

# World Journal of *Diabetes*

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## Impact of technology use in type 2 diabetes distress: A systematic review

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### Abstract

#### BACKGROUND

Diabetes distress is an important factor in treatment outcomes and results in poor behavioral and biological consequences. Technology has been used in management programs of diabetes to improve communication between patients and health care providers and to promote education about the disease and its psychological aspects, which can impact the self-efficacy of the programs. However, the true impact of technological approaches on the management of type 2 diabetes distress remains controversial.

#### AIM

To investigate the effectiveness of technology interventions on the management of type 2 diabetes distress.

#### METHODS

Studies published from 2014 to 2019 were searched in five databases: MEDLINE, PubMed, Library and Information Science Source, Academic Search Ultimate and PsycINFO. The Boolean logic search terms were: (1) T2Diabetes; (2) diabetes distress; and (3) technology OR mobile OR phone OR application OR web. We also systematically searched the reference lists of the included studies and relevant reviews. Randomized controlled trials with technology interventions, type 2 diabetes patients and diabetes distress as the outcome were selected. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was followed.

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## RESULTS

Of the 88 studies selected, nine full articles met the inclusion criteria and were subjected to final careful review. On the JADAD scale, one article was classified as having poor quality and eight as having good quality. Six out of nine articles showed that technology interventions had a positive impact on diabetes distress scale scores when compared with the initial data. Among the six articles, five showed a greater reduction in the diabetes distress scores from control interventions. Web-based interventions had good results when users received personalized feedback and routine caregiver support and attention.

## CONCLUSION

Technology interventions can contribute positively to the management of type 2 diabetes distress, especially with a tailored approach in conjunction with caregiver interaction with patients.

**Key Words:** Technology; Type 2 diabetes; Diabetes distress; Healthcare; Systematic review

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**Core Tip:** Technology interventions can impact the reduction of diabetes distress and improve the outcome and quality of life of patients with type 2 diabetes mellitus.

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## INTRODUCTION

Diabetes mellitus is one of the most prevalent diseases in the world. Today, the worldwide incidence of diabetes is estimated to be over 450 million<sup>[1]</sup>. Type 2 diabetes (T2D) comprises approximately 90% of cases and is associated with modifiable factors, genetics and aging. Target organ lesions such as nephropathy, neuropathy, retinopathy and cardiopathy are long-term results of hyperglycemia. Organ complications and attempts at diabetes control may affect physical and emotional health and patient quality of life, leading to negative psychological conditions. Patients with depressive symptoms present with more hospitalization days, poorer self-management behavior, more absenteeism, and increased morbidity and mortality. However, it is important to highlight that most diabetic patients with high levels of depressive symptoms are not clinically depressed, rather, they could be suffering from diabetic-specific distress consequences<sup>[2]</sup>.

Diabetes distress (DD) is defined as the fears, worries and concerns of individuals with type 1 or type 2 diabetes related to the emotional responses to diagnosis, risk of complications, self-management demands, unresponsive providers and quality of interpersonal relationships. Identifying patients with DD and addressing the social, personal and health-related causes of distress might have a greater impact than prescribing treatments for clinical depression<sup>[2]</sup>. Initially, to serve as a screening measure for DD, the Problem Areas in Diabetes scale (PAID), a 20-item questionnaire with no subscales, was developed and has been linked to diabetes self-care behaviors and glycemic controls<sup>[3,4]</sup>. In 2009, McGuire *et al*<sup>[5]</sup> validated the PAID-5, a short version of PAID with items 3, 6, 12, 16 and 19 of the original scale, with 94% sensitivity and 80% specificity.

In 2005, Polonsky *et al*<sup>[6]</sup> validated a specific diabetes distress scale (DDS) with a 17-item self-reported questionnaire that captures four critical dimensions of distress: Emotional burden, regimen distress, interpersonal distress and physician distress. Higher DDS scores are associated with poorer diabetes outcomes, such as high HbA1c, low self-efficacy, choosing unhealthy foods<sup>[3]</sup> and even an increase in coronary artery disease incidence<sup>[6]</sup>.

In 2008, Fisher *et al*<sup>[4]</sup> presented a two-item screening version of the DDS, with items “feeling overwhelmed by the demands of living with diabetes” and “feeling that I am

often failing with my diabetes regimen”, which showed good sensitivity (95%) and specificity (85%).

Simultaneously, in an attempt to measure DD, data management technologies, web-based interventions, telemedicine, mobile phones, applications and others have been used as modern tools of communication to improve healthcare. Some authors have already demonstrated that technological devices could enhance engagement, adherence, cost effectiveness and access to health interventions<sup>[7,8]</sup>, having an impact on blood glucose control and T2D self-management<sup>[9-12]</sup>. However, review authors have been in disagreement about the benefits of this technology in T2D distress<sup>[13,14]</sup>. The primary aim of this review is to determine the impact of programs with technological interventions regarding disease management, not just as a communication alternative, on T2D distress through a DDS measurement study.

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## MATERIALS AND METHODS

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### **Data sources and search strategy**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and checklist were followed in this study. The review protocol is registered on PROSPERO (<https://www.crd.york.ac.uk/PROSPERO/>), an international prospective register of systematic reviews with 160386 registered numbers.

The electronic databases used were MEDLINE, PubMed and EBSCO (which includes three databases with duplicates removed automatically: Library and Information Science Source, Academic Search Ultimate and PsycINFO) for studies published in English from January 2014 through December 2019. The Boolean logic search terms were: (1) T2Diabetes; (2) Diabetes distress; and (3) Technology OR mobile OR phone OR application OR web. We also systematically searched the reference lists of the included studies and relevant reviews.

### **Study selection**

Following the removal of duplicates, titles and/or abstracts were screened by the first reviewer and then a second reviewer. If a disagreement occurred, a third reviewer was consulted.

### **Inclusion and exclusion criteria**

Inclusion criteria were studies with: (1) Only subjects over 18-years-old; (2) Subjects with T2D; (3) Randomized controlled trials (RCTs); (4) Any intervention with technology; use and (5) DDS present in main or secondary outcomes.

Exclusion criteria were studies with: (1) Non-English language text; (2) absence of a control group without technological intervention; and (3) the inclusion of only pregnant women.

### **Data extraction**

The investigators collected the following from each eligible study in a full article screening: (1) Number of subjects recruited for randomization, including the presence of sample size calculations; (2) Main demographic descriptions, including age with standard deviation, gender and study design including duration; (3) Description of intervention and control groups; (4) distress outcome measures; and (5) Statistical significance results.

### **Methodologic quality**

The JADAD scale was used to measure the likelihood of bias and was applied to each selected study by the two reviewers independently.

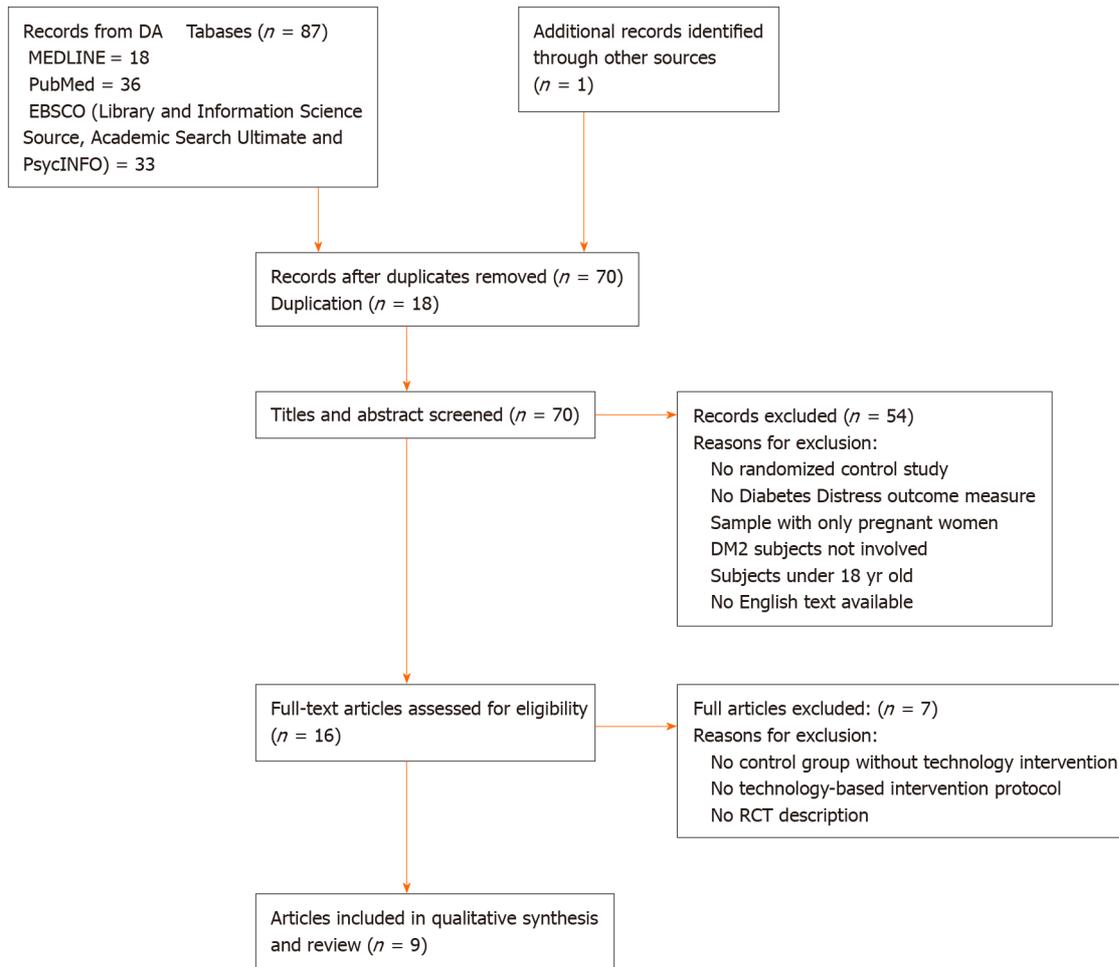
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## RESULTS

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### **Study selection**

A PRISMA flowchart (Figure 1) summarizes the results of the search, screening process and reasons for exclusion. From the database sources, we collected 87 studies: (1) MEDLINE: 18; (2) PubMed: 36; and (3) EBSCO (Library and Information Science Source, Academic Search Ultimate and PsycINFO): 33. One article from the reference lists was included. After 18 duplicates were excluded (EBSCO system automatically



**Figure 1** Flow diagram of search results and reasons for exclusion. RCT: Randomized controlled trials.

excluded duplicated references from its three databases) by the two reviewers' analysis, 70 references with titles and abstracts remained for screening. Studies with no randomized control design, no DD outcome measure, no involvement of T2D subjects, no English text available, samples with only pregnant women or individuals less than 18-years-old were excluded. Next, out of the 16 full text articles selected, 7 were excluded due to the absence of a control group without technology-based intervention or for only containing an RCT protocol description; the remaining nine full articles were analyzed for data extraction<sup>[15-23]</sup> (Figure 1).

**Data extraction**

Data extraction items are shown in Table 1. Of the nine articles analyzed, two did not present sample size calculations<sup>[15,22]</sup> including technique description. Three RCTs<sup>[17,19,23]</sup> used the DDS-17 items for the DD measure, four used the PAID-5<sup>[16,18,21,23]</sup>, one used two subscales of the DDS, the five-item Regimen Distress subscale and the five-item Emotional Burden subscale version<sup>[15]</sup>, and one used the PAID with 20 items<sup>[15]</sup>. In terms of demographics, female gender was the majority in six articles<sup>[15,16,19,20,22,23]</sup>, and in one, no gender reporting was found<sup>[17]</sup>. Follow-up varied from 8 to 48 wk. One study had an 8-wk<sup>[16]</sup> period, one had 10 wk<sup>[20]</sup>, two studies had 12 wk<sup>[17,23]</sup>, three studies had 24 wk<sup>[18,21,22]</sup> and two had 48 wk<sup>[15,19]</sup> (Table 1).

**Methodologic quality**

The quality assessment of the studies with the JADAD scale is presented in Table 2. Eight RCTs were scored with good quality (total score ≥ 3) and low bias risk. One study<sup>[22]</sup> was scored as poor quality with high bias risk. The main topic with the fewest points was blindness, and three articles had a double-blind design<sup>[19,20,23]</sup> (Table 2).

Table 1 Data extracted

Ref.	Sample	SSC	Age average	Gender	Duration	IEWT	CGITE	DDS version used and data results	Statistical significance between groups
Fisher <i>et al</i> <sup>[15]</sup> , 2014	392	No	56	53.8% Female, 46.2% Male	48 wk	My path to a healthy life computer-assisted self-management plus problem-solving therapy Technology: Phone calls and web-based diabetes self-management and diabetes distress change program	Leap ahead program delivers diabetes information only, and participants were not directed to use the information to engage in a specific or structured program of self-management or diabetes distress change	DDS (5- item Regimen Distress Subscale and 5-item Emotional Burden Subscale from DDS)	$P = 0.50$ , No significant
Nobis <i>et al</i> <sup>[16]</sup> , 2015	260	Yes	51	63% Female, 37% Male	8 wk	GET.ON Mood Enhancer personalized, guided, Internet-based diabetes self-help intervention with personalized feedback from psychologist	Control Group: Unguided psychoeducation program	DDS (PAID-5)	$P < 0.001$ , Significant
Bajaj <i>et al</i> <sup>[17]</sup> , 2016	139	Yes	56.4	NR	12 wk	Long-acting insulin glargine Titration Web Tool (LTHome), instructions on insulin administration and dosing, as well as the use of the web-based LTHome tool (containing a rules engine-based algorithm for titration), provided by a delegated nonhealthcare professional Technology: Web-based insulin titration algorithm embedded in a range of platforms, including glucometer, personal computer and mobile phones	EUT of Glargine Titration: Insulin dosing and titration instructions were provided by CDEs according to a standard protocol	17-item DDS	$P = 0.04$ ; Significant
Rondags <i>et al</i> <sup>[18]</sup> , 2016	137	Yes	52	46% Female, 54% Male	24 wk	HypoAware consists of three group sessions and is combined with two online modules. Group sessions are highly interactive and aimed at patient empowerment to improve symptom recognition, risk awareness, preventive and problem-solving strategies and coping with (the risk of) hypoglycemia Technology: two online modules	Care as usual had access to comprehensive diabetes care as normally provided by their diabetes team	DDS (PAID-5)	$P = 0.365$ , No significant
Holland-Carter <i>et al</i> <sup>[19]</sup> , 2017	563	Yes	55.1	71% Female, 29% Male	48 wk	WW approach, supplemented with phone and email counseling with a CDE Technology: WW online tools, unlimited phone calls and email diabetes educator consultation	SC, one session of face-to-face T2DM nutritional counseling by a registered dietitian as well as follow-up written information	17-item DDS	$P < 0.001$ , Significant
Newby <i>et al</i> <sup>[20]</sup> , 2017	106	Yes	47	71% Female, 29% Male	10 wk	ICBT not tailored to diabetes	TAU control group	DDS (PAID 20 items)	$P < 0.001$ , Significant
Ebert <i>et al</i> <sup>[21]</sup> , 2017	260	Yes	50.8	43.8% Female, 56.2% Male	24 wk	GET.ON Mood Enhancer personalized, guided, Internet-based diabetes self-help intervention with personalized feedback from psychologist Technology: active online training on diabetes and depression, personalized approach	Control: Usual treatment	DDS (PAID-5)	$P < 0.001$ , Significant
Schlicker <i>et al</i> <sup>[22]</sup> , 2019	253	No	50.7	62.8% Female, 37.2% Male	24 wk	GET.ON Mood Enhancer personalized, guided, Internet-based diabetes self-help intervention with personalized feedback from psychologist	Placebo online, online psychoeducation control condition	DDS (PAID-5)	$P = 0.75$ , No significant
Clarke <i>et al</i> <sup>[23]</sup> , 2019	780	Yes	58	68.8% Female, 31.2% Male	12 wk	My compass program is a fully automated, web- based cognitive behavioral, self-guided public health treatment program for common mental health problems with a personalized treatment plan based on an assessment of user symptoms. Technology: Web-based, fully automated program with self-guided cognitive behavioral treatment through personal computer or mobile	Healthy lifestyles: Placebo without therapeutic, only informative, no feedback content	17-item DDS	$P = 0.36$ , No significant

*P* values < 0.05 were considered statistically significant. SSC: Sample size calculation; IEWT: Intervention elaborated with technology; CGITE: Control group with no intervention technology elaborated; DDS: Diabetes distress scale; EUT: Enhanced usual therapy; CDE: Certified diabetes educator; WW: Weight watchers; SC: Standard care; T2D: Type 2 diabetes; ICBT: Internet cognitive behavioral therapy; TAU: Treatment as usual; NR: Not related.

## DISCUSSION

### **Main findings**

This review suggests that technology could have a positive impact on DD in T2D patients. The majority of articles selected for qualitative synthesis (six<sup>[16,17,19,20,23]</sup> out of nine<sup>[15,18,22]</sup>) showed significant DD scale improvement in the technology intervention groups over the initial data. Five articles<sup>[16,17,19-21]</sup> showed significant differences between groups. Studies with technological interventions had significantly lower DDS scores at the end than at baseline. Although a study did not find significant differences between groups, all participants showed symptom improvement in DDS scores, including the control group.

Rondags *et al*<sup>[18]</sup> did not find a significant difference in the DDS scores between the groups but described a 30% drop in the HypoAware Group (technology-based intervention) in distress concerning hypoglycemia.

Regarding quality, perhaps as a result of the RCT inclusion criteria, only one article had a high bias risk on the JADAD scale, and two had no sample size calculation, reflecting good scientific quality of the articles reviewed.

### **Type of technology intervention**

Newby *et al*<sup>[20]</sup> and Clarke *et al*<sup>[23]</sup> showed different findings for generic web-based interventions with psychological content and highlighted the necessity of a diabetes-specific web-based approach. In contrast, Nobis *et al*<sup>[16]</sup> and Ebert *et al*<sup>[21]</sup> found similar results concerning diabetic distress improvement with the same web-based mood enhancer intervention (GET.ON MED).

Web-based interventions had better results when users received program feedback personalized in its content<sup>[24]</sup>. According to this affirmative, all publications with DDS improvement in our review presented tailored technology interventions with personal adjustments in their programs<sup>[16,17,19,20,23]</sup>. Thus, it seems that more than a diabetes-tailored approach, patient-tailored and-guided technological programs were more successful in type 2 DDS improvement.

However, these findings are in contrast to the results of Mathiesen *et al*<sup>[13]</sup> in their trial about the influence of technology interventions on T2D distress. They attributed their findings to the vulnerability of T2D patients facing tailored digital interventions, resulting in an increase in distress, such as “suffering informational confusion, experiencing digital alienation, and missing the human touch”, mainly because “navigating a complex digital portal on diabetes might be more challenging than

Table 2 JADAD scale

Ref.	Randomization, method	Double blind	Descriptions of withdrawals and dropouts	Total
Bajaj <i>et al</i> <sup>[17]</sup>	1 + 1	0	1	3
Clarke <i>et al</i> <sup>[23]</sup>	1 + 1	1 + 1	1	5
Ebert <i>et al</i> <sup>[21]</sup>	1 + 1	1	1	4
Fisher <i>et al</i> <sup>[15]</sup>	1 + 1	0	1	3
Holland-Carter <i>et al</i> <sup>[19]</sup>	1 + 1	1 + 1	1	5
Nobis <i>et al</i> <sup>[16]</sup>	1 + 1	0	1	3
Rondags <i>et al</i> <sup>[18]</sup>	1 + 1	0	1	3
Schlicker <i>et al</i> <sup>[22]</sup>	1	0	0	1
Newby <i>et al</i> <sup>[20]</sup>	1 + 1	1 + 1	1	5

simply accessing the site” and the digital caregivers’ approach. Despite the limitations of this study, such as the small sample size (12 subjects) and less scientific evidence compared to the nine articles analyzed in the present review, we considered some of the authors’ conclusions to improve our considerations. For example, the success of a digital T2D-tailored program depends on the quality of the caregiver-patient relationship, and topics such as digital buddy rights choice and training for vulnerable T2D patient care or a wider social network must be included in the technology T2D intervention framework.

#### **Diabetes distress scale**

Possible biases arising from the different scales of DD in the included studies (17-item DDS, PAID and PAID-5) became null due to the use of the same distress scale in the intervention and control groups. This is the main reason to consider only DDS scales in the review and not any of the isolated distress symptoms or other measures in the outcome.

#### **Limitations**

First, our review did not discriminate psychological level in article subject recruitment, and some authors attributed differences in the impact of DD approaches to baseline depression levels<sup>[20,23]</sup>, and RCT studies may not be comparable in their demographic composition. However, we selected only RCTs, and the outcome was DDS improvement between groups with the same inclusion and exclusion criteria. That reduces possible biases such as better intervention results for populations with worse baseline levels of depression. Second, we did not exclude studies that also included type 1 diabetes patients, but we limited the participants’ ages to over 18-years-old; thus, the late depression symptoms and increased somatic burden associated with patients in the age range of T2D<sup>[25]</sup> were minimized with the exclusion of younger subjects.

#### **Future directions**

These review findings could contribute to future new approaches on the elaboration of technological strategies to cope with T2D distress and consequently improve organ complications, patient well-being and cost effectiveness in the management of T2D.

## **CONCLUSION**

The findings of the present study show that management of T2D distress can have positive outcomes with technology-based interventions and highlight that the best results come from programs that offer not only a personalized digital/technological experience for patients but also routine caregiver support and attention.

## ARTICLE HIGHLIGHTS

### Research background

High diabetes distress is associated with poorer diabetes outcomes. Technological interventions have been used as modern tools of communication to improve communication and can impact diabetes self-management, engagement and adherence. Understanding the impact of programs with technological interventions regarding disease management on type 2 diabetes distress bears clinical significance.

### Research motivation

Review authors disagree about the benefits of this technology in type 2 diabetes distress. We systematically reviewed randomized controlled trials that studied the impact of technology interventions on type 2 diabetes distress.

### Research objectives

The goal of this study is to provide comprehensive overview of the impact of technology interventions on type 2 diabetes distress.

### Research methods

We systematically searched MEDLINE, PubMed and EBSCO with the Boolean logic search terms were: (1) T2Diabetes; (2) Diabetes distress and (3) Technology OR mobile OR phone OR application OR web. We also systematically searched the reference lists of the included studies and relevant reviews.

### Research results

We found nine full articles that met the inclusion criteria. Six out of nine articles showed that technology interventions had a positive impact on diabetes distress scale scores when compared with the initial data. Among these six articles, five showed a greater reduction in the diabetes distress scores from control interventions. Web-based interventions had good results when users received personalized feedback and routine caregiver support and attention.

### Research conclusions

Technology-based interventions have a positive impact on type 2 diabetes distress management, and programs that include routine caregiver support and attention show the best results.

### Research perspectives

These review findings could contribute to the development of new approaches on the elaboration of technological strategies to cope with type 2 diabetes distress and consequently improve treatment outcomes, resulting in patient well-being and better biological consequences in the management of type 2 diabetes.

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