Systematic Review of Mobile Phone Apps Currently Available to Norwegian Users to Support Diabetes Self-Management

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Abstract

Diabetes is a chronic illness that affects millions of people worldwide. Patients who find it difficult to adhere to its complex treatment regimen face severe health implications. For example, many patients find it challenging to meet diabetes self-management demands such as frequent blood sugar checks, regular insulin and/or medication use, and consistent dietary and exercise regimens. Studies have shown that mobile health (mHealth) solutions and mobile applications (apps) offer unique opportunities for meeting these challenges and achieving better treatment adherence. With increasing mobile phone adoption, many commercial diabetes self-management apps have become available. Such fast-paced developments make it difficult for patients and healthcare providers to stay current. This systematic review of diabetes apps available to Norwegian users aims to give an overview of the apps on the market. By comparing and reviewing results across various themes, this study identifies important ones for successful diabetes self-management. This will enable identifying other areas that should be considered in the design and development of diabetes self-management apps.

Keywords: mHealth, Mobile Apps, Diabetes, Self-management, Systematic Review, Design

1 Introduction

Today, around 415 million people suffer from diabetes worldwide [1]. According to the World Health Organization, the management of this disease and its ensuing complications remains a global health emergency that currently accounts for 12% of healthcare expenditures [2].
Diabetes, in addition to its various physical impacts, also often leads to deteriorated quality of life and increased rates of depression and anxiety among patients [3,4]. Mobile health (mHealth) studies found that the use of mobile phone applications (apps) for diabetes self-management has a positive impact on individuals [5]. However, these studies note various positive and negative impacts, indicating that such apps may be a convenient and viable support system for many but not all diabetes patients depending on their preferences, health literacy, economy, etc. [6-9]. This study sheds light and begins to build an understanding of diabetes apps and their implications for users, with a special focus on apps that are currently available for Norwegian patients. The findings are relevant for identifying areas for further consideration in the use of mobile apps that are designed and developed for diabetes self-management.

1.1 Overview of Current Apps

Compared to early mobile phones, today's mobile phones and tablet PCs offer a considerably wider range of functionalities. Apps are increasingly used in managing various tasks in daily life. Currently, just under two million apps are available in the Apple App Store (operating system: iOS, developer: Apple) and more than 2.1 Million apps, in the Google Play Store (operating system: Android, developer: Google) [10].
As such, the app market is immense and constantly growing. In the Norwegian context, this is an important development because its large geographic area relative to its small population often implies long travel times for diabetes patients to speak directly to a healthcare provider. The implementation of apps as a means to communicate and self-manage illness in daily life is therefore particularly interesting in this context. Accordingly, the Norwegian Ministry for Healthcare has established a Directorate for e-Health to actively implement strategies and policies and to manage the integration of mHealth into the Norwegian Healthcare System [11].

The number of health-related apps available in Norway increased by 57% in 2016 to 259,000 apps [12]. This growth reflects a global trend, and it is particularly interesting in the context that the saturation of mobile phone usage among the Norwegian population is estimated to be 88% [13]. Here, the digitalization of the healthcare sector with digital patient files and other measures has to a large extent become a part of daily life for patients with chronic illnesses. It is important to note that according to a 2016 report by the National Center for e-Health Research (Nasjonalt Senter for E-Helseforskning), diabetes is one of the fastest developing sectors among health apps in Norway [14].

Among the categories of medicine, health, and fitness, thousands of apps, including those that target diabetes nutrition and dietary behavior for diabetes patients, are available. These apps can deliver healthcare anywhere by overcoming geographical and organizational barriers as well as time constraints [15/16]. As noted earlier, some parts of Norway are sparsely populated and therefore travel times to healthcare providers can be high. Therefore, apps for diagnosis, self-management, mitigation, treatment, or prevention of diseases such as

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diabetes [17] can be particularly valuable in the Norwegian geographic context. Apps can provide diabetes patients with greater autonomy, with the possibility to self-manage and track their illness progression on a daily life basis in real time. Diabetes self-management includes monitoring of glucose levels, lifestyle modifications, medication management, prevention of complications, and psychosocial care [18]. Self-management of a chronic illness such as diabetes often contributes to minimizing risks and complications associated with its chronic nature.

2 Method

2.1 Information Sources and Search

A systematic review of mobile phone apps in English and Norwegian in the two mobile app stores—Google Play (Android) and App Store (iOS)— was conducted from November to December 2018.

A search was conducted among apps within comparative categories, and their specifications were identified according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) (Table 2) [19, 20]. A list of relevant search terms was assembled in English and Norwegian and entered into the search engines of these two app stores. The search strategy consisted of the terms "diabetes," "diabetes mellitus," "diabetes mellitus type 1," "diabetes type 1," "diabetes mellitus type 2," "diabetes type 2," "diabetic ketoacidosis," "blood sugar," "blood glucose," "diabetes manager," "diabetes management," "diabetes diary," and "diabetes tracker" (Table1). The specific search strategy for each app store can be provided by the author upon request. Subsequently, an app review based on the information given in the Google Play Store, Apple App Store, and the apps themselves was conducted. The review of available mobile apps for diabetes self-management is based on criteria for promoting diabetes self-management as defined by Goyal and Cafazzo (monitoring blood glucose level and medication, nutrition, physical exercise, and body weight) [6].

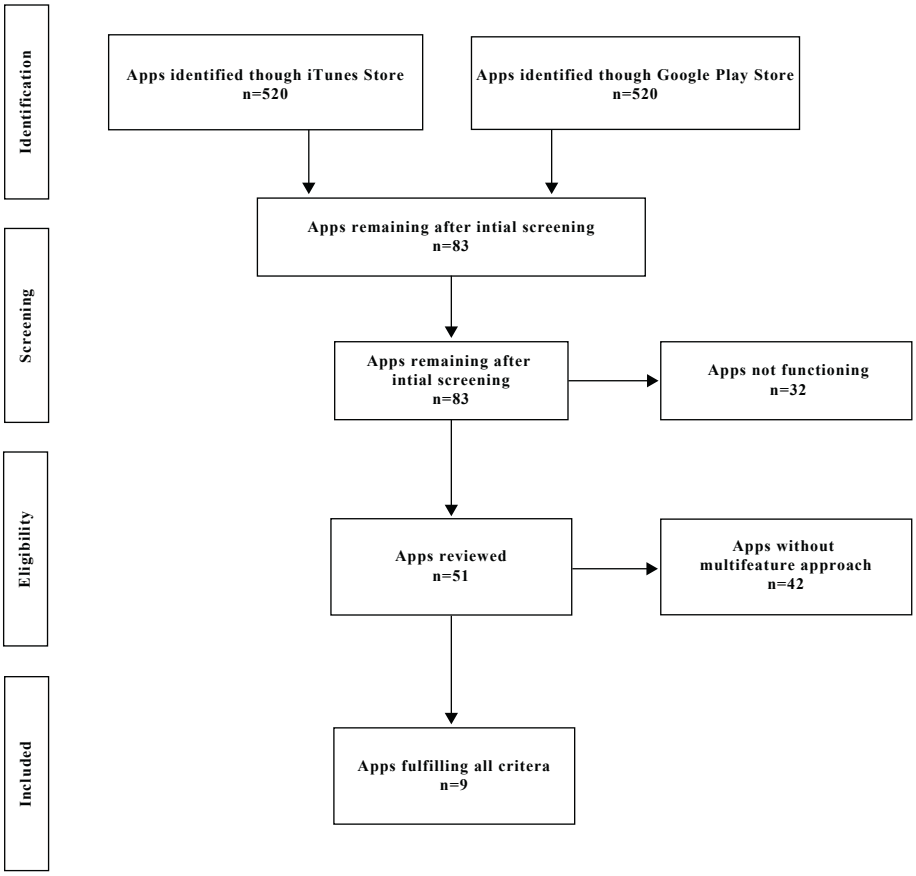
Table 1. Search terms applied in the Apple App Store and the Google Play Store

Search terms in English	Search terms in Norwegian
diabetes	diabetes
diabetes mellitus	diabetes mellitus
diabetes mellitus type 1	diabetes mellitus type 1
diabetes type 1	diabetes type 1
diabetes type 2	diabetes type 2
diabetes mellitus type 2	diabetes mellitus type 2
diabetic ketoacidosis	diabetic ketoacidosis
blood sugar	blod sukker
blood glucose	blod glukose
diabetes manager	diabetes assistent
diabetes management	diabetes rådgiver
diabetes diary	diabetes dagbok
diabetes journal	diabetes journal
diabetes tracker	diabetes sporing

2.2 Eligibility Criteria

To be eligible, an app has to be available in one of three Scandinavian languages (Norwegian, Swedish, or Danish) to be useful to local Norwegian users. This criterion was relaxed in that an app could also be available only in English if it fits all criteria described as the basis for successful diabetes self-management according to Goyal and Cafazzo. Through their research, they have defined the following criteria: monitoring blood glucose level and medication, nutrition, physical exercise, and body weight [6]. These five aspects had to be present in the app for it to be considered eligible. Additionally, the app has to specifically address diabetes self-management, although whether it targeted Type 1 or Type 2 diabetes could be unspecified. Lastly, the app had to appear among the first 20 rankings for one of the search terms to be considered viable according to the two app stores' search algorithms.

Table 2. PRISMA Flowchart



2.3 App Selection

After the search according to the abovementioned search terms, the first 20 apps in the ranking were reviewed according to the eligibility criteria. Apps had to match the inclusion and exclusion criteria set a priori. Only the first 20 apps were considered owing to the algorithms used by the two app stores for ranking various apps. Duplicates were removed and the remaining apps were screened according to the following criteria: title, introduction text, user reviews, and language availability. The remaining eligible apps were downloaded and reviewed more thoroughly based on the criteria set by Goyal and Cafazzo [6]. The levels of inclusion of features based on the selection criteria in the selected mobile apps can vary. The results were discussed with two other design researchers. In some cases, app developers were contacted to clarify the design and to determine whether the app was developed according to a specific theory and if so, which one. In cases of a nonresponse, one reminder was sent.

3 Results

3.1 Functions of Apps

During the study, 520 apps were initially found in the two app stores (Google Play and Apple App Store), of which every hit was reviewed in terms of its relevance and explicit link to diabetes mellitus. This pre-screening process was important owing to the large number of misleading descriptions of apps that were caused by the low admission requirements for new apps entering these app stores.

From this initially large number, 83 were identified as likely to be matching the criteria in the initial screening. These apps were then tested and evaluated. Of these, 32 did not meet even minimal requirements or did not work properly. While a wide range of mobile applications is available for diabetes self-management, ranging from fitness apps, carbohydrate counters, glucose trackers, to diabetes meal-planners, few combined a number of these features. This multifeature approach is, according to Goyal and Cafazzo, a key element for the promotion of diabetes self-management. The current results show that only nine out of 51 reviewed mobile apps were versatile and useful enough for successful diabetes self-management based on the selection criteria.

4 Discussion

4.1 Principal Findings

App audience
In this review, one outcome was the realization that diabetes patients are the primary users/customers for the apps available today. In fact, 96% of apps were targeted at individuals with diabetes. Physicians or health professionals were the targeted users of a smaller proportion of apps.

Language
Many apps were available in multiple languages; however, few were in a Scandinavian language (Norwegian, Danish, or Swedish), leading to the small number of apps reviewed. Further, even though many apps offered Norwegian as a language setting, some seemed to be translated by a translation algorithm. This occasionally led to misleading translations that could be detrimental in a healthcare context. Additionally, the availability of Norwegian as a language did not necessarily make the app user-friendly in the Norwegian cultural context. This is because user reviews often noted an inherent lack of local products to be found among the food databases. This was often related to comments on poor usability of an app by Norwegian users. It also points to the fact that simply providing linguistic readability is not enough; users also require cultural readability to consider the app useful. If this is not possible, as was often the case for Norwegian users, in a small country and subsequent market, the possibility of easily adding to or building a database of local food is considered helpful.

Usability
An important consideration of mobile applications is the ease with which the user and the product interact. Usability, according to Nielsen [21], involves comprehensibility, image and text presentation, understandability, and intuitiveness among other features to determine how easily users can interact with apps.

Among diabetes apps, most appear to be comprehensible. However, many did not have good fault tolerance, which refers to the ability of the app to respond well to unexpected hardware or software failures. Another technical detail was that only a small number of apps were constantly updated and that the user reviews were rather old. This could imply that the app has fallen out of favor or that the developers have lost interest in the app after a few years.

Accessibility features (i.e., screen reader, large type, color contrast) were available in many apps, with 41% of Android apps offering a large font (versus 0% of iOS apps). Paid apps tended to have more usability strategies for patients with low health literacy, such as, plain language, clearly labeled links, and organization features. Here, it is also interesting to note that “design,” “usability,” and “easy to use” were frequently mentioned in the user ratings and seemed directly correlated to users’ positive ratings and satisfaction with the app. This is something that will be examined closer in the fieldwork following this review.

Integration with other mobile applications (e.g., email, calendar, maps) was available in 44% of apps. Interestingly, the number of functions available that also correlated with positive usability according to the app reviews were functions related to self-monitoring and visual presentation of data patterns, such as graphs of glucose ratings over time and being able to export and share these with others.

Overall, apps appear to be primarily available in English, with limited available user rating data. At a broader level, paid apps do not seem to offer major advantages over free apps other than some improved features for those with low health literacy. Finally, user ratings and number of downloads do not appear to be reliable indicators of app quality.

Security
Given the large amount of physiologic data available in apps with monitoring features, data security is an issue to be considered. In the age of private data becoming a commodity traded by large companies, protection of privacy and health data has become a growing concern. This is true especially because commercial app developers often adhere to different ethical standards than healthcare providers. This inherently raises concerns, especially considering that only one of the 9 apps reviewed indicated HIPAA (U.S. Department of Health and Human Services regulations protecting the privacy and security of certain health information) [22] compliance. Most apps did have long privacy and terms of use contracts that the user has to agree to if he/she wishes to use the app. As tracking and communicating physiological data becomes increasingly prevalent and providers become accustomed to using apps to monitor such data with their patients, having security measures will likely become an important app feature.

4.2 Limitations of the Review

This review has the following limitations. A systematic search was performed by applying rigorous methods; however, the lack of transparency on the side of the apps stores in how their algorithms affect ranking and possible language biases within the search terms does not allow for a fully transparent process. Additionally, according to Martínez-Pérez et al., owing to the dramatic rate of app development, the number of available commercial apps is a moving target [23]. In particular, when considering the rate of updates and redesigns, apps often change their user interaction or visual layout quite significantly from one update to the next to stay up to date with current trends. Further, this review did not assess the quality of use of the apps found during the study as this was beyond the current scope.

4.3 Implications of Using Mobile Apps for Diabetes Self-management

Considering the great need for diabetes patients to manage and adapt to their illness in daily life, the wide range of diabetes apps available to them can be considered positive. The wide variety of apps available on the market likely allows patients to find a fitting solution for their individual needs. However, the ever-growing number of apps available can also be overwhelming for both healthcare staff and patients who are searching for reliable and well-designed apps to support them in their diabetes management efforts. Therefore, a better understanding of the usefulness and quality of apps available on the market is necessary. To achieve some kind of clarity or to establish a framework within which to operate, it is necessary to further rigorously study the development and impact of apps on diabetes self-management.

Currently, user ratings seem to be the most feasible way for patients (and possibly developers) to evaluate app options and quality. Nonetheless, many apps found in this review lack user-ratings or might be outdated. Among apps with recent user ratings, the information they contain is very varied in the actual feedback they provide. Additionally, the lack of transparency in how app stores provide user ratings raises concerns about biases arising from the algorithms employed by the various App Stores. In the Apple App Store, for example, a minimum of reviews are required before an average review rating is produced [24]. Further, the search functions in app stores tend to be cumbersome for users to navigate, with limited possibilities for advanced searching and filtering. Independent reviews and ratings exist in the form of blogs, magazines, and websites. However, diabetes and other medical apps are in a unique position in that higher risks might be involved in the use of low-quality apps as they might provide misleading information or suggestions.

This review also highlights the fact that few apps base their design and development on validated behavioral theories, such as for example the Theory of Planned Behavior. Apps also lack variety in the theories that are implemented. Primarily, the apps reviewed in this article seemed to base their approach on tracking health variables such as blood glucose levels, carbohydrate intake, and physical activity. mHealth research suggests that self-tracking and monitoring of blood glucose levels are particularly critical components of successful diabetes management [25]. More frequent monitoring, especially with the provision of feedback on the monitored data, is a key factor in health behavior change interventions according to Miltenberger [26]. However, outside of this approach to behavior change, few evidence-based tools or theories seem to have been employed in commercial apps for diabetes self-management. It seems that apps that are developed based on specific behavior change theories for diabetes management are primarily research probes rather than commercially available apps. Though these apps often clearly communicate their goals and intentions, they often only exist for the duration of the study because the researchers simply lack the funding, capacity, and, potentially, interest to further develop and support the app after the study is completed. The implementation of behavior change theories in addition to patient-centered motivational strategies in the design and development of an app seems to hold promise. The outcome of integrating features such as goal setting and problem-solving of barriers could be positive for use. In addition, individualized features such as local eating habits, personalized feedback, and tailored reminder features would likely improve user engagement and adherence.

4.4 Conclusion

This article is part of doctoral research that explores the role design can play in the daily experience of diabetes as a chronic illness. As such, it represents a preliminary study to act as groundwork for fieldwork illuminating how diabetes patients interact with, experience, and use diabetes apps. By using this study as a guideline, a new app will be developed to test the findings. However, the study results can also be used as a basis to provide app developers or designers with recommendations on what to consider when creating or re-designing a commercial app for successful diabetes self-management. There is a need for mobile apps for diabetes self-management with more specific features to increase the number of long-term users and thus influence better diabetes self-management. It might even prompt interest in attempting to integrate a larger variety of behavioral theories, learning theories and/or motivational theories among others, into new commercial app developments. This could act as a novel approach in a market with tough competition. Alternatively, it might prompt developers and

designers to consider a partnership with researchers. This could also be of interest to researchers, as it would allow them to build apps that increase in lifespan and integrate multiple perspectives into the development rather than a pure research outcome focus.

Further, this study can provide other researchers interested in this field with a dataset to build upon to potentially act as a local case study. As such, it can be used by others who would want to understand app development over time. In this regard, it can provide a snapshot of a very specific point in time, or it can act as a local case that can be compared to other countries to understand what apps are available in their local language and how they receive reviews in a local cultural context.

References

1. L. Guariguata, D. R. Whiting, I. Hambleton, J. Beagley, U. Linnenkamp, J. E. Shaw, "Global estimates of diabetes prevalence for 2013 and projections for 2035," *Diabetes Res. Clin. Pract.*, vol. 103, no. 2, pp. 137-149, Feb. 2014.
2. F. J. da Rocha, K. Ogurtsova, U. Linnenkamp, L. Guariguata, T. Seuring, P. Zhang, et al., "IDF Diabetes Atlas estimates of 2014 global health expenditures on diabetes," *Diabetes Res. Clin. Pract.*, vol. 117, pp. 48-54, Jul. 2016.
3. M. T. Schram, C. A. Baan, F. Pouwer, "Depression and quality of life in patients with diabetes: A systematic review from the European depression in diabetes (EDID) research consortium," *Curr. Diabetes Rev.*, vol. 5, no. 2, pp. 112-119, May 2009.
4. E. H. Lin, C. M. Rutter, W. Katon, S. R. Heckbert, P. Ciechanowski, M. M. Oliver, et al., "Depression and advanced complications of diabetes: A prospective cohort study," *Diabetes Care*, 2010 Feb;vol. 33, no. 2, pp. 264-269, Feb. 2010.
5. L. Whitehead, P. Seaton, "The effectiveness of self-management mobile phone and tablet apps in long-term condition management: A systematic review," *J. Med. Internet Res.*, vol. 18, no. 5, p. e97, 2016.
6. S. Goyal, J. A. Cafazzo, "Mobile phone health apps for diabetes management: Current evidence and future developments," *QJM*, vol. 106, no. 12, pp. 1067-1069, Dec. 2013.
7. M. Hood, R. Wilson, J. Corsica, L. Bradley, D. Chirinos, A. Vivo, "What do we know about mobile applications for diabetes self-management? A review of reviews," *J. Behav. Med.*, vol. 39, no. 6, pp. 981-994, Dec. 2016.
8. C. A. Caburnay, K. Graff, J. K. Harris, A. McQueen, M. Smith, M. Fairchild, et al., "Evaluating diabetes mobile applications for health literate designs and functionality," *Prev. Chronic Dis.*, vol. 12, p. E61, 2015.
9. D. C. Klonoff, D. Kerr, "Digital diabetes communication: There's an app for that," *J. Diabetes Sci. Technol.*, vol. 10, no. 5, pp. 1003-1005, Dec. 2016.
10. Statista, App stores: Number of apps in leading app stores 2018, https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores, last accessed 2019/01/29.
11. Directorate for e-Health, https://ehelse.no/english, last accessed 2019/03/20.
12. Research 2 Guidance, mHealth App Developer Economics, http://research2guidance.com/product/mhealth-app-developer-economics-2016, last accessed 2016/10/26.
13. J. Malmlund, F. Behnk, H. Moen, J. P. Suortti, "More than just a phone-A study on Nordic mobile consumer behaviour," *Deloitte Global Mobile Consumer Survey: The Nordic Cut* p. 6, 2017.
14. O. Saadatfard, E. Årsand, "m-health for diabetes management," Fact Sheet No.9/2016, 2016.
15. S. Akter, P. Ray, "MHealth - An ultimate platform to serve the unserved," *Yearbook of Medical Informatics*, vol. 19, no. 1, pp. 94-100, 2010. doi:10.1055/s-0038-1638697.
16. J. Thakkar, R. Kurup, T. Laba, K. Santo, A. Thiagalingam, A. Rodgers, C. K. Chow, "Mobile telephone text messaging for medication adherence in chronic disease," *JAMA Internal Medicine*, vol. 176, no. 3, p. 340, 2016. doi:10.1001/jamainternmed.2015.7667.
17. B. M. Silva, J. J. Rodrigues, I. D. Díez, M. López-Coronado, K. Saleem, "Mobile-health: A review of current state in 2015," *Journal of Biomedical Informatics*, vol. 56, pp. 265-272, 2015.
18. US Department of Health and Human Services, http://www.hrsa.aquilientprojects.com/healthit/mhealth.html, last accessed: 2018/10/17.
19. D. Moher, L. Shamseer, M. Clarke, D. Ghersi, A. Liberati, M. Petticrew, et al., "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement," *Syst. Rev.*, vol. 4, p. 1, Jan. 2015.
20. L. Shamseer, D. Moher, M. Clarke, D. Ghersi, A. Liberati, M. Petticrew, et al., "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation," *BMJ*, vol. 349, p. g7647, Jan. 2015.

21. Nielsen Norman Group, https://www.nngroup.com/articles/usability-101-introduction-to-usability, last accessed 2019/03/23.
22. Department of Human Health and Human Services, https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html, last accessed 2019/03/23.
23. B. Martinez-Perez, I. la de Torre-Dıez, M. Lopez-Coronado, "Mobile health applications for the most prevalent conditions by the World Health Organization: Review and analysis," *Journal of Medical Internet Research*, 2013.
24. Apple Developer, https://developer.apple.com/app-store/review/guidelines, last accessed 2019/03/20.
25. S. Knapp, P. Manroa, K. Doshi, "Self-monitoring of blood glucose: Advice for providers and patients," *Cleveland Clinic Journal of Medicine*, vol. 83, pp. 355-360, 2016.
26. R. G. Miltenberger, *Behavior Modification: Principles and Procedures* (6th ed.). Boston: Cengage Learning, 2015.