The Key Digital-Tool Features of Complex Telehealth Interventions Used for Type 2 Diabetes Self-Management and Monitoring with Health Professional Involvement: A Scoping Review

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Abstract

Background: Therapeutic education and patient self-management are crucial in diabetes prevention and treatment. Improving diabetes self-management requires a multidisciplinary team intervention, nutrition education that facilitates self-management, informed decision-making, and the organization and delivery of appropriate healthcare services. The emergence of telehealth services has provided the public with various tools for educating themselves, and for evaluating, monitoring, and improving their health- and nutrition-related behaviours. Combining health technologies with clinical expertise, social support, and health professional involvement could help persons living with diabetes improve their disease self-management skills and prevent its long-term consequences.

Objective: The primary objective of this scoping review was to identify the key digital-tool features of complex telehealth interventions used for type 2 diabetes or prediabetes self-management and monitoring with health professional involvement that help improve health outcomes. A secondary objective was to identify how these key features are developed and combined.

Methods: A 5-step scoping review methodology following Arksey and O'Malley's methodology was used to map relevant literature published between January 2010 and March 2022. Electronic searches were performed in Medline, CINAHL, and Embase databases. The searches were limited to scientific publications in English and French that either described the conceptual development of a complex telehealth intervention that combined self-management and monitoring with health professional involvement or evaluated its effects on the therapeutic management of patients with type 2 diabetes or prediabetes. Three reviewers independently identified the articles to be reviewed and extracted the data. PRISMA-ScR guidelines have been followed.

Results: This review synthesizes the results of 42 studies on complex telehealth interventions combining diabetes self-management and monitoring with the involvement of at least one health professional. The health professionals participating in these studies were physicians, dietitians, nurses, and psychologists. The digital tools involved were smartphone apps or web-based interfaces that could be used with medical devices (for example, a Bluetooth-connected blood glucose meter). We classified the features of these technologies into eight categories, depending on the intervention objective: 1- Glycemic monitoring, 2- Physical activity monitoring, 3- Medication monitoring, 4- Diet monitoring, 5- Therapeutic education, 6- Health professional support, 7- Other health data monitoring, and 8- Healthcare management. The patient-logged data revealed behaviour patterns that should be modified to improve health outcomes. These technologies, used with health professional involvement, patient self-management and therapeutic education, translate into better glycemic control and the adoption of healthier lifestyles. Likewise, they appear to improve monitoring by health professionals and foster multidisciplinary collaboration through data sharing and the development of more concise, automatically generated reports.

Conclusions: This scoping review synthesizes multiple studies that describe the development and evaluation of complex telehealth interventions used in combination with a healthcare professional's support. It suggests that combining different digital tools that incorporate diabetes self-management and monitoring features with a health professional's advice and interaction results in more effective interventions and outcomes.

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Original Manuscript

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Abstract

Context

Therapeutic education and patient self-management are crucial in diabetes prevention and treatment. Improving diabetes self-management requires a multidisciplinary team intervention, nutrition education that facilitates self-management, informed decision-making, and the organization and delivery of appropriate healthcare services. The emergence of telehealth services has provided the public with various tools for educating themselves, and for evaluating, monitoring, and improving their health- and nutrition-related behaviours. Combining health technologies with clinical expertise, social support, and health professional involvement could help persons living with diabetes improve their disease self-management skills and prevent its long-term consequences.

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The primary objective of this scoping review was to identify the key digital-tool features of complex telehealth interventions used for type 2 diabetes or prediabetes self-management and monitoring with health professional involvement that help improve health outcomes. A secondary objective was to identify how these key features are developed and combined.

Method

A 5-step scoping review methodology following Arksey and O'Malley's methodology was used to map relevant literature published between January 2010 and March 2022. Electronic searches were performed in Medline, CINAHL, and Embase databases. The searches were limited to scientific publications in English and French that either described the conceptual development of a complex telehealth intervention that combined self-management and monitoring with health professional involvement or evaluated its effects on the therapeutic management of patients with type 2 diabetes or prediabetes. Three reviewers independently identified the articles to be reviewed and extracted the data. PRISMA-ScR guidelines have been followed.

Results/Discussion

This review synthesizes the results of 42 studies on complex telehealth interventions combining

diabetes self-management and monitoring with the involvement of at least one health professional. The health professionals participating in these studies were physicians, dietitians, nurses, and psychologists. The digital tools involved were smartphone apps or web-based interfaces that could be used with medical devices (for example, a Bluetooth-connected blood glucose meter). We classified the features of these technologies into eight categories, depending on the intervention objective: 1- Glycemic monitoring, 2- Physical activity monitoring, 3- Medication monitoring, 4- Diet monitoring, 5- Therapeutic education, 6- Health professional support, 7- Other health data monitoring, and 8- Healthcare management. The patient-logged data revealed behaviour patterns that should be modified to improve health outcomes. These technologies, used with health professional involvement, patient self-management and therapeutic education, translate into better glycemic control and the adoption of healthier lifestyles. Likewise, they appear to improve monitoring by health professionals and foster multidisciplinary collaboration through data sharing and the development of more concise, automatically generated reports.

Conclusion

This scoping review synthesizes multiple studies that describe the development and evaluation of complex telehealth interventions used in combination with a healthcare professional’s support. It suggests that combining different digital tools that incorporate diabetes self-management and monitoring features with a health professional’s advice and interaction results in more effective interventions and outcomes.

Keywords

Telehealth, telemedicine, telenutrition, telemonitoring, e-coaching, scoping review, type 2 diabetes, prediabetes, diabetes management, diabetes self-management.

Introduction

Diabetes and nutrition

The prevalence of diabetes in Canada is constantly rising, and related health expenditures are among the highest in the world. In 2018, 8.1% of the Canadian population was living with this disease, and it is predicted that in 2025, five million people will be affected, i.e., 12.1% of the population [1, 2]. According to estimates, type 2 diabetes accounts for 90% of all diabetes diagnoses in the general population, type 1 diabetes for 9%, and other kinds of diabetes for 1% [3]. The prevalence of diabetes has been closely linked to dietary and lifestyle factors prevalent within the country, such as high rates of obesity and sedentary behavior, coupled with a diet often rich in processed foods. However, best practice guidelines suggest that the onset of type 2 diabetes can be delayed or prevented using early lifestyle change interventions. Since prediabetes is characterized by elevated blood glucose levels that do not yet meet the diagnostic criteria for diabetes, the therapeutic management of diabetes and prediabetes are similar [4, 5]. In both cases, a comprehensive approach is required to better control glycemia [12, 13]. Many issues are involved in preventing and achieving better disease control. They require changing lifestyles through education, supporting self-management, and preventing the development and progression of complications [6]. The Canadian Diabetes Association Clinical Practice Guidelines recommend that individuals with diabetes receive personalized nutrition counseling by a registered dietitian to optimize glycemic control and weight management. [3] Strategies include caloric reduction for overweight individuals, incorporation of low-glycemic-index carbohydrates, and adoption of a Mediterranean, Nordic, DASH, or vegetarian diet, as they are rich in protective foods [3]. These interventions are supported by evidence demonstrating improvements in glycated hemoglobin (A1C) levels, metabolic outcomes, and reductions in hospitalization rates. As stated in Diabetes Canada’s clinical practice guidelines, the care offered should be organized around the needs of people with diabetes (and of their families and close friends), as patients must be active participants for optimal engagement in self-managing their condition [4, 6]. This active patient participation must be facilitated by a multidisciplinary team (nurses, dietitians, physicians) that offers education and self-management support. Changing dietary behaviours poses a considerable challenge for people living with diabetes, yet it is a vital means of preventing the associated complications [4]. Monitoring with a dietitian's involvement has proven effective in supporting such behavioural changes [4]. Again according to Diabetes Canada's practice guidelines, all people living with diabetes should receive the services of a dietitian [4]. It has been shown that diet monitoring with a dietitian's involvement can alone reduce glycated hemoglobin levels by 1 to 2% [4]. In addition, recent evidence underscores the advantages of using telehealth to foster adherence to medical recommendations and self-management [4, 5, 7]. The scientific literature has shown the benefits of telehealth in Canada for diabetes management [3, 8]. These technological innovations facilitate patient monitoring and promote the use of different interventions that can support lifestyle changes through, for example, remote support, telemonitoring of glycemic levels, reminders about taking medication, and the use of a food diary. These innovations also allow this information to be shared with the healthcare team. In 2018, the Diabetes Canada Clinical Practice Guidelines advocate for the use of telehealth in disease management programs to improve self-management in underserviced communities and to facilitate consultation with specialized teams, highlighting its effectiveness and the importance of integrating it into shared-care models[3].

Telehealth and diabetes self-management

Telehealth refers to "the use of communications and information technology to deliver health and health care services and information over large and small distances" [9]. In the same field of application, telemedicine refers to the exchange of medical information using information and communication technologies (ICTs) to improve a patient's health condition and is delivered by at least one health professional [10]. Telemedicine services are provided using various means, including the telephone, Internet, email, mobile apps, text messaging, photos, and videos. New technologies are revolutionizing the healthcare field by creating new prospects for various care-delivery modalities [11]. They are thus paving the way to innovations and represent a real benefit in the face of new healthcare challenges, such as the aging population, rising healthcare costs, and the unprecedented challenges posed by pandemics like COVID-19 [12] Particularly in Canada, the public healthcare system faces challenges often associated with overcrowded clinics, long waiting times and limited resources [13]. Through remote consultations and continuous monitoring, telehealth has the potential to relieve pressure on healthcare facilities, improving resource allocation and optimizing patient flow management in the public healthcare system. As such, telehealth would be a pertinent response to public health organizational challenges in the Canadian context, where the universal healthcare system aims to provide equitable and accessible care to all residents.

The day-to-day management of type 2 diabetes can be a complex challenge. Patients must monitor their blood glucose levels regularly, take medication on a precise schedule, adopt a balanced diet and maintain adequate physical activity [13]. However, these requirements can be difficult to meet due to time constraints, lack of knowledge or limited resources. In addition, fluctuations in blood glucose levels can occur unpredictably, increasing the risk of short- and long-term complications [13]. In particular, nutrition plays a fundamental role in diabetes management. Dietary monitoring, nutrition education and the personalization of dietary recommendations are key aspects in optimizing health outcomes for diabetic patients. Using digital technologies, it is possible to offer ongoing, personalized nutrition support, enabling patients to make informed dietary decisions and maintain adequate glycemic control.

Recent evidence points to the enormous potential of using health technologies to facilitate access to care, patient adherence to their treatment plan, and self-management [14]. Many experts point out that diabetes is the chronic disease best adapted to self-management through telehealth [14-19]. Technological innovations have been developed to support lifestyle changes and facilitate patient monitoring. Telehealth offers a range of potential benefits for people with type 2 diabetes. Continuous blood glucose monitoring using connected sensors enables patients to receive real-time information on their blood glucose levels and be alerted to abnormal variations [2, 3]. This enables them to take immediate action to correct blood glucose levels and avoid complications. In addition, telehealth facilitates access to specialized care by enabling patients to consult healthcare professionals remotely. This reduces geographical barriers and enables patients to receive personalized advice, education and support tailored to their specific needs [7]. Regular monitoring and feedback, as well as the use of digital tools, encourage patients to better understand their condition, make informed decisions and improve their quality of life [6]. According to recent systematic reviews and meta-analyses, these telehealth interventions involving every day, web-based, and mobile technologies help reduce glycated hemoglobin levels, allow for better daily glycemic control, increase physical activity, and improve dietary habits [20, 21]. Connected glucose meters enable more convenient and accurate blood glucose monitoring, while online platforms offer an interactive space for education, support, and communication with healthcare professionals [14, 15]. Teleconsultation enables patients to consult their doctors and specialists remotely, reducing travel and time constraints [15, 16].

Combining self-management technologies with clinical expertise, social support, and health professional involvement can allow the development of telehealth solutions better adapted to the therapeutic management of patients. Telehealth interventions using this combination are therefore expanding [22] but also present advantages and limitations [10]. It enables improved care coordination, personalized interventions, and tailored patient education. However, it can lead to an increased workload for healthcare providers and raise data privacy concerns. The tension between interventions focused on service delivery and those involving healthcare providers highlights the importance of striking a balance between patient autonomy and medical expertise. An integrated, collaborative approach between patients and healthcare providers may offer the best digital health outcomes. However, further studies are needed to fill the gaps in the literature, focusing on comparative studies with usual care, evaluation of adherence and long-term accessibility, in order to optimize the use of telehealth in the self-management of type 2 diabetes.

To the best of our knowledge, no literature review has been conducted to identify the key digital-tool features of such interventions. Yet improving knowledge on this subject could advance the development of more effective telehealth interventions for people with diabetes.

The primary objective of this scoping review was to identify the key digital-tool features of complex telehealth interventions used for diabetes self-management and monitoring with health professional involvement that help improve health outcomes. The secondary objective was to identify how these key features should be developed and combined to optimize their contribution to improving health outcomes. While our review draws from the global scientific literature, the intent is to inform the future development of telehealth technologies, with a particular emphasis on the Canadian healthcare context. This focus stems from the recognition that while universal principles may guide the development of digital health tools, the specific features and their implementation must be tailored to meet the unique needs, regulations, and healthcare infrastructure of Canada. Our review aims to explicitly identify the characteristics of digital tools that have been shown to be effective in improving patient engagement, improving self-management, and leading to better health outcomes in diabetes care. By systematically cataloging these characteristics, we can provide a model for the design, development and implementation of future telehealth interventions, provided we nuance specific requirements of the Canadian health care context, such as compliance with telehealth policies. local health care, patient privacy laws, and existing health IT infrastructure. In this study, “improving health outcomes” encompasses both the positive effects of the intervention on behavioural changes (for example, eating healthier foods or doing physical activity) and the positive impact on the health condition (for example, improved glucose levels or blood pressure).

Methods

Scoping reviews exhaustively synthesize the evidence to map a vast, complex, or emerging field of study and identify gaps in the literature, ultimately highlighting priorities for future studies in the field [23]. We chose this method because telehealth has emerged in different formats and offers solutions to various pathologies. We structured our scoping review according to the five steps developed by Arksey and O’Malley [24] and the revisions made by Levac and al. [25], including 1- Identifying the research question, 2- Identifying relevant studies, 3- Studies selection, 4- Charting the data, and 5- Collating, summarizing and reporting the results. The procedure used is described in the following sections, using the PRISMA Extension for Scoping Reviews (Multimedia Appendix 1) checklist as the guidelines to ensure a rigorous and transparent reporting of the methodology and findings [26]. Several additional recommendations made by Levac and al. [25] were also followed : clearly articulate the research question for the scoping review, have two researchers independently review the full articles to determine their inclusion, have the research team collectively develop the data-charting form, and continually extract data.

Identifying the research questions

This review seeks to answer the following research questions: “What are the key digital-tool features of complex telehealth interventions used for diabetes self-management and monitoring with health professional involvement that help improve health outcomes?” How should these key features be developed and combined to help improve health outcomes? These questions stem from the lack of consensus in the scientific literature on the conceptual development, implementation, and evaluation of telehealth solutions. The research questions and objectives were developed based on the research team’s expertise and a preliminary analysis of the literature on the subject. In accordance with scoping review methodology, this review included studies that used different approaches and research designs.

In this review, we apply the World Health Organization (WHO) definition of telemedicine. “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities.” Also, In the context of telehealth technology, the term "features" refers to the various components or tools that enable the various activities associated with remote healthcare delivery.

Studies selection

The search strategy was developed in collaboration with a Université de Montréal librarian specializing in health. The keywords based on telehealth, nutrition, and diabetes were identified by examining relevant articles, their references, and the associated keywords (Multimedia Appendix 2). A systematic search was performed in the Medline, CINAHL, and Embase databases, covering the period from January 2010 to March 2022. Our search efforts were focused on these databases as they are repositories where we can find studies related to health and nutrition. Only articles published since 2010 were selected to account for the widespread adoption of smartphones. By extending our review to cover a decade, we were able to capture the significant developments in mobile applications and smartphone usage, which are pivotal in digital health. We also perused the bibliographies of the included articles to identify any additional studies. Only articles published in peer-reviewed scientific journals were examined. As proposed by the Arksey and O'Malley framework, no quality assessment was performed as it is not deemed essential for exploratory studies [25]. The methodological rigour of the published articles was not an inclusion or exclusion criterion; instead, the articles were examined to substantiate the results and discussion.

Given the rapid development of new technologies, only articles on complex telehealth interventions for managing diabetes carried out in the past 12 years were retained. We used an iterative process to develop inclusion and exclusion criteria during our searches to ensure a selection of studies more closely aligned with the research question. The searches were limited to scientific publications in English and French that either described the conceptual development of a complex telehealth intervention combining self-management and monitoring with health professional involvement or evaluated its effects on the therapeutic management of patients with type 2 diabetes or prediabetes. For inclusion in this review, the complex interventions had to be digital, have a patient interface, and concern type 2 diabetes or prediabetes self-management or monitoring. We excluded studies (i) not using a nutritional approach to investigate telehealth interventions, (ii) involving a single component, (iii) not integrating at least one health professional, (iv) concerning type 1 diabetes or gestational diabetes, (v) involving populations outside the 18+ age group, (v) or lacking empirical data, as were literature reviews. All the search results were merged in the Covidence reference management software, and duplicates were removed [27].

The review team was composed of CM, DG, KVR and BV. These four researchers determined the inclusion of relevant studies based on the title and abstract; CM and BV determined the selection based on the full-text articles. Differences were discussed in detail until a consensus was reached. The full texts of the relevant articles were retrieved for more in-depth analysis (CM).

Charting the data

The research team developed a data extraction table. It included the following information: study characteristics (for example, title, participants, results of interest, and effectiveness), intervention characteristics (for example, a brief description of the intervention, components of self-management, and components of monitoring with health professional involvement, and benefits and limitations of both the intervention and the study according to the authors or reviewers.

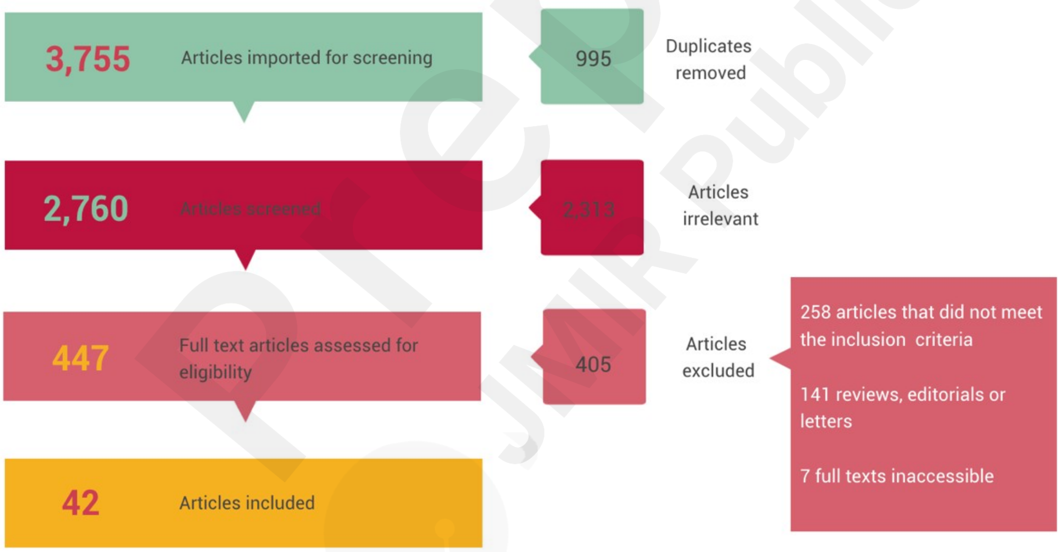
Collecting, summarizing, and reporting the results

Again according to the Arksey and O'Malley's framework [24] and the revisions by Levac et al. [25], descriptive online abstracts and thematic analyses performed with Nvivo 1.7 software were used for data analysis, yielding an approach resembling that of a narrative review. In conducting our thematic analysis, we adopted a qualitative approach to discern the impact of telehealth interventions with healthcare professionals on diabetic patient health outcomes. Through meticulous data immersion and iterative coding, we identified recurring patterns which we then shaped into themes. An initial list of these codes, forming a codebook, was iteratively refined during the data analysis process [28]. Once the codes were established, it enabled a comprehensive review of their interrelationships, aiding in the identification of the key digital-tool features of complex telehealth interventions used for diabetes self-management and monitoring with health professional involvement that help improve health outcomes. These themes were refined against the dataset to ensure coherence and direct relation to our research objectives. By integrating concrete examples from the data, we were able to provide a rich, detailed description of the telehealth features, thereby adding depth to our findings and ensuring they were both representative of real-world practices and aligned with our research questions.

Results

The database searches identified 3,755 articles, of which 995 duplicates were removed. The 2,760 remaining articles underwent the initial screening based on the abstracts and titles; 2,313 were excluded. The full-text screening involved assessing 447 articles, 405 of which were deemed ineligible as the studies either did not meet the inclusion criteria (258 articles) or were literature reviews, editorials, or letters (141 articles), or the full texts were inaccessible (7 articles). A total of 42 articles were ultimately included in this scoping review (Multimedia Appendix 3). The qualitative analysis of the 42 articles using Nvivo 1.7 yielded the coding of 1,520 references, divided among 113 codes.

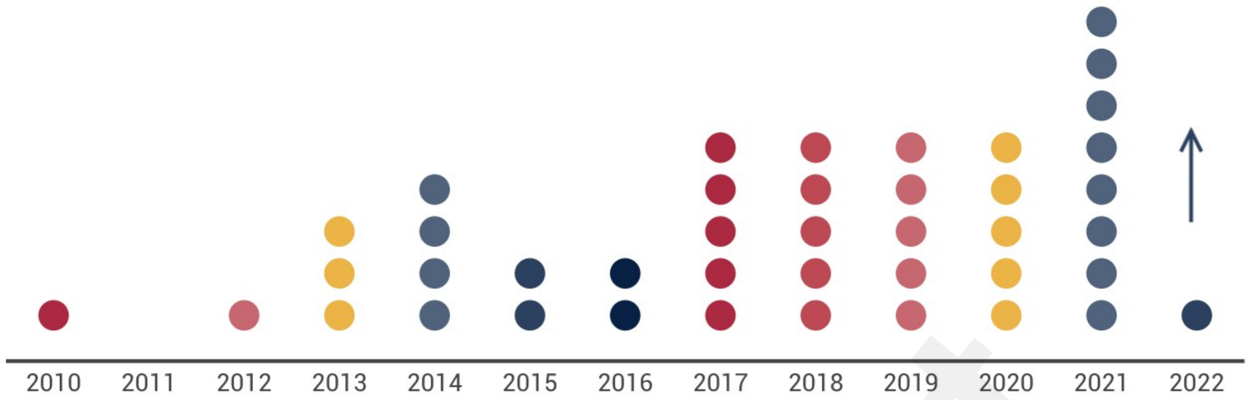
Figure 1. PRISMA



Characteristics of the studies

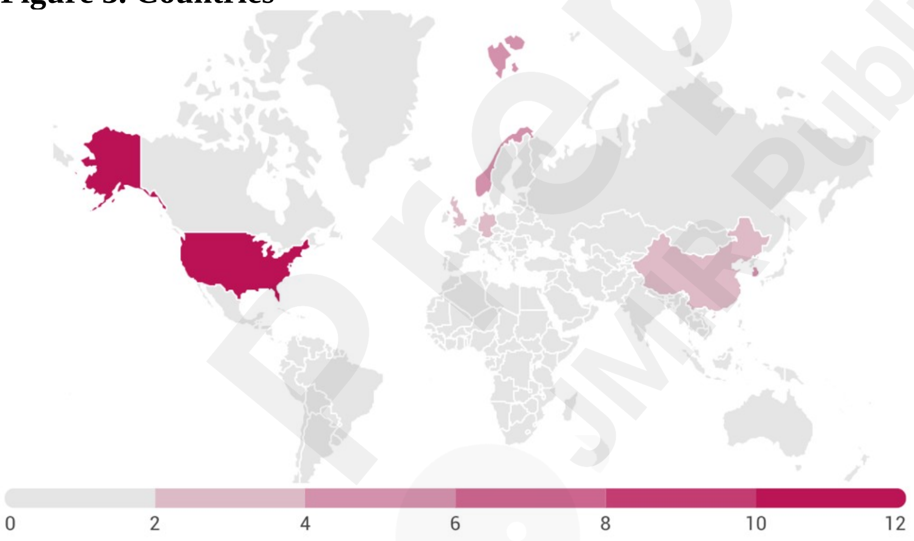
The studies were published between 2010 and 2022, most recently including 28 within the past six years [29-56]. We found that in 2021, nearly twice as many articles were published on the topic as in the preceding years. (Figure 2)

Figure 2. Years of publication



Information on complex telehealth interventions used for diabetes self-management and monitoring with health professional involvement was obtained for 18 countries. Nearly one-quarter of the studies (10/42=24%) were conducted in the United States [30, 31, 39, 48-51, 57-59]. Five of the studies were carried out in South Korea [37, 41, 44, 60, 61], 4 in Singapore [29, 43, 46, 55], 3 in Norway [32, 62, 63], 3 in the United Kingdom [33, 35, 38], 3 in Germany [40, 45, 56], and 2 in China [47, 64]. Of the studies examined, only one was conducted in each of the following countries: Australia [54], South Africa [65], Spain [66], Iran [52], Italy [67], Japan [42], Lebanon [34], Slovenia [36], Switzerland, and Taiwan [68]. (Figure 3)

Figure 3. Countries

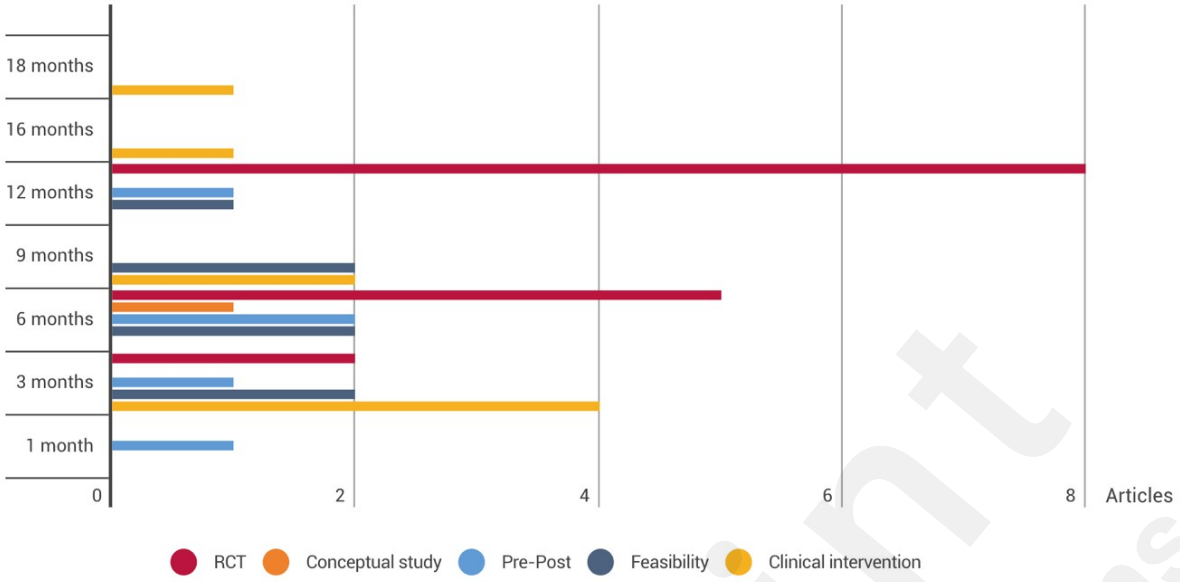


Australia	1
China	2
Germany	3
Iran	1
Italy	1
Japan	1
Lebanon	1
Norway	4
Singapore	4
Slovenia	1
South Africa	1
South Korea	5
Spain	1
Switzerland	1
Taiwan	1
United Kingdom	3
United States	11

General characteristics of the intervention

One-third of the studies were randomized controlled trials (n=14) [35, 36, 40-42, 46, 47, 55, 57-59, 62, 64, 67]. Most of these ranged from 6 months to 1 year in length (12/14= 86%). Twenty percent (20%) were feasibility studies (n=9), with the interventions ranging from 3 months to 1 year in length [33, 38, 39, 43, 44, 51, 53, 56, 69]. Nineteen percent (19%) were interventional studies (n=8), with the interventions ranging from 3 to 18 months [30, 31, 34, 48, 50, 54, 63, 68], and 10% were conceptual studies (n=5) lasting six months [45, 49, 52, 65, 66]. Nine percent (9%) were pre-post studies (n=4) in which the interventions ranged from 1 month to 1 year [29, 37, 60, 61].

Figure 4. Durations of the interventions



Health professionals involved

Twenty-one studies included doctors [29-32, 36, 40-42, 45, 47-51, 53, 58, 60, 64, 66, 68, 70], 16 studies involved dietitians [29, 31, 33, 35, 39, 43, 46, 54, 56, 59, 60, 65, 68, 70-72], 12 studies involved nurses [31, 32, 36, 41, 55, 58-62, 68, 70], four studies involved psychologists [31, 33, 67, 70], four studies involved physical educators [29, 33, 35, 60], and three studies involved case managers [36, 60, 68]. Lastly, 13 studies involved a multidisciplinary team [29, 31-33, 35, 36, 41, 58-60, 68, 70, 71] and 22 involved only one clinician [30, 39, 40, 42, 43, 45-51, 53-56, 61, 62, 64-66, 72] (Multimedia Appendix 4).

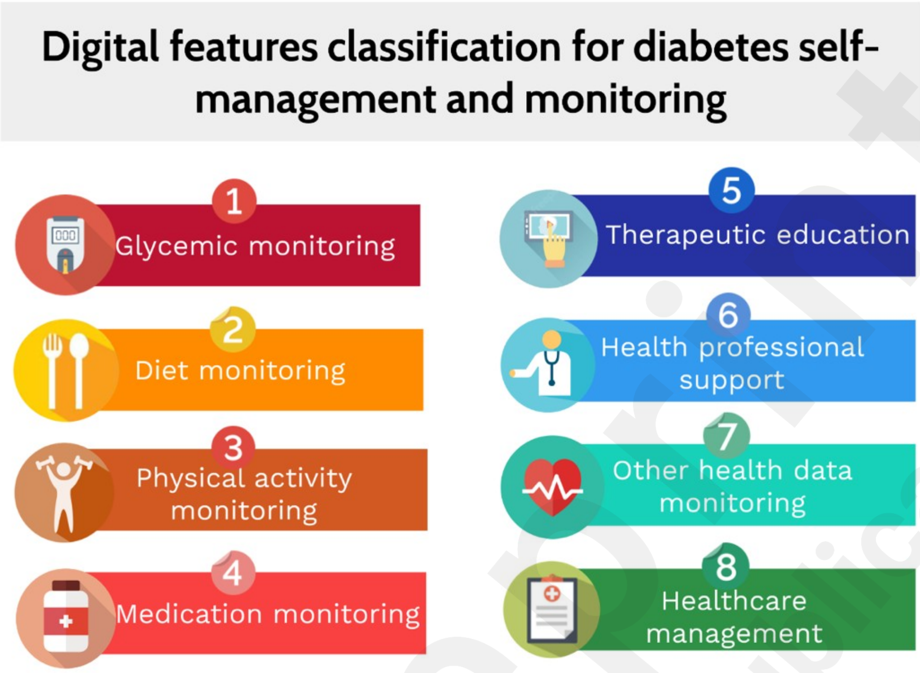
Characteristics of digital self-management

The interventions under study involved the use of a mobile app [29-34, 36-39, 41-46, 49, 51-53, 55, 59-65, 67, 70, 72] and/or a web portal [32, 35, 36, 40-42, 44, 45, 47, 48, 52, 57, 58, 60, 63, 66-68, 72], usually coupled with a blood glucose meter to optimize diabetes self-management [37, 38, 40, 41, 43, 44, 46, 48-51, 53, 55, 57, 59-64, 68, 70]. Other Bluetooth-connected devices were used in some interventions, such as a Bluetooth-connected weight scale [31, 40, 42, 43, 46, 48], a pedometer [40, 43, 45], an accelerometer [33, 42], a Bluetooth-connected smartwatch [49], and a tensiometer [42].

The types of data collected concerned glycemic monitoring, for example, through the visualization of a blood sugar curve over time [29, 32, 37, 38, 41, 43-49, 51-53, 55, 59-66, 68, 70]; physical activity monitoring, for example, using a pedometer [33, 35, 40, 43, 45, 46, 56, 61, 67]; diet monitoring, for example, using a food diary [29-33, 35, 37, 39, 41, 43-45, 47, 49, 52, 53, 55, 56, 59, 61-63, 67, 68, 70]; medication monitoring, though, for example, adherence monitoring, or the possibility of issuing remote prescriptions [30, 50]; and other health data monitoring (weight, body mass index, laboratory tests) [29, 32, 33, 40, 43, 45-47, 53, 56, 60, 65, 66]. Other features made it possible to ensure continuity of care, for example, by generating reports [34, 38, 42, 45, 47, 52, 60, 66, 67, 72], supporting therapeutic patient education, ensuring support from a health professional to help patients learn and develop skills to independently manage their chronic disease and improve their quality of life. [15, 16].

Based on our analysis of the literature, we classified the key digital-tool features that can have a positive impact on intervention outcomes into eight categories: 1- Glycemic monitoring, 2- Diet monitoring, 3- Physical activity monitoring, 4- Medication monitoring, 5- Therapeutic education, 6- Health professional support, 7- Other health data monitoring, and 8- Healthcare management. (Multimedia Appendix 5).

Figure 5. Digital features classification for diabetes self-management and monitoring



Key digital-tool features with positive impacts on the health condition

Glycemic monitoring

Twenty-two studies incorporated a blood glucose meter to precisely monitor glucose levels during interventions. They allowed the visual tracking of blood sugar curves by the patient and health professionals [37, 38, 40, 41, 43, 44, 46, 48-51, 53, 55, 57, 59-64, 68, 70]. Three studies included blood glucose meters permitting real-time continuous glucose monitoring [29, 30, 50].

Four studies included an alert system [36, 52, 68, 73] : "The online diabetes self-management system sent an SMS text message to care providers when the data exceeded the alerting range" [68]. "The application automatically sent users reminders by simple e-mail and SMS: "Please enter your blood sugar /or other parameters/ into the eDiabetes application" [36]. Nine studies included a bolus dosing system [32, 38, 45, 55, 57-59, 66, 74]: "An optional bolus dosing feature was available as an algorithm on the e-diary that allowed the patient to generate a premeal bolus insulin dose" [57]**.** Two studies allowed the remote prescription of real-time continuous glucose monitoring devices (rtCGMs) [30, 50].

The studies used different indicators to collect glycemic control data, such as (i) glycated hemoglobin in 27 studies, monitored through blood tests [29-34, 36, 40, 41, 43, 44, 46-48, 51, 54, 55, 57-60, 62-64, 67, 68, 70]; (ii) blood glucose levels in 24 studies, monitored using data recorded by a blood glucose meter or a blood test [32-34, 36, 40, 41, 43, 44, 46-48, 50, 53-55, 57-60, 63, 64, 66, 68, 70]; and (iii) hypoglycemia events in 4 studies [55, 57, 60, 70], based on self-reports or alert systems after the recording of blood glucose levels with a blood glucose meter. All interventional studies included reported a reduction of between 0.433 mmol/L and 1.554 mmol/L in fasting blood glucose levels. The studies reported a statistically significant decrease in glycated hemoglobin ranging from 0.5 to 1.65% [34, 40, 41, 57, 68], as well as a drop of up to 1.554 mmol/L in blood glucose levels [29-31, 36, 41-44, 46, 48, 56, 57, 59, 61, 62, 68, 70].

Diet monitoring

Thirteen studies included a meal planning system, with features such as generating shopping lists and recipes and calculating caloric intake [29, 31, 35, 38, 43, 44, 46, 48, 49, 52, 53, 65, 68]. Twenty-seven studies included a food diary system that could be shared with the health professional for comment [29-33, 35, 37-39, 41, 43-47, 49, 52, 53, 55, 56, 59, 61-63, 67, 68, 70]. Patients logged their data using a list of foods or by taking photographs. A caloric intake counting feature was available in 11 studies [29, 35, 38, 43, 44, 48, 49, 52, 53, 65, 68]. Five studies included a carbohydrate counting system [32, 46, 49, 53, 66]: “The app provided an automated individualized calorie limit which was computed based on body weight, gender, age and activity level. The total daily carbohydrate intake was restricted to 40% of total daily calories” [46]. “From the nutrition screen, the test persons manually entered carbohydrate values for their meals or scanned products to import the carbohydrate data into the app” [53]. Eighteen studies included pedagogical material, particularly nutrition education and knowledge evaluation [31, 33-37, 46-48, 51, 52, 55, 59, 60, 63, 64, 66, 70]. To collect data on diet, the studies used the data logged on mobile or Internet platforms or obtained from food diaries, 24h reminders, or calorie counting [32, 46, 49, 53, 66]. The health professionals evaluated diet quality using the shared data or validated questionnaires (for example, the Healthy Eating Index). The studies reported a better understanding of nutritional issues, greater confidence in maintaining a healthy diet, and improved dietary behaviour [30, 31, 40, 41, 44, 61, 68, 72].

Physical activity monitoring

Six studies monitored physical activity using a Bluetooth-connected device: Bluetooth-connected watch [49], pedometer [40, 43, 45], or accelerometer [33, 42]. Eight studies used step counting via a Bluetooth-connected pedometer or a smartphone-integrated feature [33, 35, 40, 45, 46, 56, 61, 67]. Sixteen studies included a graphic monitoring tool for monitoring physical activity [29, 32, 35, 37, 41, 43-45, 49, 52, 55, 62-65, 70]. These graphs were generated automatically using pedometer data or following patients’ manual logging of their activities based on a list of predefined physical activities. A caloric expenditure counting feature was often available: “ Type, time, and intensity of any completed physical activity, which could be translated into calories burned—(BCT: prompt self-monitoring of behaviour; provide feedback on performance)” [35]. The studies used data logged on mobile or Internet platforms and obtained from pedometers, accelerometers, or self-reported physical activity diaries to collect physical activity data. These data made it possible to adjust the automated recommendation messages and the messages from the health professionals with whom the data were shared. The studies reported a trend toward increased weekly physical activity due to the technology-motivated engagement [30-38, 41-47, 50, 54, 55, 57, 60, 62-64, 66-68, 70].

Medication monitoring

Sixteen studies included a medication-adherence tracking device, [30, 32, 37, 38, 41, 45, 49, 52, 53, 55, 59, 61, 63-65, 68], 8 of which had a reminder feature [32, 37, 45, 52, 55, 61, 63, 68]. Six studies included an insulin dose-adjustment device used by the health professional or patient (for example, using a bolus dose algorithm) [29, 40, 48, 57, 66, 70]. Regarding the medication data collected, six studies reported medication adjustments [29, 40, 48, 57, 66, 70], seven studies analyzed the monitoring of prescribed insulin doses [30, 32, 55, 57, 58, 66, 68], and five studies administered questionnaires on medication adherence [31, 34, 50, 57, 67]. Lastly, some studies reported decreased oral anti-diabetic doses following the interventions [31, 40, 48, 68].

Therapeutic education

Patients were provided various pedagogical tools to support their therapeutic education in twenty studies [31, 33-37, 43, 46-48, 51, 52, 55, 59, 60, 63, 64, 66, 70, 72]. Of these tools, online course modules were used in 4 studies [43, 48, 63, 66]. Other tools were used to advance nutritional literacy [31, 35, 46, 59], or talked about or referred to relevant articles on topics such as using a blood glucose meter, diabetes complications, physical activity, and tobacco use [33, 35, 36, 43, 46, 48, 52, 55, 59, 66, 70]. Lastly, two studies proposed meditation or mindfulness exercises [51, 55]. Personalized recommendation tools were used in 11 studies [29, 37, 45-48, 51, 52, 60, 63, 66]. These recommendations were either delivered by a health professional following analysis of the patient's logged data, generated automatically by an artificial intelligence algorithm, or planned according to a therapeutic education protocol. The pedagogical materials were often supported by electronic notebook tools where patients could jot down topics to discuss with their health professionals [52, 64, 67].

Health professional involvement

Communication between the health professional and patient was ensured through a chat feature in 13 studies [31, 35, 43, 46, 47, 49, 51, 52, 59, 60, 63, 66, 68], by email in seven studies [31, 33, 36, 43, 66, 67, 69], by text messaging in fourteen studies [29, 36, 37, 41, 42, 44, 48, 54, 58, 62, 63, 67, 68, 70], by phone calls in thirteen studies [31, 33, 40, 48, 55-58, 60, 62, 67, 68, 70], and by videoconferencing in four studies [55, 60, 67, 68].

Thirty-three studies included a tool for displaying patient data [30, 32-37, 39, 41-49, 51-59, 63-66, 68, 70, 72], eleven of them in real-time, in the form of a graphic report. Three studies included a decision support tool [34, 45, 64], while twelve studies included a tool for setting and monitoring therapeutic goals that could be shared by the care provider and patient [29, 32, 33, 37, 45, 46, 53, 59, 61, 63, 68, 70].

Other health data monitoring

The monitoring of other health data concerned with weight loss. Fourteen studies monitored weight using a graphic representation over time [29, 32, 33, 40, 42, 43, 45-47, 53, 56, 60, 65, 66]. Of these studies, six collected automated data using a Bluetooth-connected weight scale [31, 40, 42, 43, 46, 48]. In addition, seven studies enabled the sharing of blood test results [38, 40, 60, 61, 64, 65, 68]. Kobayashi et al. used a Bluetooth-connected tensiometer to transmit blood pressure readings to a cloud-based server, making it possible to summarize and present the data to patients and their primary care physicians to promote self-management, monitoring, and follow-up [42]. The studies reported a statistically significant reduction in weight ranging from 3 to 6.2 kg [29, 40, 43, 46, 56, 60] and in body mass index ranging from 1.6 to 4 kg/m^2 [29, 34, 42, 48, 56, 60].

Healthcare management

Twenty studies included personal spaces in their technologies [31-35, 38, 40, 42, 45, 47, 49, 51-53, 61, 63, 66-68, 72]. In these spaces, it was possible to view a dashboard summarizing the logged health data, monitor exchanges with health professionals, and generate reports that could be shared by the patient and downloaded by the health professionals for inclusion in the medical file [34, 38, 42, 45, 47, 52, 60, 66, 67, 72]. Social support was promoted through links to social networks in six studies [31, 35, 37, 41, 44, 48]. Six other studies included an online appointment scheduling tool, facilitating monitoring and follow-up by the health professionals [32, 33, 35, 53, 64, 67]. Lastly, Holmen et al. made technical support available seven days a week to users of their technology [70].

Combination of interventions

Studies showing significant positive results were combining the involvement of a healthcare professional to monitoring of glycemia, diet, physical activity and medication [41, 57, 61]. One study combined support from a healthcare professional to glycemic, diet, physical activity monitoring, therapeutic education and follow up of body weight [29]. Some studies only added to involvement of a healthcare professional, glycemic and physical activity monitoring [40], glycemic monitoring alone [51, 58], diet and medication monitoring with [31] or without therapeutic education [35], diet monitoring and therapeutic education [72], physical activity and body weight monitoring [42]. Two studies with positive significant results evaluated the combination of a healthcare professional, glycemic, diet and medication monitoring [30] and therapeutic education and body weight follow-up [34]. Most often combined strategies were involvement of a healthcare professional, glycemic and diet monitoring (Multimedia Appendix 6).

Discussion

Results synthesis

This study mapped telehealth interventions aimed at patients with type 2 diabetes supported by a health professional. Despite the range of scientific literature available, the complex nature of these interventions and the heterogeneity of study designs, populations, organizational care contexts, measures, and result indicators used, this review revealed a trend suggesting the effectiveness of telehealth interventions with health professional involvement in improving health outcomes. The use of everyday technologies in these interventions could facilitate their accessibility and usability, which would facilitate their implementation in the longer term. Based on our exploration of the literature, we were able to classify the key features of digital tools that may have a positive effect on intervention outcomes into eight categories: 1- Glycemic monitoring, 2- Diet monitoring, 3- Physical activity monitoring, 4- Medication monitoring, 5- Therapeutic education, 6- Health professional support, 7- Other health data monitoring, 8- Healthcare management. (Figure 5)

Duration of the intervention varied significantly between studies, with interventions ranging from one to 18 months. A recent meta-analysis on the effectiveness of telemedicine applications for chronic diseases found that for people living with type 2 diabetes, HbA1c began to decrease after up to 12 months of telemedicine intervention compared with 6 months interventions [75]. These results were also supported in a study from Timpel and al, where HbA1C began to decrease in participants after 12 months of long-term telemedicine [76]. Given that HbA1c is a recognized indicator of glycemic control over a retrospective period, reflecting average blood glucose levels over about three months, it is regarded as a standard for assessing the effectiveness of long-term diabetes interventions [77]. This measure offers a more stable view of a patient's glycemia than instantaneous measurements, which can be influenced by many immediate factors [77]. Longer interventions could allow for more accurate adjustments in treatments and disease management behaviors, and provide enough time for these changes to result in improvements in glycemic control.

The health professionals involved in these studies were primarily physicians, dietitians, and nurses. Nearly half (n=19) of the studies involved a multidisciplinary care team [29, 31, 34, 37, 38, 41, 44, 48, 50, 52-54, 57-59, 63, 67-69] (Multimedia Appendix 4). The studies showed that health technologies would help optimize the therapeutic education and monitoring of people living with type 2 diabetes through collecting and sharing information between consultations. Care provider personnel would thus be better able to focus on other aspects of their practice during consultations. Some interventions used a videoconferencing platform for consultations with the health professional to make the exchanges more natural and pleasant [55, 60, 67, 68]. A recent narrative review, including 12 randomized controlled trials assessing the effectiveness of telemedicine versus conventional counseling, demonstrated that counseling and monitoring of patients living with diabetes via telemedicine was more effective than conventional counseling [78]. Similarly, health technologies could help improve the efficiency of practical tasks performed by health professionals, for example, by producing more concise, automatically generated reports that can be shared among the care team, thus fostering interdisciplinary monitoring and follow-up. They also offer the possibility of monitoring patients in real-time and sharing targeted information with them, thereby facilitating timely adjustments. Telehealth tools enable continuous monitoring of blood glucose levels, physical activity, diet, medication intake and other health indicators. This enables patients and healthcare providers to quickly detect fluctuations in blood sugar levels and take appropriate action to maintain optimal blood sugar control [1]. The features of telehealth tools can provide personalized recommendations and advice based on each patient's specific data [2]. For example, patients can receive medication reminders, nutritional advice tailored to their dietary preferences and suggestions for physical activities based on their condition and health goals [2]. Telehealth tools offer educational resources and information on type 2 diabetes [3]. Patients can access educational materials, explanatory videos, meal plans and tips to improve their understanding of the disease and its management [3]. This promotes patient empowerment by enabling them to actively participate in the management of their health [3-5]. Telehealth tools can include features such as appointment reminders, food diaries and physical activity logs. These features help patients track their progress, stay engaged with their treatment and maintain their motivation [3, 5].

Our findings are in line with the Chronic Care Model [79]. Telehealth interventions, as observed in our study, frequently incorporate goal-setting tools that empower patients to set and track health-related objectives, aligning with the model's emphasis on self-management support. Additionally, our results underscore the vital role of healthcare professional support within telehealth interventions, enabling remote monitoring and timely guidance, consistent with the model's focus on patient-centered care. Social support emerged in our findings, with patients benefiting from the encouragement of their social networks—a concept aligned with the Chronic Care Model's recognition of involving the patient's social support system. Lastly, our research highlights the inclusion of educational materials in telehealth interventions, providing patients with essential knowledge about their condition, in line with the model's emphasis on patient education. Together, these elements within telehealth strategies contribute to patient empowerment, improved self-management, and enhanced outcomes for chronic condition management, such as diabetes, emphasizing the importance of a comprehensive approach to healthcare delivery, even in remote or virtual settings.

However, there are also potential limitations and challenges associated with the use of telehealth tools for the management of type 2 diabetes. The use of telehealth tools may be limited by Internet access, technological skills, and the availability of the necessary devices [2, 3]. Marginalized or disadvantaged populations may face digital disparities, limiting their ability to benefit fully from these tools. It is thus essential to recognize that some patients may require additional human support. Interaction with healthcare providers may be necessary to answer questions, resolve problems and provide emotional support. Furthermore, the use of telehealth tools involves the collection, storage and sharing of sensitive health data. It is crucial to implement robust security measures to protect data confidentiality and prevent privacy breaches [2, 6]. Telehealth tools use monitoring devices to collect data, such as glucose meters or continuous glucose sensors. However, these devices can have technical limitations and measurement errors, which can affect the accuracy of the data collected and potentially influence treatment decisions [5, 6]. Given that diabetes management is characterized by a long process of therapeutic education, monitoring, and follow-up, technological support would be a helpful asset in primary healthcare as it would help maintain motivation [29, 37, 40, 46, 54, 61, 72] through the use of numerous tools (goal-setting tools and shared decision-making support tools, recipes, informational content, etc.), by facilitating interactions with a health professional, and by promoting access to care (for example, with the possibility of multilingual resources).

Recommendations for future designs

Telehealth offers many opportunities for diabetes self-management and monitoring, enabling patients to benefit from remote care, continuous monitoring and personalized support. The use of continuous glucose monitoring devices, mobile apps, online platforms and other technologies facilitates the collection and tracking of diabetes-related data [7]. The introduction of online educational resources, interactive learning modules and self-help tools to help patients better understand their disease, manage their diet, physical activity, medication, and blood glucose monitoring promotes patient self-management and empowerment [8, 9]. Also, online support via secure messaging to answer patients' questions and concerns supports therapeutic education and keeps them engaged. Indeed, technology developers will need to set up clear and effective communication channels between patients and healthcare professionals. This may include online consultations, secure message exchanges and regular reports on patient progress [9]. Finally, it will be important to consider the integration of these telehealth interventions into existing healthcare systems, ensuring coordination and continuity of care. It will be necessary to ensure that data collected by remote monitoring devices are accessible to healthcare professionals and integrated into patients' medical records [10].

Limitations of included studies

The studies identified in this review involved voluntary patient participation. In particular, the studies favoured individuals with good technology literacy. The selection bias inherent in voluntary patient participation and the preference for tech-literate individuals suggest that the findings might not be generalizable to the broader diabetic population. The indicators used to assess the effectiveness of the interventions were primarily dietary intake, clinical indicators such as glycemia, glycated hemoglobin, blood pressure, cholesterol, physical activity, medication adherence, motivation, and the use of telehealth technology. While positive changes in these indicators were noted in most clinical results, this may translate into something other than rigorous clinical parameters. Different strategies were used to collect data, notably involving innovative digital tools (although the latter did not undergo a validation study). In addition, lifestyle changes (dietary planning, physical activity) were measured using the patient self-administered digital questionnaires, leaving the door open to all biases inherent in self-reporting. A meta-analysis of these data would help inform a position in this regard.

The heterogeneity of the included studies posed a real challenge in interpreting the results. Aside from the various methods used, which yielded different levels of evidence, the interventions were based mainly on effecting behavioural changes through therapeutic education supported by digital tools and a health professional. Yet none of the studies assessed the impact of the context within which these technologies were used, such as concurrent public health policies, on the results (for example, diabetes or obesity prevention campaigns, promotion of a balanced diet, physical activity, or tobacco use).

Moreover, the literature states that 90% of people with diabetes have at least one other chronic disease. Yet few interventions have provided integrated management of diabetes and other pathologies. Specifically, renal and cardiac risks have not always been assessed. The multi-pathological context should be systematically considered when designing studies, as multiple medication use (for example, sulfonylureas, insulin) can cause iatrogenic hypoglycemia and influence the clinical parameters [80-82]. Likewise, the different stages of diabetic severity should be documented to foster a more accurate interpretation of results.

The varying durations of interventions, ranging from one to 18 months, and the differing technologies used, emphasize that outcomes such as HbA1c improvements are not uniform across all studies. The positive association observed with longer interventions and HbA1c reduction may not hold true in every context or for every patient demographic. The role of healthcare professionals in these interventions is undoubtedly significant, but the translation of these findings into practice must consider the individual needs and circumstances of diverse patient populations, including access issues and technological literacy. The integration of everyday technologies appears promising for broader implementation; however, this assumption requires careful consideration of digital disparities that may exist, particularly among marginalized or disadvantaged groups.

Strengths and limitations of this review

To further leverage the qualitative nature of the content analyzed in the studies, we performed a descriptive content analysis of the data using Nvivo 1.7 software. This allowed us to supplement our research with a narrative account of the selected studies. The abundance of literature on the subject attests to a worldwide questioning of digital health policies. The COVID-19 pandemic doubled the number of annual publications on the topic. Given the rapid development of technologies and research, which has only escalated in recent years, a systematic review would help provide invaluable data on the effectiveness of these interventions. This scoping review included studies published in peer-reviewed journals and is thus subject to publication bias due to the well-documented notion that researchers and journals tend to publish positive results. In addition, we limited ourselves to selecting studies published in French or English from 2010 given the rapid pace of technological development and consequent rapid increase in literature. Future researchers should consider more inclusive approaches, such as conducting systematic reviews that encompass gray literature and unpublished studies. This ensures a more comprehensive and unbiased overview of the existing literature on the topic.

The results of this review did not allow us to identify how the eight key digital tool features should be developed and combined to help improve health outcomes. However, the strategies most often combined with telehealth interventions facilitating interaction with health professionals were glycemic, diet and physical activity monitoring. A few studies also included medication monitoring and therapeutic education. Future studies should perform in-depth analyses of the usability and acceptability of these technologies to highlight the design issues and shed light on health policies.

The diversity of interventions analyzed underscores the necessity to acknowledge the unique challenges and issues inherent to each specific population. Such issues can encompass socio-economic factors, cultural differences, accessibility to health services, and varying levels of health literacy, all of which can significantly influence the effectiveness of interventions. For instance, interventions that succeed in urban environments with high connectivity and technologically savvy populations may not yield identical results in rural or low-income areas where internet access and digital literacy are scarce. Moreover, the cultural context may impact patient engagement and the suitability of educational materials. Each population may hold distinct health beliefs, practices, and priorities, which must be considered during the design and implementation of health interventions. Recognizing these disparities is critical to understanding why results from one group cannot be generalized to another. Public health strategies must develop resource allocation policies, and create interventions focused on the users' needs. Hence, while telehealth presents a promising avenue for improving diabetes management, its application must be nuanced and considerate of the public health challenges unique to each specific population to be truly effective and equitable.

Future research prospects

With regard to gaps in the literature, some questions require further research. This scoping review revealed a need for long-term implementation studies, possibly because telehealth programs require a less structured time commitment and could be used over extended periods. Long-term evaluation studies are also needed to facilitate the implementation of telehealth interventions. Further studies on adherence and engagement will explore the factors that influence patients' adherence to telehealth interventions and their engagement in diabetes self-management. These studies will also help to identify effective strategies for encouraging patients' active participation and maintaining their motivation over the long term. Evaluation frameworks should incorporate reports on participant engagement and satisfaction, acceptability, security, and costs into future telehealth interventions, as these will facilitate their translation into clinical practice. In addition, the measurement of the effects of interventions should include measures other than clinical data, such as PREMs and PROMs to ensure that these interventions are meeting the needs of patients. Also, multimorbidity was rarely mentioned in the studies and warrants further research to assess the impact of these interventions on health. Additional studies could define standardized assessment criteria for telehealth interventions that support the therapeutic management of patients with diabetes and multiple comorbidities. The impact of telehealth interventions on equity of access to care for vulnerable populations, including low-income populations, rural or remote populations and culturally diverse groups will need to be studied. A better understanding of these impacts will help identify potential barriers and strategies to reduce disparities and improve equitable access to telehealth [10]. Finally, it will be vital to evaluate the effectiveness of integrating telehealth interventions into existing healthcare systems, including collaboration between healthcare professionals, data sharing and care coordination. This will help distinguish best practices for successful integration of telehealth into clinical care and existing healthcare systems [10]. Three studies assessed the impact on the cost of care [48, 58, 64]. The macroeconomic implications of these telehealth interventions on healthcare systems warrant future studies to shed clearer light on health policies. Lastly, the COVID-19 pandemic has revealed the various structural and organizational shortcomings of healthcare around the globe. It has also accelerated the dissemination and adoption of digital tools and advanced the digital ambitions of governments worldwide. The abundance of publications means that future studies can perform a meta-analysis of randomized controlled trials. The analysis underscores the critical role of multidisciplinary healthcare teams and promotes the integration of ubiquitous technologies into daily health management practices to achieve superior patient outcomes. Furthermore, this review stresses the necessity of considering the long-term viability, patient adherence, and the seamless incorporation of telehealth solutions into current healthcare frameworks in subsequent research.

Finally, the results of this scoping review, while derived from international research, were not found to include studies conducted in Canada, indicating an opportunity for research tailored to the Canadian context. For the implementation of future telehealth interventions to improve diabetes management in Canada, it is recommended to consider the specificities of the Canadian healthcare system, such as the heterogeneity of its organization across different provinces, the diversity of its population, and its varied health resources. It would be wise to design personalized interventions that address the unique needs of diabetic patients within the Canadian population, particularly in indigenous communities that are disproportionately affected by diabetes, including linguistic and cultural considerations. Strategies for equitable access to telehealth technologies for marginalized or remote populations should also be considered. Training healthcare professionals in telehealth tools and best practices for virtual care is equally essential. Moreover, interdisciplinary and intersectoral collaboration would be beneficial to effectively integrate telehealth into primary care, allowing for coordinated and consistent follow-up. Lastly, by anticipating challenges related to privacy and data security, interventions should incorporate robust security measures to protect sensitive patient information, while focusing on a personalized approach and the development of patient-centered interventions and technologies.

Conclusion

This review systematically maps out the effectiveness of telehealth interventions for managing type 2 diabetes, with a focus on the enhanced outcomes gained through the involvement of healthcare professionals. It presents a detailed categorization of the pivotal characteristics of digital tools into eight distinct areas that significantly influence the success of these interventions. The evidence-based data suggest that participation in sustained telehealth interventions with health professional involvement helps improve health outcomes and type 2 diabetes-related behaviour, reducing the risks of complications. However, despite our identification of the key digital-tool features of these interventions, it remains to be seen how to combine and translate them into long-term usable parts in specific care contexts. The results are nonetheless promising for future healthcare, as they point to consolidating care through a single platform, which could improve patients' quality of life while encouraging active self-management. They also shed light on developing evidence-based telehealth programs that can be adapted to specific care contexts and offer decision-makers more effective options for funding diabetes management programs. Ultimately, this review aims to enrich the understanding of telehealth's role in diabetes care and to outline specific domains for future research that will inform policy-making and the advancement of telehealth practices.

Conflicts of Interest

None declared.

Abbreviations

BMI : Body Mass Index
EDI : Eating Disorder Inventory
HbA1c : Hemoglobin A1C

PREMs : Patient-reported experience measures
PROMs : Patient-reported outcomes measures
rtCGMs : Real-time continuous glucose monitoring devices
SDSCA : Summary of Diabetes Self-Cares Activities

Multimedia Appendix 1 [PRISMA-ScR]

Multimedia Appendix 2 [Search Statement]

Multimedia Appendix 3 [Data extraction table]

Multimedia Appendix 4 [Health professionals involvment]

Multimedia Appendix 5 [Digital features of the interventions]

Multimedia Appendix 6 [Studies showing significant positive health outcomes]

References

1. Wild, S., et al., *Global prevalence of diabetes: estimates for the year 2000 and projections for 2030*. Diabetes care, 2004. **27**(5): p. 1047-1053.
2. Atlas, D., *International diabetes federation*. IDF Diabetes Atlas, 7th edn. Brussels, Belgium: International Diabetes Federation, 2015. **33**.
3. Canada, D., *Diabetes Canada 2018 clinical practice guidelines for the prevention and management of diabetes in Canada*. 2018: Diabetes Canada.
4. Ivers, N.M., et al., *Diabetes Canada 2018 clinical practice guidelines: key messages for family physicians caring for patients living with type 2 diabetes*. Canadian Family Physician, 2019. **65**(1): p. 14-24.
5. Association, T.A.D., *6. Glycemic Targets: Standards of Medical Care in Diabetes—2022*. Diabetes Care, 2022. **45**: p. S83.
6. Nathan, D., *for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) study research group. Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes.* N Engl J Med, 2005. **353**: p. 2643-2653.
7. Toma, T., et al., *Online social networking services in the management of patients with diabetes mellitus: systematic review and meta-analysis of randomised controlled trials*. Diabetes research and clinical practice, 2014. **106**(2): p. 200-211.
8. Smith, A.C., et al., *Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19)*. Journal of telemedicine and telecare, 2020. **26**(5): p. 309-313.
9. Picot, J. and T. Cradduck, *The telehealth industry in Canada*. Industry Canada, Ottawa, 1997.
10. KAIRY, D., *Telereeducation, telereadaptation et e-sante: definition, evolution et diversite des points de vue sur ces concepts.* Actualites en Medecine Physique et de Readaptation,

2017. **1**: p. 6–7.
11. Yaya, S. and C. Raffelini, *Technological transformations and evolution of the medical practice: current status, issues and perspectives for the development of telemedicine*. Revue medicale de Bruxelles, 2009. **30**(2): p. 83-91.
12. Bhattacherjee, A., et al., *The differential performance effects of healthcare information technology adoption*. Information Systems Management, 2006. **24**(1): p. 5-14.
13. Kabir, M.J., et al., *Challenges in the implementation of an electronic referral system: A qualitative study in the Iranian context*. The International Journal of Health Planning and Management, 2023. **38**(1): p. 69-84.
14. Ramadas, A., et al., *Web-based interventions for the management of type 2 diabetes mellitus: a systematic review of recent evidence*. International journal of medical informatics, 2011. **80**(6): p. 389-405.
15. Crosson, J.C., et al., *Typical electronic health record use in primary care practices and the quality of diabetes care*. The Annals of Family Medicine, 2012. **10**(3): p. 221-227.
16. Tenforde, M., et al., *The association between personal health record use and diabetes quality measures*. Journal of general internal medicine, 2012. **27**(4): p. 420-424.
17. Marcolino, M.S., et al., *Telemedicine application in the care of diabetes patients: systematic review and meta-analysis*. PloS one, 2013. **8**(11): p. e79246.
18. Malanda, U.L., et al., *Self-monitoring of blood glucose in patients with type 2 diabetes mellitus who are not using insulin*. Cochrane Database of Systematic Reviews, 2012(1).
19. Pal, K., et al., *Computer-based diabetes self-management interventions for adults with type 2 diabetes mellitus*. Cochrane Database of Systematic Reviews, 2013(3).
20. Howland, C. and B. Wakefield, *Assessing telehealth interventions for physical activity and sedentary behavior self-management in adults with type 2 diabetes mellitus: An integrative review*. Research in nursing & health, 2021. **44**(1): p. 92-110.
21. Anderson, A., et al., *Telehealth interventions to improve diabetes management among Black and Hispanic patients: A systematic review and meta-analysis*. Journal of racial and ethnic health disparities, 2022: p. 1-12.
22. Draznin, B., et al., *7. Diabetes Technology: Standards of Medical Care in Diabetes-2022*. Diabetes Care, 2022. **45**(Supplement_1): p. S97-S112.
23. May, C.R., et al., *Integrating telecare for chronic disease management in the community: what needs to be done?* BMC health services research, 2011. **11**(1): p. 1-11.
24. Arksey, H. and L. O'Malley, *Scoping studies: towards a methodological framework*. International journal of social research methodology, 2005. **8**(1): p. 19-32.
25. Levac, D., H. Colquhoun, and K.K. O'Brien, *Scoping studies: advancing the methodology*. Implementation science, 2010. **5**(1): p. 69.
26. Page, M., et al., *The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 372: n71. doi: 10.1136/bmj. n71*. Go to original source... Go to PubMed, 2021.
27. Babineau, J., *Product review: covidence (systematic review software)*. Journal of the Canadian Health Libraries Association/Journal de l'Association des bibliothèques de la santé du Canada, 2014. **35**(2): p. 68-71.
28. Mak, S. and A. Thomas, *Steps for conducting a scoping review*. Journal of Graduate Medical Education, 2022. **14**(5): p. 565-567.
29. Ang, I.Y.H., et al., *A Personalized Mobile Health Program for Type 2 Diabetes During the COVID-19 Pandemic: Single-Group Pre–Post Study*. JMIR diabetes, 2021. **6**(3): p. e25820.
30. Bergenstal, R.M., et al., *Remote Application and Use of Real-Time Continuous Glucose Monitoring by Adults with Type 2 Diabetes in a Virtual Diabetes Clinic*. Diabetes technology &

therapeutics, 2020(100889084, d3x).
31. Berman, M.A., et al., *Change in Glycemic Control With Use of a Digital Therapeutic in Adults With Type 2 Diabetes: Cohort Study*. JMIR diabetes, 2018. **3**(1): p. e4.
32. Bradway, M., et al., *Measuring the Effects of Sharing Mobile Health Data During Diabetes Consultations: Protocol for a Mixed Method Study*. JMIR research protocols, 2020. **9**(2): p. e16657.
33. Cassidy, S., et al., *Assessing the feasibility and acceptability of Changing Health for the management of prediabetes: Protocol for a pilot study of a digital behavioural intervention*. Pilot and Feasibility Studies, 2019. **5**(1): p. 139.
34. Doocy, S., 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 and uHealth, 2017. **5**(10): p. e158.
35. Haste, A., et al., *Web-Based Weight Loss Intervention for Men With Type 2 Diabetes: Pilot Randomized Controlled Trial*. JMIR diabetes, 2017. **2**(2): p. e14.
36. Iljaz, R., et al., *E-healthcare for Diabetes Mellitus Type 2 Patients - A Randomised Controlled Trial in Slovenia*. Zdravstveno varstvo, 2017. **56**(3): p. 150-157.
37. Jeon, E. and H.-A. Park, *Experiences of Patients With a Diabetes Self-Care App Developed Based on the Information-Motivation-Behavioral Skills Model: Before-and-After Study*. JMIR diabetes, 2019. **4**(2): p. e11590.
38. Johnston, P., *Monitoring of blood glucose levels, ketones and insulin bolus advice using 4SURE products and app-based technology*. British Journal of Nursing, 2022. **31**(1): p. 34-39.
39. Jung, H., et al., *A Novel Food Record App for Dietary Assessments Among Older Adults With Type 2 Diabetes: Development and Usability Study*. JMIR formative research, 2021. **5**(2): p. e14760.
40. Kempf, K., et al., *Efficacy of the Telemedical Lifestyle intervention Program TeLiPro in Advanced Stages of Type 2 Diabetes: A Randomized Controlled Trial*. Diabetes care, 2017. **40**(7): p. 863-871.
41. Lee, D.Y., et al., *Effect of Voluntary Participation on Mobile Health Care in Diabetes Management: Randomized Controlled Open-Label Trial*. JMIR mHealth and uHealth, 2020. **8**(9): p. e19153.
42. Kobayashi, T., et al., *Automated Feedback Messages With Shichifukujin Characters Using IoT System-Improved Glycemic Control in People With Diabetes: A Prospective, Multicenter Randomized Controlled Trial*. Journal of Diabetes Science and Technology, 2019. **13**(4): p. 796-798.
43. Koot, D., et al., *A Mobile Lifestyle Management Program (GlycoLeap) for People With Type 2 Diabetes: Single-Arm Feasibility Study*. JMIR mHealth and uHealth, 2019. **7**(5): p. e12965.
44. Ku, E.J., et al., *Clinical efficacy and plausibility of a smartphone-based integrated online real-time diabetes care system via glucose and diet data management: a pilot study*. Internal medicine journal, 2020. **50**(12): p. 1524-1532.
45. Lamprinos, I., et al., *Modular ICT-based patient empowerment framework for self-management of diabetes: Design perspectives and validation results*. International journal of medical informatics, 2016. **91**(ct4, 9711057): p. 31-43.
46. Lim, S.L., et al., *Effect of a smartphone app on weight change and metabolic outcomes in asian adults with type 2 diabetes: a randomized clinical trial*. JAMA network open, 2021. **4**(6): p. e2112417-e2112417.
47. Liu, Y., Z. Yu, and H. Sun, *Treatment effect of type 2 diabetes patients in outpatient department based on blockchain electronic mobile medical app*. Journal of Healthcare

Engineering, 2021. **2021**.
48. McKenzie, A.L., et al., *A Novel Intervention Including Individualized Nutritional Recommendations Reduces Hemoglobin A1c Level, Medication Use, and Weight in Type 2 Diabetes*. JMIR diabetes, 2017. **2**(1): p. e5.
49. Modave, F., et al., *DiaFit: The Development of a Smart App for Patients with Type 2 Diabetes and Obesity.* JMIR diabetes, 2016. **1**(2).
50. Polonsky, W.H., et al., *Impact of participation in a virtual diabetes clinic on diabetes-related distress in individuals with type 2 diabetes.* Clinical Diabetes, 2020. **38**(4): p. 357-362.
51. Quinn, C.C., et al., *Mobile Diabetes Intervention Study of Patient Engagement and Impact on Blood Glucose: Mixed Methods Analysis.* JMIR mHealth and uHealth, 2018. **6**(2): p. e31.
52. Salari, R., et al., *Mobile-based and cloud-based system for self-management of people with type 2 diabetes: Development and usability evaluation.* Journal of medical Internet research, 2021. **23**(6): p. e18167.
53. Schmocker, K.S., F.S. Zwahlen, and K. Denecke, *Mobile App for Simplifying Life With Diabetes: Technical Description and Usability Study of GlucoMan.* JMIR diabetes, 2018. **3**(1): p. e6.
54. Schusterbauer, V., et al., *Two-Stage Evaluation of a Telehealth Nutrition Management Service in Support of Diabesity Therapy.* Studies in health technology and informatics, 2018. **248**(ck1, 9214582): p. 314-321.
55. Wang, W., et al., *A randomized controlled trial on a nurse-led smartphone-based self-management programme for people with poorly controlled type 2 diabetes: A study protocol.* Journal of advanced nursing, 2018. **74**(1): p. 190-200.
56. Zaharia, O.P., et al., *Improving insulin sensitivity, liver steatosis and fibrosis in type 2 diabetes by a food-based digital education-assisted lifestyle intervention program: a feasibility study.* European Journal of Nutrition, 2021. **60**(7): p. 3811-3818.
57. Bastyr, E.J., 3rd, et al., *Performance of an Electronic Diary System for Intensive Insulin Management in Global Diabetes Clinical Trials.* Diabetes technology & therapeutics, 2015. **17**(8): p. 571-9.
58. Levy, N.K., et al., *The mobile insulin titration intervention (MITI) study: Innovative chronic disease management of diabetes.* Journal of General Internal Medicine, 2015. **30**(SUPPL. 2): p. S547-S548.
59. Tang, P.C., et al., *Online disease management of diabetes: engaging and motivating patients online with enhanced resources-diabetes (EMPOWER-D), a randomized controlled trial.* Journal of the American Medical Informatics Association : JAMIA, 2013. **20**(3): p. 526-34.
60. Chung, Y.-S., Y. Kim, and C.H. Lee, *Effectiveness of the smart care service for diabetes management.* Healthcare informatics research, 2014. **20**(4): p. 288-94.
61. Kim, Y., H. Lee, and J.M. Seo, *Integrated diabetes self-management program using smartphone application: a randomized controlled trial.* Western journal of nursing research, 2022. **44**(4): p. 383-394.
62. Torbjornsen, A., et al., *A Low-Intensity Mobile Health Intervention With and Without Health Counseling for Persons With Type 2 Diabetes, Part 1: Baseline and Short-Term Results From a Randomized Controlled Trial in the Norwegian Part of RENEWING HEALTH.* JMIR mHealth and uHealth, 2014. **2**(4): p. e52.
63. Nes, A.A.G., et al., *The development and feasibility of a web-based intervention with diaries and situational feedback via smartphone to support self-management in patients with diabetes type 2.* Diabetes research and clinical practice, 2012. **97**(3): p. 385-93.
64. Jia, W., et al., *Study protocol for the road to hierarchical diabetes management at primary care (ROADMAP) study in China: A cluster randomised controlled trial.* BMJ Open, 2020.

10(1): p. e032734.
65. Esau, N., N. Koen, and M.G. Herselman, *Adaptation of the RenalSmartÂ® web-based application for the dietary management of patients with diabetic nephropathy*. South African Journal of Clinical Nutrition, 2013. **26**(3): p. 132-140.
66. Hidalgo, J.I., et al., *glUCModel: a monitoring and modeling system for chronic diseases applied to diabetes*. Journal of biomedical informatics, 2014. **48**(100970413, d2m): p. 183-92.
67. Castelnuovo, G., et al., *TECNOB: study design of a randomized controlled trial of a multidisciplinary telecare intervention for obese patients with type-2 diabetes*. BMC public health, 2010. **10**(100968562): p. 204.
68. Chen, L., et al., *Evaluating self-management behaviors of diabetic patients in a telehealthcare program: longitudinal study over 18 months*. Journal of medical Internet research, 2013. **15**(12): p. e266.
69. Bradway, M., et al., *Analysing mHealth usage logs in RCTs: Explaining participants' interactions with type 2 diabetes self-management tools*. PloS one, 2018. **13**(8): p. e0203202.
70. Holmen, H., et al., *A Mobile Health Intervention for Self-Management and Lifestyle Change for Persons With Type 2 Diabetes, Part 2: One-Year Results From the Norwegian Randomized Controlled Trial RENEWING HEALTH*. JMIR mHealth and uHealth, 2014. **2**(4): p. e57.
71. Castelnuovo, G., et al., *TECNOB Study: Ad Interim Results of a Randomized Controlled Trial of a Multidisciplinary Telecare Intervention for Obese Patients with Type-2 Diabetes*. Clinical practice and epidemiology in mental health : CP & EMH, 2011. **7**(101245735): p. 44-50.
72. Chang, A.R., et al., *Effects of dietary app-supported tele-counseling on sodium intake, diet quality, and blood pressure in patients with diabetes and kidney disease*. Circulation, 2019. **139**(Supplement 1).
73. Bird, D., et al., *Randomised controlled trial of an automated, interactive telephone intervention to improve type 2 diabetes self-management (Telephone-Linked Care Diabetes Project): study protocol*. BMC public health, 2010. **10**(100968562): p. 599.
74. Kesavadev, J., et al., *Telemedicine for diabetes care: An Indian perspective - feasibility and efficacy*. Indian journal of endocrinology and metabolism, 2015. **19**(6): p. 764-9.
75. Ma, Y., et al., *Telemedicine application in patients with chronic disease: a systematic review and meta-analysis*. BMC Medical Informatics and Decision Making, 2022. **22**(1): p. 1-14.
76. Timpel, P., et al., *Mapping the evidence on the effectiveness of telemedicine interventions in diabetes, dyslipidemia, and hypertension: an umbrella review of systematic reviews and meta-analyses*. Journal of medical Internet research, 2020. **22**(3): p. e16791.
77. Sherwani, S.I., et al., *Significance of HbA1c test in diagnosis and prognosis of diabetic patients*. Biomarker insights, 2016. **11**: p. BMI. S38440.
78. Kusuma, C.F., et al., *A review of the effectiveness of telemedicine in glycemic control in diabetes mellitus patients*. Medicine, 2022. **101**(48): p. e32028.
79. Bodenheimer, T., E.H. Wagner, and K. Grumbach, *Improving primary care for patients with chronic illness*. Jama, 2002. **288**(14): p. 1775-1779.
80. Nourine, I., *Influence des comorbidités sur la prise en charge du diabète de type 2 de la personne âgée*. 2016, Université de Lorraine.
81. uk, U.H.S.G.s.h.s.a., *Risk of hypoglycaemia in types 1 and 2 diabetes: effects of treatment modalities and their duration*. Diabetologia, 2007. **50**: p. 1140-1147.
82. Budnitz, D.S., et al., *Emergency hospitalizations for adverse drug events in older Americans*. New England Journal of Medicine, 2011. **365**(21): p. 2002-2012.

Supplementary Files

Figures

Prisma.

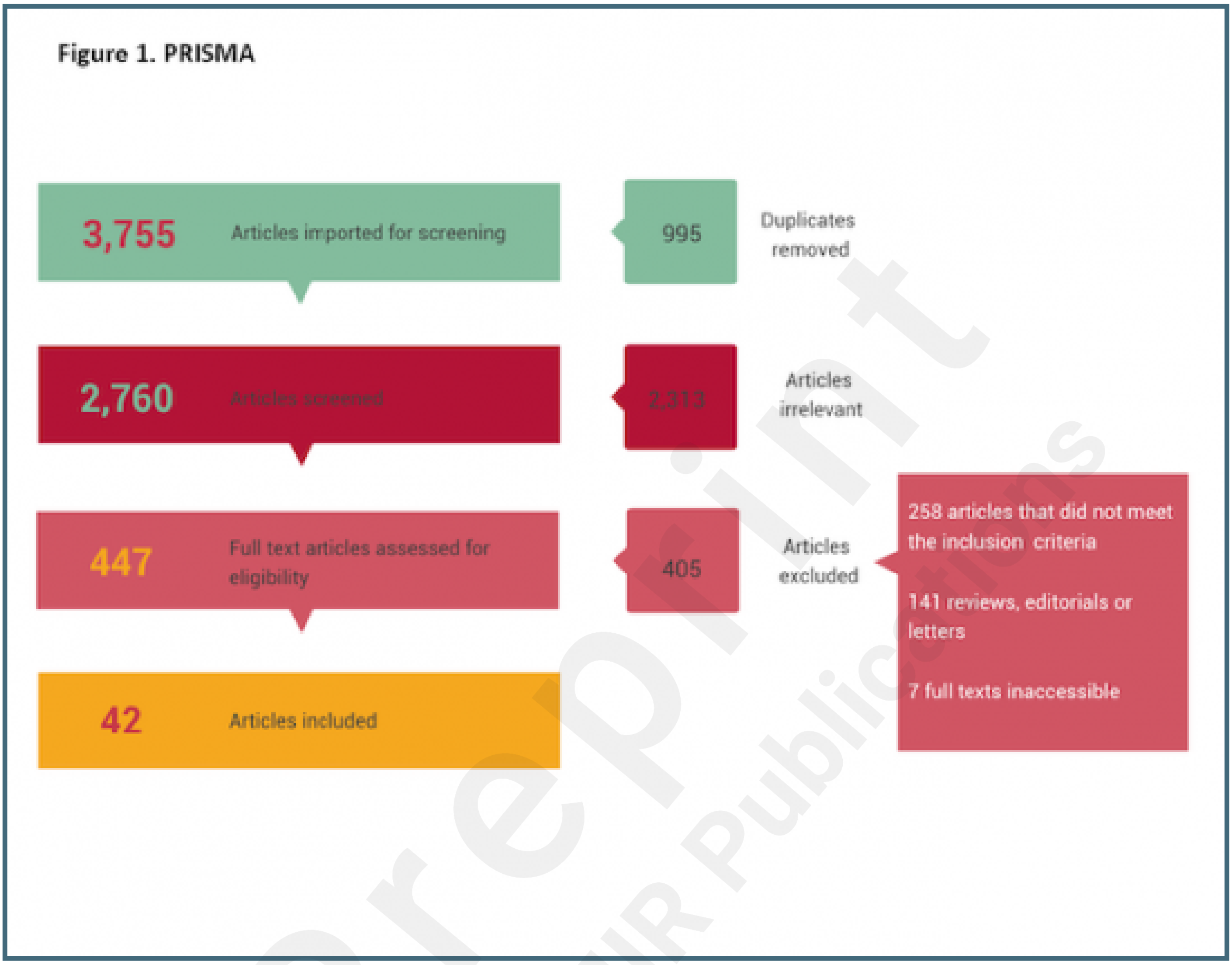
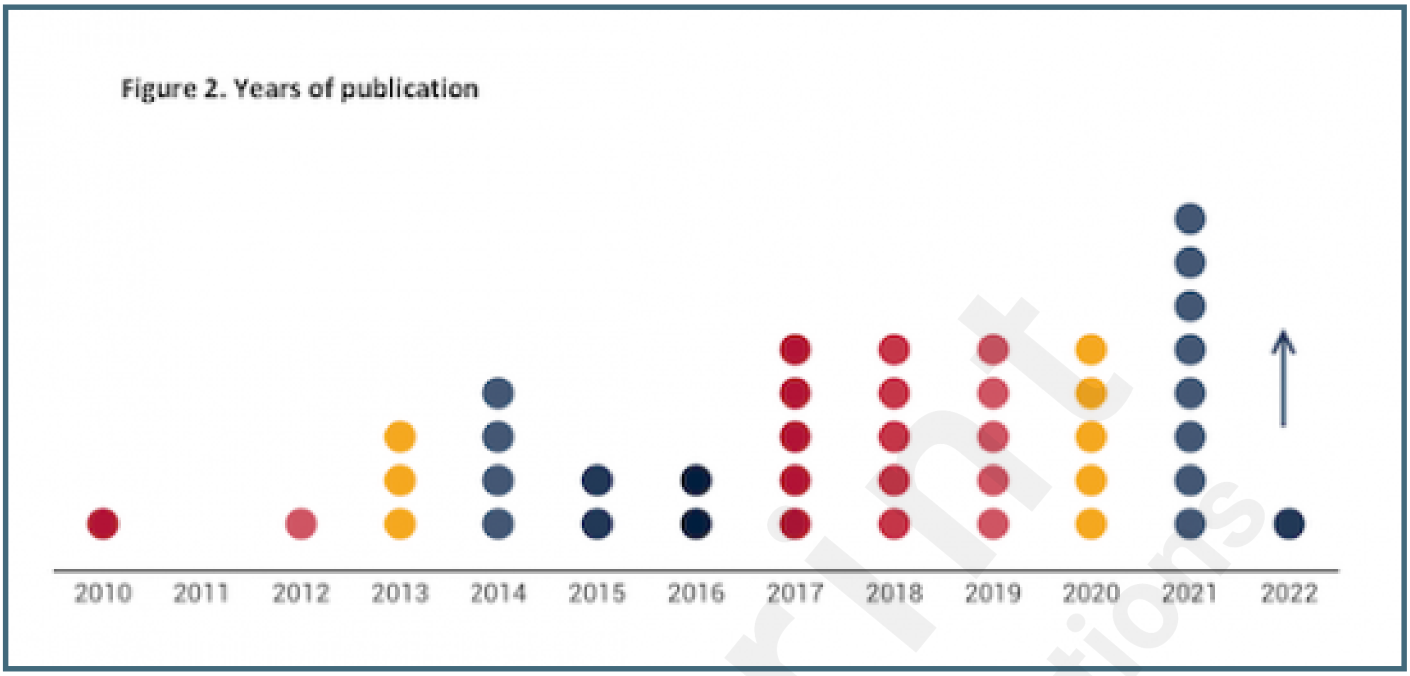


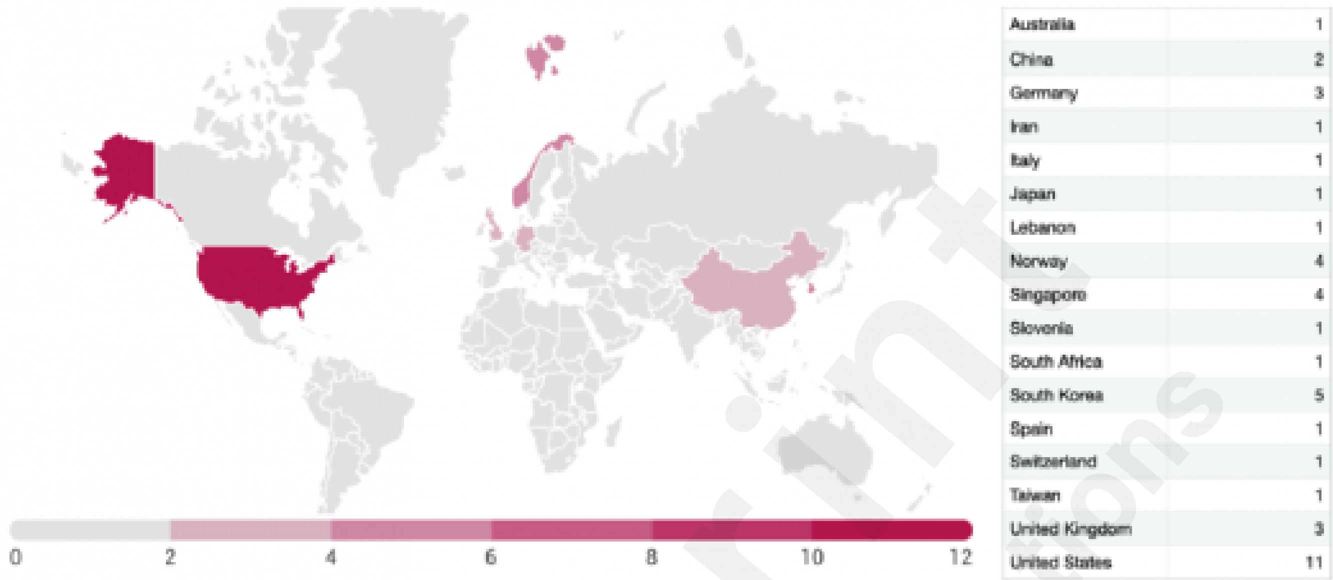
Figure 1. PRISMA

Years of publication.

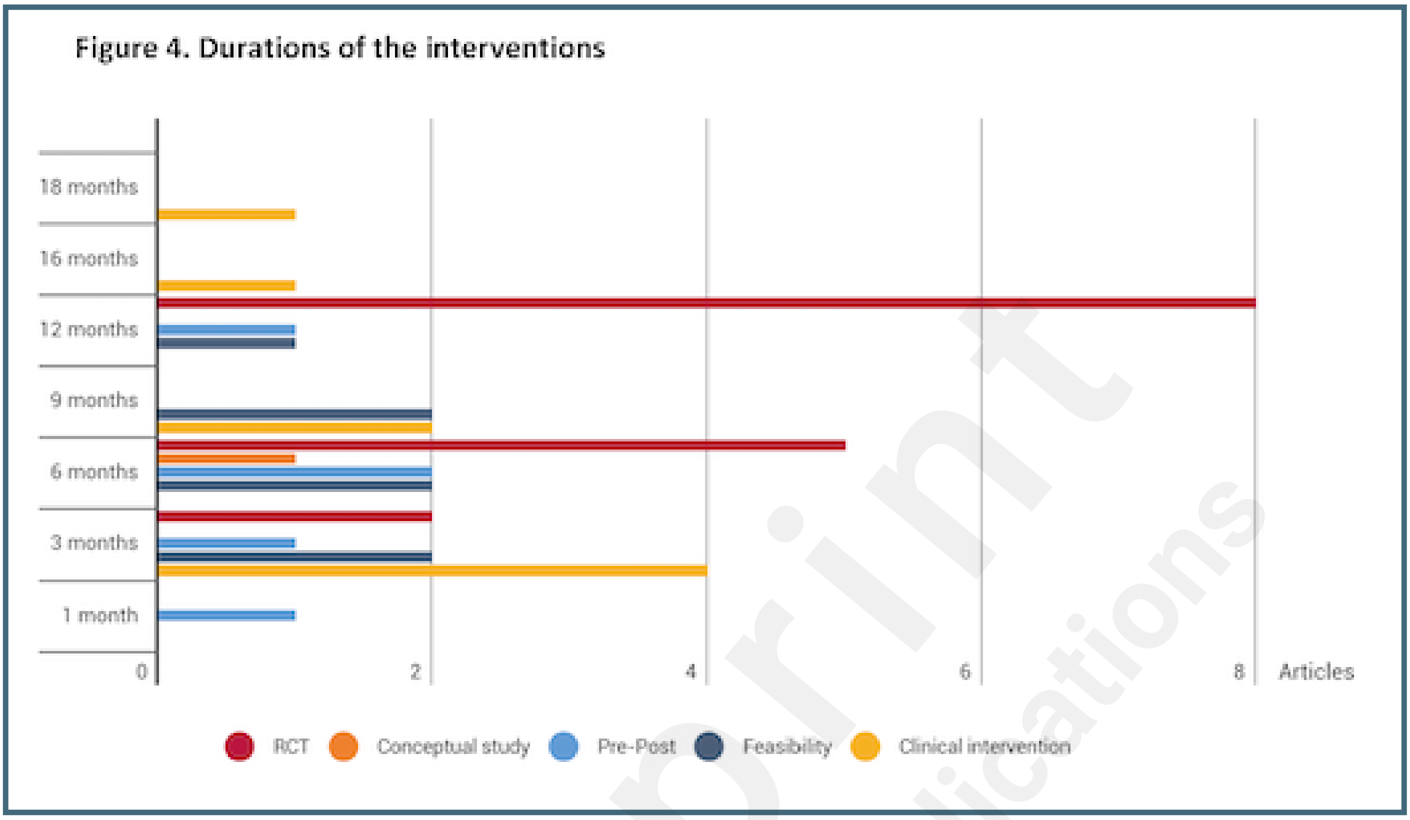


Countries.

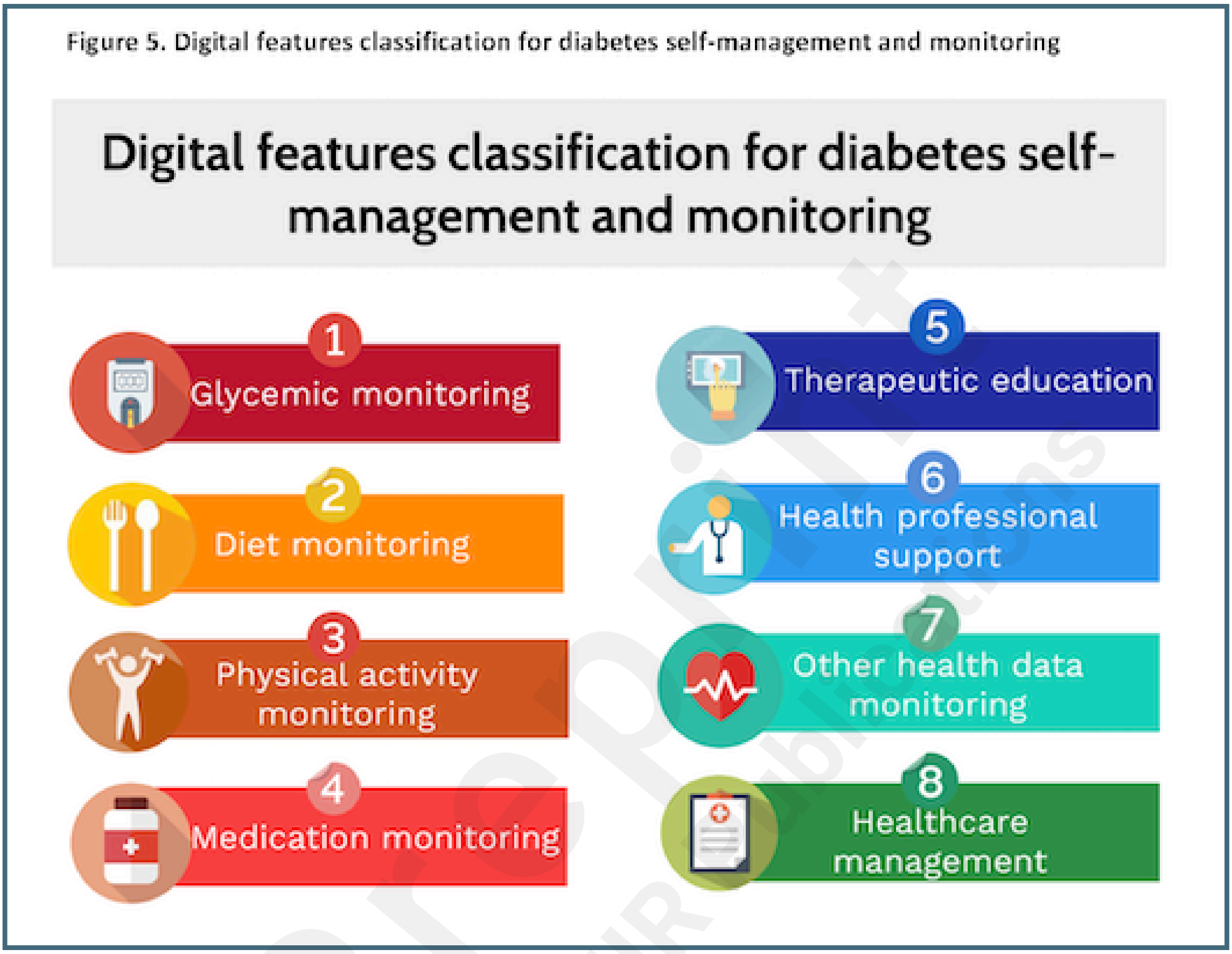
Figure 3. Countries



Durations of the interventions.



Digital features classification for diabetes self-management and monitoring.



Multimedia Appendixes

PRISMA-ScR.
URL: http://asset.jmir.pub/assets/026f5cff8733f1d5806062dfba1341ec.pdf

Search Statement.
URL: http://asset.jmir.pub/assets/37a33a75cf66adabbcb9dad9811b8515.docx

Data extraction table.
URL: http://asset.jmir.pub/assets/6db8ecd039eb190f1ba4682b39217861.xlsx

Health professionals involvment.
URL: http://asset.jmir.pub/assets/418e68ce4d82c38e736cddda8d3a0d45.xlsx

Digital features of the interventions.
URL: http://asset.jmir.pub/assets/a37a51dd77efaa62e0f90de3d5a9b630.xlsx

Studies showing significant positive health outcomes.
URL: http://asset.jmir.pub/assets/e5de2fed190b5bb3f2a2c748cef092bb.xlsx

Related publication(s) - for reviewers eyes onlies

PRISMA Scr Checklst.
URL: http://asset.jmir.pub/assets/8351253919636f3ecc651c50fee4f76a.pdf

Search strategy.
URL: http://asset.jmir.pub/assets/af80a8546909d7c6db19c35b8f13cf73.pdf