

Type-1 Diabetes self-management mobile and web applications: A Systematic Review of their functions, features and impact on psychological wellbeing.

Titouan Cloarec, Carla Toro, Petra Hanson, Katie Cunneen, David Nickson, Simon Leigh

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Titouan Cloarec^{1*} MSc, BSc; Carla Toro¹ PhD; Petra Hanson^{1*} PhD; Katie Cunneen^{1*} MSc; David Nickson^{1*} PhD; Simon Leigh¹ PhD

¹ University of Warwick Coventry GB

*these authors contributed equally

Corresponding Author:

Titouan Cloarec MSc, BSc

University of Warwick
Medical School Building, Gibbet hill road
Coventry
GB

Abstract

Background: People living with type 1 diabetes must adhere to an intense self-care regimen, which may impact their psychological wellbeing and contribute to poor self-management behaviours. Despite the potential of mobile health and web-based applications for diabetes management, most prioritise glycaemic control and often overlook psychological wellbeing.

Objective: This review assessed psychological wellbeing changes and identified functions and features of mobile and web-based interventions that may enhance the wellbeing of people with type 1 diabetes.

Methods: Relevant studies were identified through PubMed, Web of Knowledge, Embase, Scopus, APA, and Cochrane Central until November 2024. Studies were included if they quantitatively assessed the impact of mobile health or web-based apps on psychological wellbeing in people with type 1 diabetes using validated screening tools.

Results: Eight of the 2142 articles identified met the inclusion criteria and were included in the review. Six types of functions were identified, each incorporating different sets of features: (1) Therapy, (2) Education, (3) Self-Management, (4) Peer Support, (5) Healthcare Provider–Patient Support, and (6) Parental Support. Psychological wellbeing improved in only two of the eight studies. However, the limited number of studies and variability in study design and participant characteristics limited the ability to identify specific functions and features that effectively improved psychological wellbeing.

Conclusions: This review highlights the limited effectiveness of mHealth interventions in improving psychological wellbeing in people living with type 1 diabetes. While some interventions showed promise, the findings emphasise the need for targeted, theory-based approaches and participatory design to improve support and long-term outcomes.

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Original Manuscript

Type-1 Diabetes self-management mobile and web applications: A Systematic Review of their functions, features and impact on psychological wellbeing.

Authors: Titouan Y Cloarec, Katie Cunneen, Simon Leigh, David Nickson, Petra Hanson, Carla Toro

Institution of Origin: University of Warwick, Warwick Medical School

ORCID Identifiers:

Titouan Y. Cloarec: 0009-0009-6808-8874

Katie Cunneen: 0000-0002-0666-1622

Simon Leigh: 0000-0002-6843-6447

David Nickson: 0000-0003-1995-224X

Petra Hanson: 0000-0002-6845-1049

Carla Toro: 0000-0001-6351-1340

Corresponding Author:

Titouan Y. Cloarec

Titouan.cloarec@warwick.ac.uk

Affiliations:

Warwick Medical School, The University of Warwick, Coventry, UK

Titouan Cloarec, David Nickson, Petra Hanson, Simon Leigh and Carla Toro

Department of Psychology, The University of Warwick, Coventry, UK

Katie Cunneen

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1. Abstract:

People living with type 1 diabetes must adhere to an intense self-care regimen, which may impact their psychological wellbeing and contribute to poor self-management behaviours. Despite the potential of mobile health and web-based applications for diabetes management, most prioritise glycaemic control and often overlook psychological wellbeing. This review assessed psychological wellbeing changes and identified functions and features of mobile and web-based interventions that may enhance the wellbeing of people with type 1 diabetes.

Relevant studies were identified through PubMed, Web of Knowledge, Embase, Scopus, APA, and Cochrane Central until November 2024. Studies were included if they quantitatively assessed the impact of mobile health or web-based apps on psychological wellbeing in people with type 1 diabetes using validated screening tools.

Eight of the 2142 articles identified met the inclusion criteria and were included in the review. Six types of functions were identified, each incorporating different sets of features: (1) Therapy, (2) Education, (3) Self-Management, (4) Peer Support, (5) Healthcare Provider–Patient Support, and (6) Parental Support. Psychological wellbeing improved in only two of the eight studies. However, the limited number of studies and variability in study design and participant characteristics limited the ability to identify specific functions and features that effectively improved psychological wellbeing.

This review highlights the limited effectiveness of mHealth interventions in improving psychological wellbeing in people living with type 1 diabetes. While some interventions showed promise, the findings emphasise the need for targeted, theory-based approaches and participatory design to improve support and long-term outcomes.

Keywords: Mobile health intervention; Web-based intervention, psychological wellbeing; systematic review; type 1 diabetes; mental health

2. Abbreviations

App(s): Application(s)

BA: Behavioural Activation

CBT: Cognitive behavioural therapy

DD: Diabetes Distress

DDS: Diabetes Distress Scale

DSME: Diabetes Self-Management Education

GSD: Guided self-determination

HCP: Healthcare Professionals

IT: Interpersonal Therapy

mHealth: Mobile Health

PAID: Problem Areas in Diabetes

3. Research in Context

What is already known about the subject?

- o People with type 1 diabetes are at a higher risk of developing psychological wellbeing problems, including anxiety, depression, and diabetes-related distress.
- o Psychological wellbeing challenges in type 1 diabetes can affect management of the condition, leading to the development of health-related complications.
- o Digital health solutions, particularly mobile and web-based interventions, may offer solutions for managing psychological wellbeing but have not been extensively studied in the context of type 1 diabetes.

What is the key question?

- o What are the current functions and features of mobile and web-based interventions for improving psychological wellbeing outcomes for people with type 1 diabetes and how effective are they?

What are the new findings?

- o Current functions and features of mobile and web-based interventions that may influence psychological wellbeing outcomes in type 1 diabetes were identified.
- o Existing interventions in this area are limited and do not produce significant improvements psychological wellbeing.
- o There is a need for targeted, theory-based approaches and the integration of participatory design in future interventions to enhance support and long-term outcomes.

How might this impact clinical practice in the foreseeable future?

- o The findings may encourage the development of more effective mobile and web-based interventions, to improve psychological wellbeing support for people with type 1 diabetes and provide a more holistic care.

4. Introduction

Type 1 diabetes is an autoimmune disease affecting approximately nine million people in 2022, with 1.52 million under the age 20 [1]. It is characterised by an immune-mediated depletion of insulin-

producing beta cells, resulting in a lifelong dependence on exogenous insulin [2]. People living with type 1 diabetes are therefore required to have an intense self-care regimen involving daily insulin administration, glucose monitoring, carbohydrate counting and physical activity [3]. Adherence to this self-care regimen is essential as prolonged hyperglycaemia (high blood glucose levels), can lead to severe and potentially life-threatening diabetes-related complications [4].

The demanding self-care regimen for people living with type 1 diabetes is thought to contribute towards the higher prevalence of psychological wellbeing problems compared to the general population [5, 6]. These include diabetes distress (DD), depression, anxiety and eating disorders [7]. For example, one in three people living with type 1 diabetes experience substantial DD [8]. Furthermore, the prevalence of depression was found to be significantly higher in people with type 1 diabetes compared to the general population (22% vs 13%) [9, 10], further highlighting the significant psychological challenges they experience. These psychological challenges are strongly associated with poor self-management behaviours, such as less frequent blood glucose monitoring and sub-optimal glycaemic control. In recognition of this, psychological wellbeing has become a recognised priority in diabetes care [11] and has led to the development of targeted psychological interventions to support patients with the unique challenges of living with diabetes.

Studies evaluating psychological interventions such as cognitive behavioural therapy (CBT) or guided self-determination (GSD) demonstrate subtle clinical benefits in type 1 diabetes management [12]. Although changes in glycaemic control were not found, these interventions enhanced self-reported patient functioning, reduced diabetes-related distress, and improved mental health outcomes [12]. This highlights the potential of targeted psychological treatments to support the mental wellbeing of people managing type 1 diabetes. However, psychological therapies are not part of standard care [13] due to various reasons including limited availability of healthcare professionals, challenges in scaling these programs to all patients in need, and the significant logistical and time requirements for health professionals, families, and patients [13, 14].

Digital health interventions via mobile health (mHealth) and web-based applications (apps) offer the opportunity for type 1 diabetes patients to manage their condition at minimal costs [15]. The majority of type 1 diabetes mHealth app studies to date have primarily focused on glycaemic control as a primary outcome, with limited focus on psychological wellbeing [16, 17]. *Knox et al. (2019)*, conducted a systematic review to assess the effectiveness of digital health interventions targeting psychological and physical health outcomes for children and young people with type 1 diabetes [18]. Among the 30 studies included, only four out of ten studies measuring a psychological outcome reported an improvement in psychological wellbeing, however, this was not statistically significant [18]. The intervention in these studies included text messaging, games, and a training program for self-management. Similarly, *Garner et al. (2022)* reviewed 15 studies on digital interventions for psychological wellbeing in youths aged 5–25, finding improvements in self-efficacy through gaming and self-management apps, but no consistent overall benefits for psychological wellbeing [19].

Overall, these previous reviews have highlighted a gap that current digital interventions, particularly mHealth apps, fail to address psychological wellbeing effectively, despite its important role. As established in *Garner et al (2022)*, there is a lack of consistent evidence showing improvement in psychological wellbeing for young people with type 1 diabetes [19]. This highlights the need to identify specific functions, the main purpose of the intervention, and their features, the components or elements of the intervention designed to carry out specific functions, to improve the psychological wellbeing for people with type 1 diabetes.

Building on the findings of *Garner et al. (2022)* and *Knox et al. (2019)*, this review aims to provide an updated synthesis of the current evidence focusing on both children and adults with type 1 diabetes. This review will assess changes in psychological wellbeing and identify functions and features in mHealth and web-based apps that may underpin improvements to psychological wellbeing.

5. Methods

The current systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [20]. The protocol for this review was registered at the international prospective register of systematic reviews (PROSPERO), an online database for systematic review protocols (CRD42024509788) [21].

5.1 Search Strategy

EMBASE, PubMed, Cochrane Central, Scopus, Web of Science and APA PsycINFO were searched for relevant peer-reviewed articles on (26th November 2024). Search terms were categorised by population (Type 1 diabetes), intervention (mHealth and web-based applications) and outcomes (psychological wellbeing) The search strategy is detailed in Table S1 in the supplementary material.

References cited in previously published systematic reviews and the included studies were manually searched to identify additional papers.

5.2 Eligibility

Articles were included if they: (1) were available in English; (2) involved patients with type 1 diabetes aged 10 years or older using mHealth applications; (3) quantitatively assessed the impact of the mHealth intervention on psychological wellbeing using validated screening tools such as Problem Area in Diabetes (PAID) or Diabetes Distress Scale (DDS). Eligible study designs include single-arm studies, before-and-after studies, randomized controlled trials, observational studies, and quasi-experimental designs.

Articles were excluded if they: (1) were systematic reviews and meta-analyses, (2) were qualitative studies, (3) had incomplete information (4) participants under the age of 10, (5) included participants with type 2 diabetes, gestational diabetes, pre-diabetes, or did not separate type 1 diabetes and type 2 diabetes within the results for papers involving both types and (6) focused on other forms of digital health (e.g. wearable devices or telehealth involving virtual consultation).

5.3 Study Selection

Selected articles from database searches were uploaded to Rayyan [22], a software used for systematic reviews and duplicates were removed. Abstracts and titles of all studies were reviewed independently through Rayyan with a second reviewer (KC). Discrepancies were resolved by discussion. In cases of disagreement, a third reviewer (PH) would review the articles and determine whether they should be included for full-text review.

Full text of the articles was reviewed by one review author (TC) with a secondary reviewer (KC) screening 20% of all articles. In case of disagreement, a third reviewer (DN) reviewed the articles and determined if they should be included.

5.4 Data Extraction

Data were extracted by one review author (TC) and a random 10% sample was independently extracted by a second author (KC) into an excel spreadsheet. The following information was extracted from the articles (see Tables S2a-f): Year of study, study design, population characteristics, mHealth and web-based app functions and features, and outcome measures (Psychological & Physical).

5.5 Risk of Bias Assessment

One author (TC) assessed the risk of bias in included studies using the Risk of Bias 2 (RoB2) tool for Randomised Control Trials (RCT) and the Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I) tool assessment for non-randomised studies [23, 24]. The RoB2 tool assesses five domains of bias, categorising each as low risk, some concerns, or high risk, following a predefined algorithm to determine an overall risk of bias score. Similarly, the ROBINS-I tool evaluates seven domains, rating each as low, moderate, serious, or critical risk of bias, with an overall score derived from these ratings. A 10% sample of included studies was independently assessed by a second author (KC).

6. Results

6.1 Study Selection

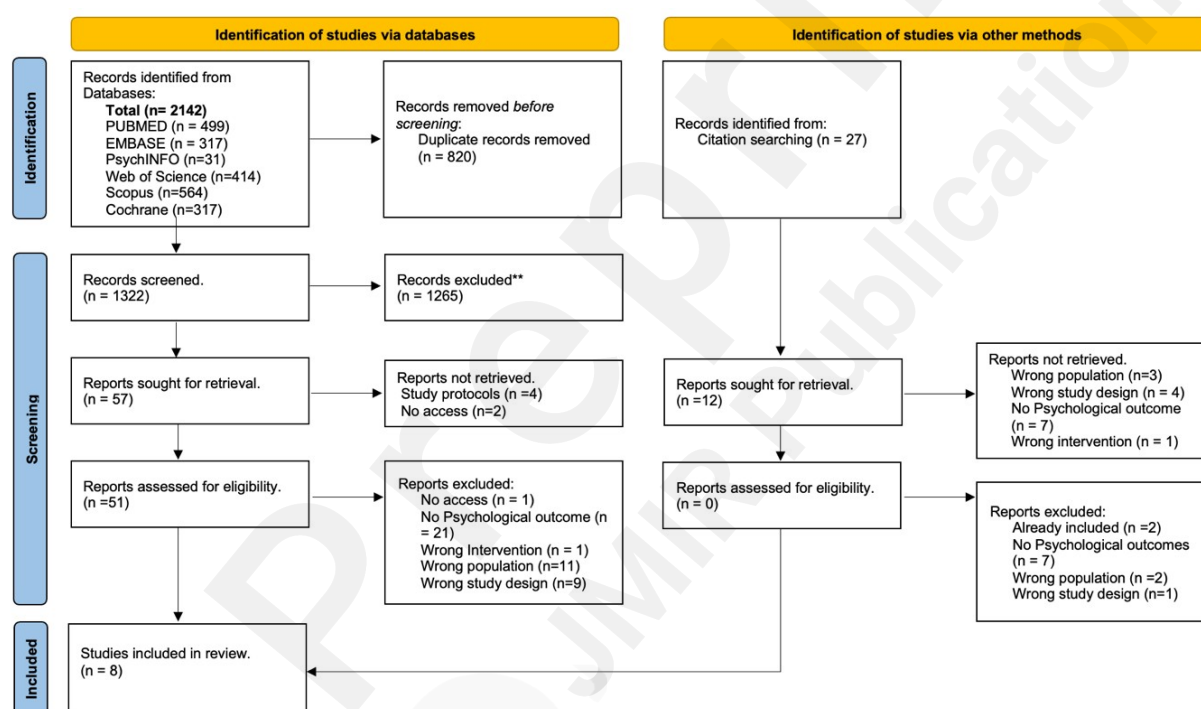


Figure 1: PRISMA Flow Diagram summarising literature search and articles selection process

Figure 1 illustrates the literature search and selection process. The database search yielded a total of 2142 articles. From these, 51 remained for full text review after duplicates were removed. Following full-text review, eight studies were included. 43 articles were excluded for the following reasons (1) Not being able to access the full text; (2) Articles not reporting psychological wellbeing outcomes; (3) Not using a mHealth or web-based app; (4) Not separating type 1 diabetes and type 2 diabetes

participants in the result sections or participants mean age being below 10 years old; (5) the study was qualitative without a quantitative element. Study design and participant characteristics for the included articles are summarised in Table 1.



Study	Aim	Intervention type	Study Design	Participant	Sample Size	Mean Age (SD) in years	Female Sex (%)	Diabetes Duration in Years (SD)
1. Carreira et al. (2023) [25]	To administer an Internet-based CBT program for the treatment of mild-moderate depressive symptomatology in individuals with T1D and to evaluate the efficacy of this program.	Web	RCT	Adults with T1D (≥ 18 years old) Mild to moderate depressive symptoms	65	37.48 (11.01)	74	18.71(12.72)
2. Tack et al. (2018) [26]	To evaluate a prototype integrated mobile phone diabetes app in people with T1D	Mobile	Cohort	Adults with T1D (≥ 18 years old)) Diabetes Duration (≥ 2 years)	19	43.8(14.1)	63	22.8(14)
3. Singh et al. (2023) [27]	To assess the efficacy of an internet-based CBT intervention, in adolescents with T1D and depressive symptoms.	Web	Cohort	Adolescents with T1D (13-17 years old) Mild or moderate depressive symptoms	7	15.1(1.2)	86	6(3.4)
4. Drion et al. (2015) [28]	To investigate whether the use of a digital diabetes diary results in a change in quality of life for patients with T1D	Mobile	RCT	Adults with T1D (≥ 18 years old))	63	33	37	17

	compared with the standard paper diary.							
5. Hilliard et al. (2020) [29]	To evaluate the feasibility and acceptability of a new, strengths-based mHealth app for parents of adolescents with T1D.	Mobile	RCT	Adolescents with T1D (12-17 years old) Diabetes Duration (≥ 6 months)	80	15.3(1.5)	59	5.7(3.4)
6. Castonsøe-Seidenfaden et al. (2018) [30]	To assess the feasibility and acceptability of a mobile-friendly web app aimed at enhancing self-management among young people.	Web	RCT	Individuals with T1D (4-22 years old) T1D for at least a year	151	Intervention: 17.6(2.6) Control: 17.6(2.7)	56	Intervention: 8.3(4.3) Control: 7.7(4.7)
7. Xie et al. (2023) [31]	To evaluate users' satisfaction with a web application and investigate changes in self-reported frequency of-, fear of-hypoglycaemia, and diabetes-related self-efficacy.	Web	Mixed Methods	Adults with T1D (≥ 18 years old))	207	49.3(13.8)	65	25.2(14.7)
8. Cuixart et al. (2024) [32]	To examine whether an app for diabetes management, together with teleconsultations, can have a positive impact and replace current clinical care.	Mobile	RCT	Adults with T1D (≥ 18 years old)) Diabetes Duration (≥ 1 year)	25	44.5(14.8)	48	21.3(14.1)

Abbreviations: T1D: Type 1 diabetes, RCT: Randomized Controlled Trial, CBT: Cognitive behavioural therapy,

Table 1: Detailed Study Characteristics and Participant Information for the Included Studies



6.2 Characteristics of included studies.

Study Design and Duration

The eight included articles were published between 2015 and 2024. Included studies were published in the USA [27, 29], the Netherlands [26, 28], Spain [25, 32], Denmark (30) and Canada (31). The selected articles included five RCTs [25, 28–30, 32], two cohort studies [26, 27] and one mixed methods study [31]. Intervention durations ranged from 6 weeks [26] to 12 months [30–32], with two lasting less than three months [25, 26] and the remaining six lasting more than three months. Of the five RCTs, all reported participant randomisation, but two did not clearly specify how randomisation was conducted [29, 30].

Participant characteristics

The articles included participants ranging in age from 10 to 49 years old. These studies included adults with type 1 diabetes (≥ 18 years old) [25, 26, 28, 31, 32] and three studies involving participants aged 10- to 18-years with type 1 diabetes [27, 29, 30]. The sample size for the different studies ranged from seven participants [27] to 207 participants [31], with a total of 617 participants in all eight studies. 59% of participants were female across all studies [27]. Diabetes duration of participants ranged from 5.7 years [29] to 25 years [31].

Participant recruitment

Of the eight studies, six of the studies used routine clinical visits to recruit participants [25–29, 32]. The other participants were recruited through a registry of people with type 1 diabetes [31] and the other via telephone calls [30].

Study	Therapy	Education	Self-management	Peer-Support	HCP-patients support	Support for Parents
1. Carreira et al. (2023) [25]	Includes nine weekly sessions based on CBT, covering depression, diabetes distress, diabetes, Coping in diabetes amongst others					
2. Tack et al. (2018) [26]			Logbook: Record key diabetes metrics Carbohydrate Tracking: Save standard meals and find carb values. Custom Settings: Adjust target glucose levels, set alarms, configure bolus calculator ratios, and enable warnings. Bolus Advice: Get insulin dosing recommendations based on personal data and carb-to-insulin ratios.	Online community to connect with peers.	Communicate via messages with HCP through a secure connection.	
3. Singh et al. (2023) [27]	Includes 14 online self-directed modules involving CBT, BA, and IP					Information for parents to support the adolescent
4. Drion et al. (2015) [28]			Enter diabetes-related self-care data: blood glucose values, carbohydrate intake, medication, physical exercise, and notes.			
5. Hilliard		3 brief			List of	List of 16

et al. (2020) [29]		videos featuring psychologist (for parents)			messages for parents to copy and paste into a text message and personalize to praise their teens.	strengths behaviours for parents to mark if their teen engaged that day, plus a free text option. List of teens most frequent 3 strengths over the previous week
6. Castonsøe - Seidenfaden et al. (2018) [30]			Info & Tips: Covers carb counting, T1D topics (e.g., driver's license), and hypoglycaemia tips. Reminders: Set alerts for self-management tasks.	Chat Room to chat with peers	Enables users to contact their HCP	Provides parents with information about how to support their teen
7. Xie et al. (2023) [31]		Six categories of learning modules with several courses in each. - Contains videos, Quizzes testimonials and PDFs	Automated carbohydrate counting calculator	Discussion Forum : All users share the same discussion forum moderated daily by the Support coordinator Users can post in the language of their choice and "like" or respond to other posts.		
8. Cuixart et al. (2024) [32]			Diabetes diary with automatic collection and analysis of data on glycemia			

			(including estimation of HbA1c) and the possibility to manually enter information on food intake, physical activity, and insulin dose			
			• a bolus calculator • reminders about blood glucose monitoring • the possibility to save pictures of food consumed			

Abbreviations: T1D: Type 1 diabetes, HCP: Healthcare Professionals, CBT: Cognitive behavioural therapy, BA: Behavioural Activation and IP: Interpersonal Psychotherapy

Table 2: Categories of functions with the included features within mHealth and web-based applications.

6.3 Features and functions

The functions within each mHealth and web-based interventions for each study were divided into the following categories (1) Therapy (2) Education (3) Self-Management (4) Peer support (5) HCP (Healthcare professionals) - patient support and (6) Support from parents. The function categories including the various features within each intervention are outlined in Table 2.

Out of the eight studies, three had therapy as a core function. These included features involving 8–10 self-directed modules focusing on CBT in three studies [25, 27], Behavioural Activation (BA) [25], and Interpersonal Therapy (IT) [27].

Two studies [29, 31] incorporated educational functions. One mHealth intervention used videos to educate parents of teenagers with type 1 diabetes on the importance of praising their teens [29], while the other intervention focused on general type 1 diabetes self-management [31]. The second study also included interactive features, such as quizzes and testimonials, to enhance engagement [31].

Five of the studies included had Self-Management functions [26, 28, 30–32]. These included features such as entering blood glucose values [26, 28, 32], carbohydrate counting [26, 28, 32], bolus calculators [26, 32] and setting reminders or alarms [26, 30].

Three studies incorporated peer-support functions, such as forums and group chats features, into the mHealth and web-based interventions [26, 30, 31]. Additionally, three interventions allowed participants to message healthcare providers directly [26, 29, 30].

Finally, four studies included functions that are parent-specific: one study [26] developed a

mobile-friendly web app to help parents identify and reinforce positive diabetes-related behaviours using strength-based marking. The remaining two studies [27, 30] focused on providing parents with information on effectively supporting their teens with diabetes.

Study	Outcomes Measured	Scales	Baseline Severity	Results	Function included
1.Carreira et al. (2023) [25]	HbA1c Diabetes Distress Depression Fear of Hypoglycaemia Anxiety	- DDS BDI-FS FH-15 STAIT-S STAIT-T	64-75 mmol/mol Low Diabetes Distress - - - -	NS Significant (p=0.022)* Significant (p=0.002) ** NS NS Significant (p=0.003)**	Therapy
2.Tack et al. (2018) [26]	HbA1c Diabetes Distress Fear of Hypoglycaemia	- PAID HFS-WS	53-64 mmol/mol Moderate Diabetes Distress -	Significant (p=0.047)* NS NS	Self-management Peer-support HCP-patients support
3.Singh et al. (2023) [27]	HbA1c Diabetes Distress Depression	- PAID-T PHQ-9 CES-D	53-64 mmol/mol High Diabetes Distress - -	NS NS NS NS	Therapy Support for paren
4.Drion et al. (2015) [28]	HbA1c Diabetes Distress	- PAID	64-75 mmol/mol Low Diabetes Distress	NS NS	Self-management
5.Hilliard et al. (2020) [29]	HbA1c Diabetes Distress	- PAID-T	75+ mmol/mol High Diabetes Distress	NS NS	Education HCP-patients support Support for paren
6.Castonsøe-Seidenfaden et al. (2018) [30]	HbA1c Diabetes Distress	- PAID	75+ mmol/mol Low Diabetes Distress	NS NS	Self-management Peer-support HCP-patients support Support for Paren
7.Xie et al. (2023) [31]	HbA1c Fear of Hypoglycaemia	- HFS-II	53-64 mmol/mol -	NS Significant (p=0.001)**	Education Self-management Peer-support
8.Cuixart et al. (2024) [32]	HbA1c Diabetes Distress	- DSS-S	53-64 mmol/mol Low Diabetes Distress	NS NS	Self-management

Abbreviations: NS: Not significant

$P < 0.05$; ** $p < 0.01$

Table 3: Physical and psychological outcomes of mHealth and web-based intervention

6.4 Study Outcomes

Psychological Wellbeing

Of the eight studies, significant improvements in psychological wellbeing were observed in only two [25, 31]. The first study, which utilised an internet-based CBT intervention targeting mild to moderate depressive symptoms, reported reductions in DD ($p=0.022$), depression ($p=0.002$), and anxiety ($p=0.003$), despite the intervention lasting only nine weeks [25]. The second study, a 12-month trial of a self-guided web application designed to enhance T1D self-management, demonstrated significant improvements in fear of hypoglycaemia ($p=0.001$) [31]. The functions associated with improvements in these studies included Therapy [25] and educational, with self-management and discussion forums functions [31].

Glycaemic Control

Only one study [26] reported improvements in glycaemic control within six weeks. This study involved a mobile app featuring data logging, a bolus calculation function, a peer-support forum, and direct messaging with healthcare providers (HCPs).

6.5 Study Quality

Based on the RoB2 evaluation of the five RCT studies (see Table S3a), four studies were considered to have some concern of bias [28–30, 32]. This concern was primarily due to the inability to blind participants to the intervention. One study was deemed to have a high risk of bias due to high attrition rates [25].

In the ROBINS-I evaluation of three non-randomized intervention studies (see Table S3b), all three studies reported a moderate risk of bias [26, 27, 31]. This was mainly due to the high attrition rates and the presence of uncontrolled confounders in each of the studies.

7 Discussion

This systematic review identified eight studies that explored the effects of mHealth and web-based interventions on the psychological wellbeing of people with type 1 diabetes. Only two of the eight studies reported significant positive effects on psychological wellbeing,

indicating a low overall effectiveness rate. The mixed findings may be due to significant variability in study designs, participant characteristics, and intervention components, making it challenging to identify consistent patterns of effectiveness or specific functions and features that enhance psychological wellbeing. Nevertheless, six categories of functions used in the included interventions were identified: 1) Therapy, 2) Psychoeducation, 3) Self-Management, 4) Peer Support, 5) HCP Support, and 6) Parent Support.

Therapy

Of the two studies that demonstrated a positive impact on psychological wellbeing, one incorporated elements of therapy. This study utilised an internet-based CBT program [25], which significantly improved DD, depression and anxiety levels in participants [25]. This finding aligns with previous research highlighting the effectiveness of CBT in managing psychological wellbeing issues among individuals with type 1 diabetes [33]. However, another study that combined CBT and BA components, showed no significant effect on psychological wellbeing [27]. This lack of effect may be attributed to the study's original design for youth without chronic conditions, making it less suited to address the unique challenges faced by the type 1 diabetes population [27].

Education

Educational content, alongside therapy, plays an important role in type 1 diabetes interventions by enhancing knowledge about the condition and its practical management [34]. Two studies incorporated educational content delivered in distinct forms [29, 31]. The first utilised psychoeducational videos but reported no improvement in psychological wellbeing [29]. This outcome may be due to the study's design, which primarily targeted parents of people with type 1 diabetes rather than those living with the condition. Consequently, the

intervention may have failed to address the psychological needs and unique challenges faced by people with type 1 diabetes directly. Additionally, the limited benefits observed in previous studies using psychoeducation for type 1 diabetes may be attributed to several factors, including the absence of psychology specialists in intervention design, low patient engagement, and the inherent difficulty of altering established management behaviours [35, 36]. In contrast, the second study involved Diabetes Self-Management Education (DSME) features, which helped empower individuals to manage their condition more effectively and showed reduced fear of hypoglycaemia. These improvements may be related to the participatory approach in developing the intervention, involving a broad range of type 1 diabetes stakeholders, including patients, healthcare professionals, and family members.

Self-management

Self-management features, such as glucose tracking and carbohydrate counting, are the most included components of mHealth apps and were the predominant feature identified in this review [37]. Most self-management features primarily support physical health and do not directly address psychological wellbeing, as noted by Knox et al. (2019) [18]. Therefore, when psychological outcomes are considered, they are often measured as secondary outcomes, as shown by three of the five studies, which assessed psychological well-being as a secondary outcome [28, 30, 32]. Hence, self-management features for type 1 diabetes might need to be supplemented with additional strategies that explicitly target psychological health to fully address the needs of individuals living with type 1 diabetes.

Stakeholder support

To date, parent involvement in developing mHealth and web-based interventions for type 1 diabetes is limited and shows minimal effects on psychological wellbeing outcomes, as

support for parents' features is usually secondary [27, 30]. Considering that family conflict, parenting style, support, involvement, and relationship quality are closely linked to psychological health outcomes in youth with type 1 diabetes [38], it is surprising that the content targeting parents does not play a more significant role in intervention design. One study developed an intervention for parents and adolescents with type 1 diabetes [29]. While the intervention did not directly address adolescent stress factors or psychological difficulties, parent-teen communication was positively influenced. Given its importance, further studies should focus on designing interventions to better support parents and their relationship with their children to help them better manage their condition.

Finally, half the studies identified peer and healthcare support functions and features within mHealth and web-based apps. However, only one of the studies involving a discussion forum for users to communicate with each other found an improvement in psychological wellbeing [31]. Whilst these studies did not show any improvement in psychological wellbeing, the incorporation of peer and healthcare support in mobile health apps are beneficial [39]. A previous systematic review of peer support interventions showed that five out of eight studies utilising video-based telehealth improved DD or depression [40]. This suggests that incorporating video-based features could facilitate communication between healthcare providers and other type 1 diabetes peers.

There are several factors that made identifying specific functions and features. Firstly, the duration of interventions may have influenced the outcomes of the studies. Some studies included in the review were relatively short-term, with two studies lasting under three months. Short study durations may not have allowed participants sufficient time to experience or fully sustain psychological changes. Long-term studies are more likely to capture the cumulative effects of interventions

and provide insights into their lasting impact. For example, although the CBT study demonstrated significant improvements in psychological wellbeing over nine weeks, it remains uncertain whether these benefits would persist without continued engagement [25].

Secondly, differences in the participants baseline characteristics, particularly the severity of DD may have influenced the results. Most studies found no significant improvements in psychological or glycaemic outcomes, despite varying levels of baseline DD. Among the studies reviewed, six out of eight reported low to moderate DD, with only one showing improvement. This suggests that individuals with milder distress levels may have limited potential for noticeable change, making it harder to observe significant benefits from interventions.

Finally, as highlighted previously, five of the eight studies in this review treated psychological wellbeing outcomes as secondary, which may have impacted the design and implementation of targeted interventions. Prioritising psychological wellbeing as a primary outcome in future research would allow for the development of interventions explicitly aimed at improving mental health, potentially leading to more consistent and significant improvements.

Nevertheless, potential beneficial factors include using a participatory approach to develop the intervention. Two studies that showed improved psychological wellbeing or glycaemic control adopted a participatory approach involving patients with type 1 diabetes [26, 31] along with HCPs and researchers specialised in type 1 diabetes, including a psychologist [31]. This highlights the importance of involving type 1 diabetes stakeholders in developing an mHealth intervention, as also established within *Yakubu et al.* [40]. Engaging patients ensures that interventions are relevant, user-friendly, and aligned with patients needs. In addition to participatory design,

integrating psychological and behavioural theories in intervention development appears to play a pivotal role, as highlighted by *Garner et al. (2022)* [19]. The absence of these may be concerning, given their documented efficacy. Future interventions should prioritise the integration of behavioural theories to enhance their relevance and efficacy.

Overall, identifying specific features that may impact psychological wellbeing is challenging due to the inconsistent evidence and the limited number of studies available. Additionally, the variability in the scales used to measure DD-related psychological outcomes and the differences in follow-up periods between interventions contribute to the observed heterogeneity across studies. Nevertheless, mHealth intervention may provide unique advantages for individuals with type 1 diabetes. Future studies should ensure that mHealth and web-based interventions are developed using evidence-based psychological theories, as these have shown to be more effective [40]. Studies should also include a participatory approach when designing the intervention with various type 1 diabetes stakeholders, such as patients, carers, and HCPs, to ensure that they are effective and engaging for patients.

Strengths and Limitations

A key strength of this review was including individuals with type 1 diabetes aged 10 and above, broadening our understanding of how mHealth and web-based interventions support psychological wellbeing across different age groups. This also ensures a more inclusive representation of the varied experiences and needs within the type 1 diabetes population. The review also adhered to the PRISMA guidelines and followed a registered protocol, ensuring methodological transparency and

adherence to reporting standards. Additionally, the clear eligibility criteria, ensured the inclusion of relevant studies, and the replicability of the review. Furthermore, it identified key intervention functions and features, offering practical insights to guide future app development tailored to user needs.

However, the review is not without limitations. The included studies showed significant variation in intervention types, durations, sample sizes, design processes and outcomes measures. Due to the heterogeneity of the studies, identifying specific functions and features that could support the psychological wellbeing of patients with type 1 diabetes proved challenging. Additionally, the limited number of papers included in this review, along with the use of different versions of questionnaires to measure DD, anxiety, and depression, hindered the ability to conduct a meta-analysis and introduced further inconsistencies in assessing psychological outcomes. In addition, the digital interventions may have been more beneficial for individuals recently diagnosed with type 1 diabetes, as they would have had more to learn about managing the condition. However, the participants in this study had lived with type 1 diabetes for at least five years, suggesting they likely had significant experience in self-management, limiting the impact of the interventions. Lastly, by excluding publications that included both type 1 diabetes and type 2 diabetes, we may have missed papers with data that might have been informative.

Conclusion

This review highlights the limited effectiveness of mHealth interventions in improving psychological wellbeing and glycaemic control in individuals with type 1 diabetes. While some interventions demonstrated promising results, the findings emphasise the need for more targeted and theory-based approaches. By addressing the

challenges identified in this review, future interventions can offer more comprehensive support to individuals with type 1 diabetes.

8 Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

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10. Authors' relationships and activities

SL is the director of research and insights at VISFO. All other authors declare that there are no relationships or activities that might bias, or be perceived to bias, their work.

11 Contribution statement

All authors contributed to the conception, writing and review of this manuscript. All authors approved the final version to be published.

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Supplementary Files

Multimedia Appendixes

Untitled.

URL: <http://asset.jmir.pub/assets/b99f08416fffbdc1d483e208cafd6a7a.docx>