (29.54%)
	Private app development company	27 (61.36%)

[a]NGO, public institutions or European projects

TB and BCT characteristics

We identified the presence of 10 TBs and 21 BCTs in our app sample (Table 2). The maximum number of TBs observed per app was 7 in 2 apps, median number was 2, 5 apps did not present any TB. Four apps had no BCT present and other 4 had only 1, while only 1 app had more than 10 (n = 12). Median number of BCTs per app was 3 [0 – 12].

Inter-rater reliability in BCT coding was 0.68 (substantial agreement), and reconciliation process was used to revise coding in the whole app sample.

Table 2. Prevalence of TBs and BCTs in app sample

	Name	**Occurrence**	**Percentage**

Target Behaviour (TB)			
	Tracking symptoms	26	59.09%
	Medication adherence	13	29.55%
	Tracking diet	12	27.27%
	Tracking weight	11	25.00%
	Archiving health information	9	20.45%
	Physical activity	6	13.64%
	Attending medical appointments	3	6.82%
	Tracking emotional symptoms	3	6.82%
	Drinking water	2	4.55%
	Tracking sleep	2	4.55%
Behaviour Change Technique (BCT)			
	2.4 Self-monitoring of outcome(s) of behaviour	31	70.45%
	2.7 Feedback on outcome(s) of behaviour	25	56.82%
	2.3 Self-monitoring of behaviour	19	43.18%
	7.1 Prompts and cues	17	38.64%
	5.1 Information about health consequences	14	31.82%
	1.3 Goal setting (outcome)	11	25.00%
	8.7 Graded tasks	5	11.36%
	1.4 Action planning	4	9.09%
	2.6 Biofeedback	3	6.82%
	2.2 Feedback on behaviour	3	6.82%

	3.2 Social support (practical)	2	4.55%
	6.2 Social comparison	2	4.55%
	4.1 Instruction on how to perform the behaviour	1	2.27%
	6.1 Demonstration of the behaviour	1	2.27%
	9.1 Credible source	1	2.27%
	5.4 Monitoring of emotional consequences	1	2.27%
	10.4 Social reward	1	2.27%
	1.1 Goal setting (behaviour)	1	2.27%
	3.1 Social support (unspecified)	1	2.27%
	3.3 Social support (emotional)	1	2.27%

The most common TBs were “Tracking symptoms” (e.g., in the case of apps for hypertension, measuring blood pressure and recording the values in the app journal) (n = 30), “Medication adherence” (recording medication name and dosage and setting alarms to remember taking them) (n = 13), “Tracking diet” (in the case of diabetes apps, noting food quantities in an app journal) (n = 12), “Tracking weight” (n = 11), and “Archiving health information” (recording clinical tests results in an app journal) (n = 9). For BCTs, the most common were “Self-monitoring of outcome(s) of behaviour” (n = 31), followed by “Feedback on outcome(s) of behaviour” (n = 25), “Self-monitoring of behavior(s)” (n = 19), “Prompts/Cues” (n = 17), “Information about health consequences” (n = 14) and “Goal setting (outcome)” (n = 11). All TBs and BCTs mentioned above were encountered in more than 20% of analyzed apps.

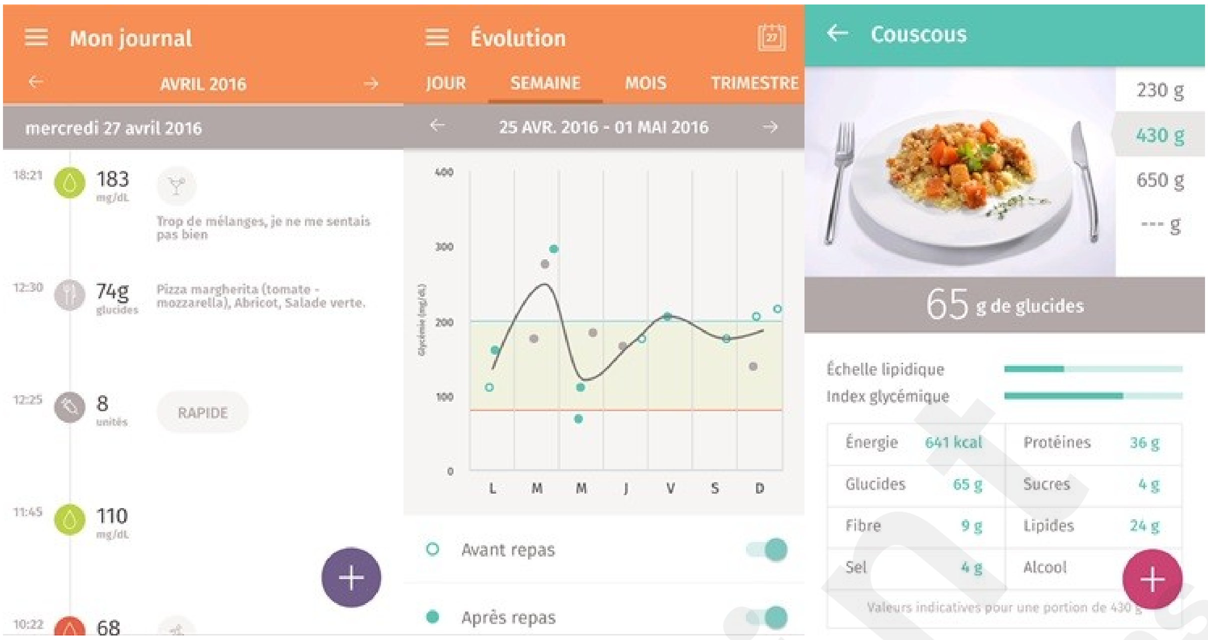
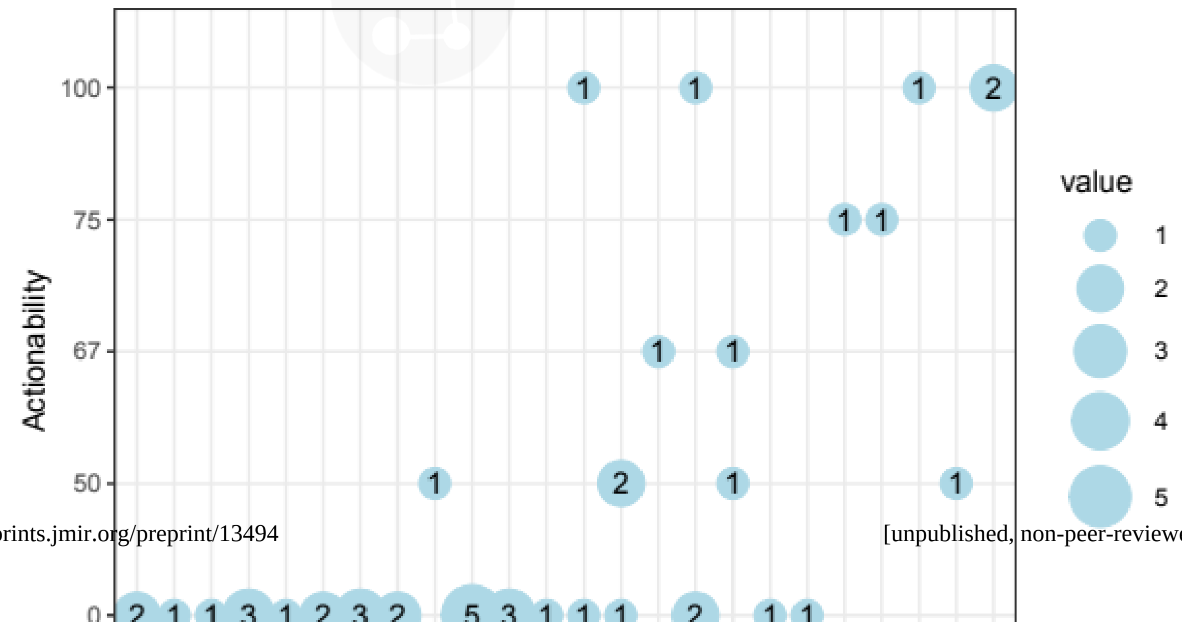


Figure 2 – Examples of TBs and BCTs used in apps, from Gluci-Check app. From the left, "Tracking symptoms" and "Self-monitoring of outcome(s) of behaviour", then "Feedback on outcome(s) of behaviour" and "Goal setting (outcome), and last "Tracking diet" and "Self-monitoring of behaviour". Source: App description on Google Play store.

Figure 2 shows examples of TBs and BCTs. The first screen shows a blood glucose journal, corresponding to the TB "Tracking symptoms" and the BCT "Self-monitoring of outcome(s) of behaviour". The second shows a graph with blood glucose levels variation through a period of one week along with the blood glucose target range defined by the user and his/her healthcare provider, corresponding to the BCT "Feedback on outcome(s) of behaviour" and "Goal setting (outcome)". The third, a food journal corresponding to TB "Tracking diet" and BCT "Self-monitoring of behaviour", since this specific app is designed for people with type 1 diabetes and knowing the amount of carbohydrates in meals is essential for adjusting insulin dosage.

Understandability and Actionability scores

Two of 44 apps had an actionability score of 100%. Mean understandability score was 43.5% (SD = 22.24), median 42%, and values ranged from 9% to 92%. For actionability, mean score was 23.5% (SD = 36.86), median 0%, ranging from 0% to 100%. Thirty apps (68.18%) had null actionability (no clearly stated actions the user could take regarding the self-management behaviours the app targeted). Figure 3 shows the co-occurrence of understandability (x-axis) and actionability (y-axis) scores in the sample.



Inter-rater reliability for understandability scores was 0.65 (substantial agreement) and for actionability scores was 0.02 (poor agreement). Both coders rated actionability as low for most apps, and differences were mostly related to an interpretation ambiguity in the first item of actionability assessment “The material clearly identifies at least one action the user can take”, of which all 3 other actionability items were dependent on. The fact that there were only 4 items to evaluate also influenced the different scores. Disagreements were discussed and the process of reconciliation led to revising the scores for the other apps in the sample.

Understandability and actionability scores were positively correlated (ρ = 0.67, P < .001), and so were the numbers of BCT and TB per app (ρ = 0.62, P < .001). Understandability had a positive correlation to the number of BCT per app (ρ = 0.35, P = .021), and number of TB per app (ρ = 0.31, P = .041). This may suggest that apps with more TBs and BCTs also tended to present this content in a way that is easier to understand. Actionability had moderate positive correlations to TBs per app (ρ = 0.24, P = .123), BCT per app (ρ = 0.29, P = .054), not statistically significant.

Discussion

The use of mHealth apps for supporting health-related behaviour change and patient empowerment is being widely discussed as solution to healthcare challenges worldwide, particularly in chronic conditions. This review showed that in 2018 in France the potential of mHealth is far from being achieved. The apps available for download on Google Play had relatively limited behaviour change content and, although moderately easy to understand for diverse audiences, they did not commonly point to clear actions users may take to self-manage the condition targeted. To better support patients with chronic conditions, apps can be improved by building on more solid behaviour change research and applying it in ways that are easier to understand and act upon.

By searching directly on Google Play, we found only 39 apps available in French targeting self-management in the 4 groups of chronic conditions with highest mortality rates (cardiovascular diseases, cancer, respiratory diseases and diabetes), among 704 apps with different purposes and languages. This suggests that, for a patient or healthcare professional interested to use apps to manage a chronic condition, finding an appropriate app can be challenging. Moreover, our literature search identified only 5 apps available in France and in French. In another review with similar methodology performed in Canada with mHealth apps in English, of the total of 107 apps for depression analyzed, 48 were found through literature search [24]. This highlights the variability of the mHealth apps offer worldwide both in terms of availability and research, and the importance of studying the evolution of this domain in different countries and languages.

Targeting specific key behaviours in interventions and combining active components (BCTs) that are potentially effective for behaviour change in the context of chronic conditions is crucial to achieve the intended change and, consequently, improve and maintain quality of life [36,37]. In our sample, the most common TB was “Tracking symptoms”, and an important prevention behaviour, “Physical activity”, was present in only 6 apps. Median number of TBs per app was 2, ranging from 0 to 5. The modifiable behaviours described as priorities by the World Health Organization (WHO) as risk factors increasing mortality rates, such as tobacco use, alcohol consumption and excessive salt intake, were not addressed in any of the analyzed apps. There was substantial variation in the number of BCTs present and the majority of the apps focused on self-monitoring, confirming the focus on monitoring behaviours, like previously shown in the literature. We observed 20 BCTs in our sample and median number of BCTs per app was 3, ranging from 0 to 12. Conroy et al. (2014) [22] observed 26 BCTs in total and most top-ranked apps for physical activity incorporated less than 4 BCTs (ranging from 1 to 13) and Direito et al. (2014) [23] found 26 in total, with an average of 8.1 BCTs per app (ranging from 2 to 18), with free apps (as most apps evaluated in our study), presenting a slightly smaller average (6.6, ranging from 3 to14). In both studies, “Provide instruction” was the most common BCT, which was not observed for the case of chronic conditions mHealth apps in our study. Similar to the results of Martinez-Pérez et al. (2013) [38] for mHealth apps for the most prevalent conditions by the WHO, we found more assistive and monitoring characteristics in apps in our sample than informative and educational ones, also reinforced by the most common TB, “Tracking symptoms”. “Demonstration of the behaviour” was an uncommon BCT, and videos or illustrations to clarify the use of measurement equipment (such as blood glucose or pressure monitors) were rare. Furthermore, only a third of apps presented “Information about health consequences”, which is indispensable for understanding complications related to the chronic conditions discussed here. “Goal setting (outcome)” was also frequent (more than 60%) in physical activity apps [22], while in our work it was present in less than one-fourth of apps. Goal management BCTs (“Goal setting” and “Goal review”) were found to be effective in physical activity and dietary behaviour change interventions [39-42]. Also, the combination of self-monitoring techniques with at least one other self-regulation technique (intention formation, feedback on performance, specific goal setting and review of behavioural goals) is shown to be more effective than other interventions [41]. Moreover, “Action planning”, highly related to actionability and overcoming emergencies, was present in only 5 apps. We were thus able to identify limited behavioural change content and a focus on monitoring rather than goal management or education.

The apps in our study were to a large extent not suitable to low literacy audiences. Median understandability and actionability scores were 42% and 0%, respectively. In a previous study that applied the PEMAT-A/V to 43 apps intended for parent education (parenting, child health or infant health) [43], 30 apps had understandability scores between 76% and 100%, while for actionability, 19 apps had scores in this range. We found most apps had hard to read text (small font and too much text). In previous work with a different methodology, Meppelink et al. (2017) [44] showed that almost 80% of Dutch health information websites were over recommended B1 reading level (B1 reading level means 95% of the population can understand the information). In addition, the predominantly low actionability of the apps in our study shows that we are still far from fulfilling the potential of mHealth tools to increase patient autonomy. More than half of the analyzed apps did not present any clearly stated action or had any suggestions concerning the data recorded by users on health-related events. For mHealth apps to fully achieve their potential to support chronic conditions treatment, clearly indicating actions is imperative (for example, diabetes apps need to indicate that patients need to intervene immediately if high or low blood glucose is recorded and give concrete physical activity suggestions to users). In our study, apps with more TBs and BCTs were also more understandable, indicating developers who consider behavioural content may also be more careful with being comprehensible for users; levels of actionability were low irrespective of behavioural content. We therefore highlight actionability as a priority to address in app development: stating actions users can take, addressing users directly when describing actions, presenting actions in short explicit steps and explaining how to use data visualization to take action [20].

Strengths and Limitations

Our study used a three-pronged search strategy to identify apps relevant for our research questions: two strategies likely employed by users to identify apps in the marketplace (top-ranked mHealth apps and active keyword search) and one strategy to identify apps that have been subject to scientific research (literature search). However, only Android app marketplace was examined in this study and, although Google has the largest portion of the mobile app market and most apps are present in both marketplaces, not considering the second most popular app marketplace (iOS) can lead to omission of relevant apps. Nonetheless, we believe our search strategies enabled us to obtain a representative sample to describe the current state-of-the-art in mHealth self-management support. Secondly, we only considered peer-reviewed papers and conference articles published in English, even though we were looking for apps available in France and in French. A future study of the iOS marketplace and French databases may be useful to complement our findings. We have also downloaded and assessed both behavioural content, and understandability and actionability by two independent coders interacting directly with the apps, not only the descriptions available in the commercial marketplace. Thus, we were able to obtain a comprehensive assessment of the properties examined and reflect also on the assessment tools used.

We identified several issues for further improvement. First, while the BCT taxonomy enables systematic coding with good inter-coder reliability, there is no consensus to date on classifying TBs apart from broad domains [45]. We have followed commonly-used terminology to describe TBs in this study, yet our descriptions would have certainly benefited from standardized labels. TB definition and selection is a key step in behaviour change [46] and working towards a consensus on TB classification would further facilitate evidence synthesis. Second, since PEMAT was developed for educational materials using audio and video resources, we encountered a few difficulties when applying its criteria to apps. For example, app names and descriptions are commonly less informative in apps than what is expected for other health-related educational materials, names may be unrelated to the condition, and descriptions do not necessarily contain all app features. These characteristics may be interpreted as low understandability but may also be due to different design conventions in apps which may have be considered as an underestimation of understandability in our sample. PEMAT-A/V was selected after careful review of several tools, as it was considered best suited to app assessment by the research team. However, we would support a future adaptation of PEMAT for apps, which could aim to reconcile the usual brevity of the app medium with the requirements of effective communication for different audiences. Third, our study focused on the content and format of apps, and excluded other criteria for judging app quality, from user engagement and functionality [47] to data security and ethical and legal standards [48]. A comprehensive evaluation was beyond the scope of our review and would need to consider multiple dimensions.

Conclusions

Our findings suggest that mHealth apps available in France could be improved in terms of content and format. It also illustrates how two readily available tools, the BCT taxonomy and the PEMAT, can provide useful insights into the potential of an app to support patient empowerment. These tools can be used by different stakeholders in app development or to assess the existing offer, to ensure an effective contribution of apps to patient care, and we would recommend their inclusion in broader app development and evaluation guidelines. Given the prevalence of the chronic conditions considered here, it is essential to make sure different levels of health literacy are considered when developing health-related materials. Also, the development of mHealth apps should involve users and consider their behavioral support needs and be accompanied by research on whether their content and use are able to effectively change behaviour. Apps could also benefit from integrating more instructions for intended users on actions to perform, more modifiable behavioural risk factors and more behaviour change content, especially BCTs associated with increased effectiveness in modifying TBs.

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Conflicts of Interest

None declared.

Abbreviations

BCT – Behaviour Change Techniques
mHealth apps – mobile health applications
PEMAT – A/V – Patient Education Material Assessment Tool for audiovisual materials
TB – Target behaviours
WHO – World Health Organization

Multimedia Appendix 1

PRISMA checklist.

Multimedia Appendix 2

Search strategy in Google Play store, PubMed (MEDLINE), IEEE and Web of Science.

Multimedia Appendix 3

App sample with data extracted from Google Play store.

Multimedia Appendix 4

R markdown and report with statistical and exploratory analyses.

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Flowchart of screening process.