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Review Article

# Type 1 diabetes-related distress: Current implications in care

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ABSTRACT

Type 1 diabetes (T1D) is a complex chronic disease associated with major health and economic consequences, also involving important issues in the psychosocial sphere. In this regard, T1D-related distress, defined as the emotional burden of living with T1D, has emerged as a specific entity related to the disease. Diabetes distress (DD) is an overlooked but prevalent condition in people living with T1D, and has significant implications in both glycemic control and mental health in this population. Although overlapping symptoms may be found between DD and mental health disorders, specific approaches should be performed for the diagnosis of this problem. In recent years, different DD-targeted interventions have been postulated, including behavioral and psychosocial strategies. Moreover, new technologies in this field may be helpful to address DD in people living with T1D. In this article, we summarize the current knowledge on T1D-related distress, and we also discuss the current approaches and future perspectives in its management.

## 1. Introduction

Type 1 diabetes (T1D) is a complex and demanding chronic disease characterized by a severe lack of insulin synthesis which needs to be supplied exogenously [1,2]. In this context, people living with T1D need to follow a lifelong treatment (often starting at early stages of life) based on multiple daily injection insulin therapy (MDI) or continuous subcutaneous insulin infusion, also with a strict monitorization of glucose levels to optimize dosing decisions, which may allow to achieve an optimal glycemic control and prevent chronic complications associated with the disease [1,2]. It should be noted that, at the same time, healthy lifestyle habits, including an adequate adherence to diet plans and carbohydrate counting, or physical activity, are also decisive points regarding T1D care [3–5].

Even though important innovations in the management of T1D has emerged in the last few years, given the complexity of the disease, most people living with T1D do not achieve these glycemic goals, or require remarkable and sustained efforts to accomplish these objectives [6,7]. This fact may generate, on many occasions, exasperation, frustration, or stress not only in people living with T1D, but also in their relatives/caregivers or health care teams [8,9].

In recent years, there has been a growing awareness of the fact that the chronicity and complexity of T1D may have a major psychosocial impact on patients presenting this condition. Indeed, it is well known that T1D is associated with a higher risk for the development of mental health problems, as compared with the general population [10,11]. In parallel, the increasing understanding of the importance of emotional experiences that have a direct effect on both mental health and quality of life in people living with T1D makes necessary to address specific entities, such as diabetes distress (DD), as an important part of the comprehensive care in T1D [12,13].

Although a precise definition of DD is lacking, this concept could be summarized as the emotional burden of living and managing such a demanding chronic disease as T1D [14]. A high prevalence of DD may be observed in people living with T1D, ranging from 30 to 50 %, according to different studies [15–17]. Therefore, the recognition and management of DD in people living with T1D is imperative in clinical settings.

In this review, we summarize the current evidence regarding the

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impact of DD on people living with T1D, and we also evaluate the potential strategies to address this issue in this population.

## 2. Identifying distress in people living with type 1 diabetes

### 2.1. Type 1 diabetes-related distress and other mental health problems

Identifying distress in people living with T1D can be challenging, as different characteristics/symptoms may overlap between DD and different mental health disorders/emotional problems [13]. Accordingly, DD, depression, and burnout, which are common psychological complications in people living with T1D, may be difficult to differentiate in clinical practice, as similar or even overlapping characteristics can be found among these entities [13]. It should be pointed out that DD is not a psychiatric disorder, but a construct of negative emotions, stress, fears and/or concerns related to the burden of T1D and its potential complications [12–14]. Therefore, DD represents a specific concept limited to people living with diabetes, which may be particularly evident in people coping with T1D. However, it could be argued that the DD construct might be considered under the current Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) category, when considering depressive symptomatology (Depressive Disorder Due to Another Medical Condition, defined as “a mood disorder diagnosis where there is a prominent and persistent period of depressed mood or markedly diminished interest/pleasure thought to be related to the direct physiological effects of another medical condition") [18]. In this regard, the current concept of Depressive Disorder Due to Another Medical Condition may limit the concept of DD, as the DD construct involves a broader spectrum of emotions that often coexist, beyond a depressed mood. Indeed, the DD construct may not be able to reflect a direct pathophysiological correlate of T1D, but the emotional reaction to the fact of living with this demanding disease.

On the other hand, depression is defined by the DSM-5 as the presence of 5 or more symptoms (including depressed mood, loss of interest/pleasure, weight loss/gain, insomnia/hypersomnia, psychomotor agitation/retardation, fatigue, feeling of worthless or excessive/inappropriate guilt, decreased concentration, or thought of death/suicide) [18]. Of note, whereas DD may be a consequence of the burden of living with diabetes, symptoms of depression are not always associated with T1D, although people living with T1D are 2–3 times more likely to develop depression than the general population [19,20]. Remarkably, the dimensions related to depression may include specific subconcepts, (i.e., change in sleep, loss of appetite or energy, among others), while DD may be more related to the subconcepts of fear of hypoglycemia, physician distress (i.e., disappointment with physicians who are in charge of the management and care of T1D), worries about long-term complications, or feeling overwhelmed [13]. Nevertheless, both DD and depression have been reported to overlap in different points, such as the manifestation of feelings of fear, guilt, and loneliness, or the presence of a negative mood [13].

Similar to depression, diabetes burnout overlaps with DD in some respects, although this concept may be more closely linked to symptoms of physical, mental or emotional exhaustion, detachment from the support system or from diabetes care, also including the feeling of inability for the self-management of diabetes [13]. However, whereas depression and DD are considered as two different entities, there is no widespread agreement regarding the separation between the concepts of DD and diabetes burnout and, therefore, some authors argue that diabetes burnout may be included within the definition of DD [13,21].

Notably, the prevalence of other mental health problems beyond DD, diabetes burnout, or depression has been reported to be high in T1D, and the coexistence of some of these disorders may also be frequent. Thus, symptoms of anxiety may be present in up to 32 % of people living with T1D, and can be often found together with depressive symptoms in this population [22]. Moreover, a nationwide population-based Swedish cohort study including more than 20,000 subjects diagnosed with childhood-onset T1D showed that this disease increased the risk for the development of any psychiatric diagnosis, and also specific diagnosis of depression, anxiety, and stress-related disorders [23].

In light of the above, it could be stated that T1D is associated with distinct psychosocial complications. Among them, DD is a particularly frequent and overlooked problem related to this disease. Therefore, despite the presence of overlapping manifestations between DD and other prevalent issues that can be found in people living with T1D, clinicians in charge of patients with T1D should be aware of the magnitude of DD in this population and perform person-centered approaches (including addressing emotional and psychological aspects related to the burden of T1D) for an early detection of this problem.

### 2.2. Validated scales for the screening of type 1 diabetes-related distress

Currently, there are different scales for the diagnosis of DD in people living with T1D, although the most widely used of them are the Problem Areas in Diabetes Scale (PAID) and the Diabetes Distress Scale (DDS) [24,25].

On the one hand, the PAID, a psychometrically robust questionnaire standardized for the first time in adults with T1D, is composed of a total of 20 items that are scored on a 5-point Linkert scale (from “not a problem” to “serious problem”) [24]. These items (all related to diabetes) include questions regarding negative emotions, problems related to treatment/food, concerns about glycemic control/ chronic complications, and lack of support [24]. Scores of each item are summed, considering a total score $\geq$ 40 points a significant distress [24]. Of note, a 5-item short-version of PAID (PAID-5) is also available [26]. Additionally, for specific subgroups of people living with T1D, different versions of the PAID may be used, including PAID-T (teenagers) and PAID-C (children), as well as their correspondent parent versions (P-PAID-T and P-PAID-C, respectively) [27,28].

The Diabetes Distress Scale (DDS) is another helpful questionnaire for the evaluation of DD in people living with T1D, although it was initially validated for people living with type 2 diabetes [25]. Similar to PAID, it is based on a 6-point Linkert scale (from “not a problem” to “a very serious problem”) for 17 items, and yields a total diabetes distress score plus 4 subscales scores, which address different type of distress (i.e., emotional burden, physician-related distress, regimen-related distress, and interpersonal distress), considering a mean item distress of $\geq$ 3 as a significant level of distress [25]. Remarkably, a 28-item scale derived from the DDS is also available to be used in people living with T1D (T1-DDS) [29]. This specific scale comprises the evaluation of 7 major sources of distress in this population, including powerlessness, negative social perceptions, physician distress, friend/family distress, hypoglycemia distress, management of distress, and eating distress [29]. Recently, a short-form version of the DDS for people living with T1D (T1-DDS-7) has also been developed [30].

Despite the fact that both PAID and DDS (and their different versions) are helpful tools in the screening of DD, it should be noted that some differences may be found between them [31]. Therefore, the PAID may be more focused on food-related problems and complications, also allowing the identification of dysfunctional copying styles, quality of life, and emotional aspects, including depressive symptoms, whereas the T1-DDS collects more information regarding medical-related distress, as well as motivational and behavioral challenges in relation to diabetes self-management, also presenting a strong association with metabolic outcomes [31]. T1-DDS may also be more clinically helpful due to its specific characteristics and its potential in identifying specific sources of DD, which may facilitate targeted interventions [31].

## 3. Factors associated with type 1 diabetes-related distress

Several factors may have a direct influence on the development of DD, such as fear and concerns related to glycemic control and potential long-term complications, fear of hypoglycemia, self-care burden, glycemic-centered approaches in health care systems, or the lack of social support (Fig. 1). Indeed, reciprocal interactions may be found among the different determinants associated with T1D-related distress. It is also important to bear in mind that some subgroups of people living with T1D may have a greater risk for the development of DD, which will be discussed in the following subsections.

### *3.1. Concerns related to glycemic control and potential long-term complications*

A suboptimal metabolic control, which may eventually lead to the development of chronic complications, has been demonstrated to be one of main sources of DD, although it should be noted that a poor metabolic control may also be a consequence of DD, as it will be discussed later [29,32]. Besides, a good metabolic control may also be associated with high levels of DD, as the presence of other sources of DD (e.g., self-care burden) or concerns related to fear to worsen glycemic control might play a role in its etiology [12,29,33]. Importantly, an elevated proportion of people living with T1D report a high degree of fear about chronic complications [34,35]. Indeed, people living with T1D may have a deeper understanding of the potential implications of glycemic control than people living with type 2 diabetes, and may be more concerned about long-term complications of the disease [36]. Moreover, a higher DD has been reported in those patients with chronic complications, and the presence of these complications is considered to be an independent predictor of different mental health problems in people living with T1D, including DD [15,29].

### *3.2. Fear of hypoglycemia*

Fear of hypoglycemia is a major contributor of DD in people living with T1D. In fact, fear of hypoglycemia is considered as one of the most prevalent symptoms among people living with T1D and DD [13]. Despite important advances in technology, hypoglycemia is a very common complication that results from the chronic treatment with insulin therapy, and people living with T1D may experience feelings of vulnerability and unsafety from the possibility of a serious event of hypoglycemia. Hypoglycemia has significant repercussions on the quality of life of people living with T1D [37], and may also have a negative effect on the emotional status, social behavior or interpersonal relationships [38].

### *3.3. Self-care burden*

Self-care burden in T1D may involve different points. On the one hand, although notable innovations in the management of T1D have been developed in the last few years, patients with this disease are supposed to follow a strict self-monitorization of glucose levels and to self-administrate insulin several times a day, also making a significant number of decisions over the day, which may result in different feelings/symptoms closely related to DD, such as frustration, powerlessness, or burn-out [13,39]. Additionally, people living with T1D may have to make important efforts to maintain different behavioral habits, including those related to food and eating patterns [40]. Of note, some of these issues may have a negative impact on social interactions. Therefore, considering all these factors together, different burdens in self-management may result in high levels of DD in people living with T1D.

### *3.4. Glycemic-centered approaches*

Despite the fact that T1D is associated with major psychosocial implications, most health care systems are predominantly focused on glycemic targets. In line with this, the disappointment with physicians or other health care professionals who are in charge of the management of T1D, known as physician-related distress, has emerged as an important part of DD [13]. It should be noted that patient-physician relationship has a decisive influence on the emotional experience of the disease, and the approach of difficulties regarding the management of T1D [41]. Therefore, a glycemic-centered approach (excluding important emotional aspects of the disease), and communication strategies based on impositions, recrimination, or threats may lead to the deterioration of the patient-physician relationship and the arising of DD [41].

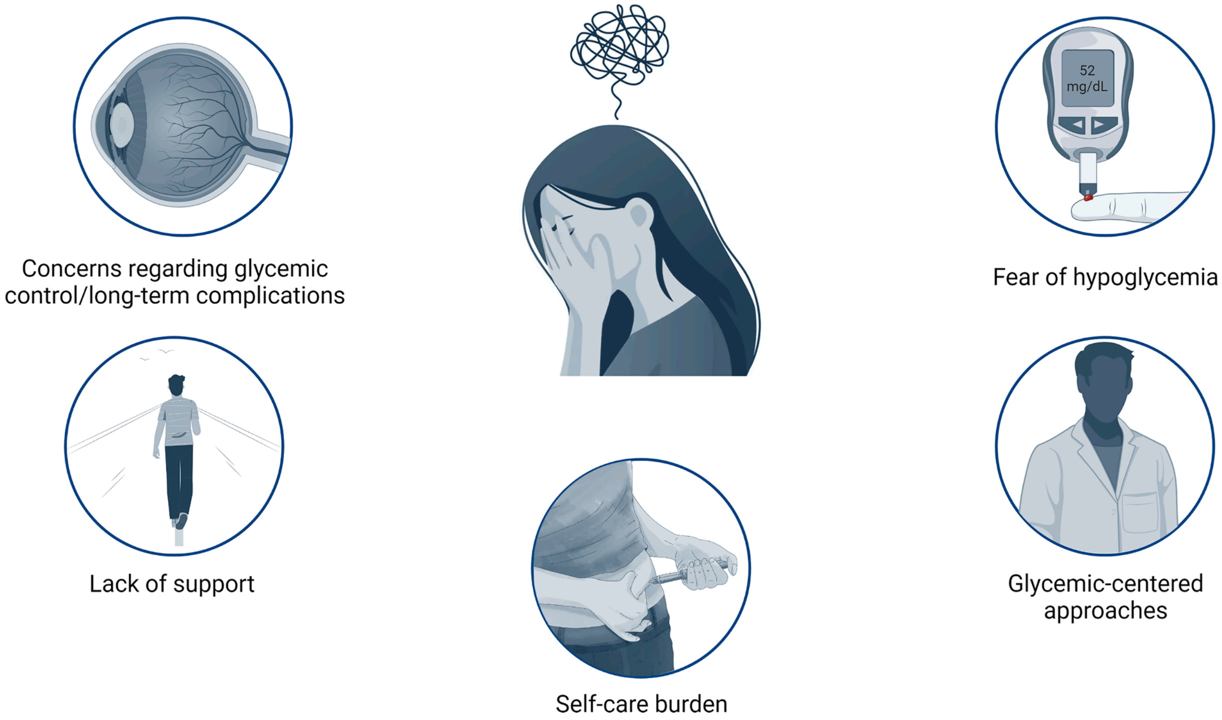

**Fig. 1.** Main factors associated with type 1 diabetes-related distress.

### 3.5. *Lack of support*

It is well known that the lack of family/social support is closely related to the development of DD in people living with T1D [29], also resulting in problems in the management of the disease and a lower quality of life [42,43]. In this regard, social support networks, including family members and friends play a key role in helping to improve T1D self-management and well-being [44]. Moreover, different problems, such as diabetes stigma and the perception and/or anticipation of negative reactions and disapproval in social situations are important determinants in the etiology of DD [45].

### 3.6. *High-risk subgroups*

Clinicians should be aware of the fact that specific subgroups of people living with T1D may be at greater risk of DD. Accordingly, the prevalence of DD has been demonstrated to be higher in women than in men [33], and this problem is more frequent among adolescents and young adults with T1D [46]. A shorter diabetes duration may also be a risk factor for the development of DD [47]. It is noteworthy that the prevalence of DD is also higher among ethnic minorities, including non-hispanic black individuals, or individuals with a low-socioeconomic background, which may also be at risk of other forms of racial-ethnic inequity [48,49].

## 4. Clinical and psychosocial implications of type 1 diabetes-related distress

As DD is often associated with a deterioration of self-management and/or motivation in people living with T1D, it may result in the worsening of glycemic control. In fact, a bidirectional relationship between DD and glycemic control can be found among people living with T1D (Table 1). In this regard, several cross-sectional studies have shown that a high DD is linked to higher HbA1c levels in this population, and elevated scores in the different scales for the assessment of DD (e.g., PAID) are independent predictors of higher HbA1c levels in people living with T1D [49–51]. Interestingly, in a recent study, Ehrmann et al. showed that the percentage of days with elevated DD (estimated by the use of ecological momentary assessment) was significantly associated with hyperglycemia, and time with DD was related to HbA1c levels prospectively [32].

Notably, additional longitudinal studies have evaluated the role of DD in glycemic control. Thus, Strandberg et al. reported that people living with T1D presenting an elevated baseline DD were at risk of prolonged poor metabolic control after adjusting for confounders [52], whereas in a longitudinal retrospective study, Déniz-García et al. observed that DD was associated with long-term glycemic variability [53]. Besides, decreases in distress have been associated with reductions in HbA1c [54]. Moreover, different trials have demonstrated that specific interventions focused on improving DD, may also achieve significant reductions in HbA1c, although this improvement in glycemic control might be modest [55,56]. However, studies evaluating the potential longitudinal association between DD and other glycemic parameters (e.g., time in range) or T1D- related complications are lacking.

Several studies have also found that the relationship between depression and glycemic control in people living with T1D may be mediated by DD [57,58]. Additionally, specific forms of DD, such as work-related DD may also be associated with a worse glycemic control, as intentional hyperglycemia is often chosen in order to avoid interferences with work [59].

Finally, it should be pointed out that, although high levels of DD can be associated with a poor metabolic control, leading to the deterioration of glycemic parameters in people living with T1D, patients with a good glycemic control might also be susceptible of presenting DD.

On the other hand, some of the psychosocial implications of DD have been discussed in previous sections. Accordingly, DD is closely

**Table 1**
Selected clinical studies evaluating associations between diabetes distress and glycemic control in people living with type 1 diabetes.

| Study | Design | Participants | Main results |
|---|---|---|---|
| Van Bastelaar et al. [57] | Cross-sectional study | 627 patients with diabetes (280 participants with T1D) | Direct association between DD and HbA1c. DD mediated the association between depression and HbA1c. |
| Strandberg et al. [52] | Prospective study (3-year follow-up) | 235 adults with T1D | Direct association between baseline DD (especially regimen-related distress) and HbA1c over time. |
| Hessler et al. [54] | Cross-sectional and prospective study (9-month follow- up) | 224 adults with T1D | Direct association between DD and HbA1c. DD mediated the association between higher HbA1c levels and higher percentage of missed insulin boluses. |
| Hagger et al. [58] | Cross-sectional study | 450 adolescents (aged 13–19) with T1D | DD mediated the association between depressive symptoms and elevated HbA1c. |
| Fisher et al. [55] & Hessler et al. [56] | Randomized controlled trial (education/ behavioral or emotion-focused approaches during 9 months) | 301 adults with T1D and elevated DD and HbA1c | Direct association between baseline DD and HbA1c. Modest reductions in DD and HbA1c after both interventions; reductions in DD did not affect glycaemic outcomes directly but through improvements in self-care behavior. |
| Hansen et al. [59] | Cross-sectional study | 1030 adults with T1D | Work-related DD was associated with intentional hyperglycemia at work and higher HbA1c levels. |
| Fegan-Bohm et al. [49] | Cross-sectional study | 187 children (aged 9–13) with T1D | Direct association between DD and HbA1c in children from racial/ethnic minority groups or lower socioeconomic status. |
| Nagel et al. [50] | Cross-sectional study | 419 young adults (aged <30) with T1D | DD correlated with HbA1c levels, regardless of diabetes device use. |
| Hong et al. [51] | Cross-sectional study | 313 adolescents (aged 13–17) with T1D | Direct association between DD and HbA1c. |
| Ehrmann et al. [32] | Prospective study (3-month follow- up) | 178 adults with T1D | The percentage of days with elevated DD (estimated by using ecological momentary assessment) was significantly associated with hyperglycemia (measured by CGM), and time with DD was directly related to HbA1c levels prospectively. |
| Déniz-García et al. [53] | Retrospective study (6-year follow- up) | 411 patients with T1D (aged >14) | DD was associated with long- term glycemic variability. |

CGM, continuous glucose monitoring; DD, diabetes distress; HbA1c, glycated hemoglobin; T1D, type 1 diabetes.

associated with other mental health problems, such as depression [60,61], anxiety disorders [62], or suicidal ideation/intended self-injury [63]. Of note, psychological repercussions may be different according to age. Therefore, in children living with T1D, DD can interfere with psychosocial development and hamper academic performance [64], whereas DD in adults with T1D may result in problems related work life or social relationships [65,66]. Some studies have also reported reciprocal negative interactions between DD and sleep quality [67,68]. As sleep quality has a key role in nocturnal glycemic variability and may also affect the time spent in hypoglycemia, clinicians should also be aware of the importance of this point [69,70].

## 5. Addressing distress in people living with type 1 diabetes

As illustrated in previous sections, T1D is a complex disease that needs to be managed through holistic approaches. Accordingly, the American Diabetes Association recommends a person-centered communication approach for patients with diabetes, also considering a multidisciplinary team (including education specialists, clinicians, nurses, nutritionists, exercise specialists, and mental health professionals, among other health care providers) in order to provide a comprehensive diabetes care [71]. A collaborative relationship between health care professionals and people living with T1D, based on empathy, together with nonjudgmental/no-blame approaches is also essential not only to improve the medical outcomes related to the disease, but also to achieve a better self-care management and well-being [71].

It also should be noted that development of specific communication skills may help clinicians to successfully address DD in people living with T1D. In this regard, Fisher et al. proposed 5 strategies to include in the interventions related to DD [12]. Therefore, after the systematic and regular assessment of DD, a focus on feelings, beliefs and expectations of people living with T1D should be performed (including different techniques, such as the acknowledgement and labelling of feelings, frequent summarizing and reflection, normalization of the situation, and using double reflections that include content about the management of diabetes, but also feelings) [12]. Also, helping in gaining perspective, together with the development of concrete plans and an appropriate follow-up should be considered [12].

Apart from the promotion of person-centered, holistic approaches for the management of T1D and its psychosocial implications, including DD, additional strategies may be helpful to address this issue. In the following subsections, we discuss the role of specific interventions and diabetes technologies in reducing DD in people living with T1D.

### 5.1. *Current approaches in the management of type 1 diabetes-related distress: the role of specific interventions*

Different DD-targeted interventions may lead to significant reductions in DD in people living with T1D. Among them, both behavioral/educational, skill-based interventions and those approaches focused on the psychological aspects of the disease play an important role. Previously, results from meta-analyses reported that psychological interventions are effective in reducing DD [72], although the combination of psycho-educational interventions might be the most helpful approach in the management of DD [73].

Recent randomized trials have evaluated the effectiveness of DD-targeted interventions in people living with T1D (Table 2). Thus, the T1-REDEEM trial, including 301 participants with T1D, demonstrated that both education/behavioral and emotion-focused interventions led to important reductions in DD [55]. Interestingly, the authors argued that the absence of differences between interventions could be

**Table 2**
Clinical trials assessing the role of specific interventions in reducing diabetes distress in people living with type 1 diabetes.

| Study | Participants | Intervention | Main results |
|---|---|---|---|
| Fisher et al. [55] | 301 adults with T1D | Educational/behavioral versus emotion-focused intervention (full-day workshop and 4 online meetings over 3 months). | Significant reductions in DD in both education/behavioral and emotion-focused interventions, with no differences between groups. |
| Hood et al. [75], Weissberg-Benchell et al. [76] | 264 adolescents (aged 14–18) with T1D | Penn Resilience Program (based on the promotion of resilience by 4 key constructs: a sense of hopefulness, an optimistic explanatory style, coping strategies, and problem-solving skills) compared with advanced diabetes education (duration of interventions: 4.5 months). | Substantial reductions in DD following Penn Resilience Program. Maintained results 3 years after the intervention. |
| Patton et al. [78] | 42 parents of young children with T1D | Manualized intervention based on cognitive/behavioral principles to reduce DD for childhood hypoglycemia using a three-pronged approach (included 10 sessions delivered remotely through telemedicine: seven weekly group sessions and three individual sessions specific for each family) versus usual care. | Significant reductions in fear of hypoglycemia. |
| Schmitt et al. [80] | 260 adults with diabetes and elevated distress and/or depressive symptoms (166 participants with T1D) | Educational stepped care program combining different treatment approaches (cognitive-behavioral therapy group treatment/ single cognitive-behavioral therapy via telephone) for depression (initial inpatient phase of 2 weeks followed by 1-year outpatient phase) versus usual care. | No significant differences in DD between groups after the intervention. Depression symptoms, well-being and acceptance improved after the stepped care approach. |
| Bisno et al. [74] | 53 young adults (aged 18–25) with T1D | 12-month educational intervention encompassing telehealth with or without virtual group appointments. | Significant improvements in DD in participants attending virtual group appointments. |
| Amiel et al. [77] | 99 adults with T1D and treatment-resistant impaired awareness of hypoglycaemia | 6-week psychoeducation program focussed on changing cognitive barriers to avoiding hypoglycemia versus evidence- based behavioral program. | Significant reductions in DD in both psychoeducation/behavioral program, with no differences between groups. |
| Martyn-Nemeth et al. [79] | 14 adults with T1D | 8-week, technology-assisted behavioral sleep intervention combining digital lessons, sleep tracker, and weekly coaching phone calls assessments. | Significant improvements in DD in the intervention group. |
| THR1VE! (NCT03845465) | 200 adolescents (aged 13–17) with T1D | Text- message-based positive affect intervention and diabetes education versus education only. | Primary outcome: changes in HbA1c, (secondary outcomes include changes in DD). Estimated study completion date: September 2023. |

DD, diabetes distress; HbA1c, glycated hemoglobin; T1D, type 1 diabetes.

explained, in part, by the sense of "community" experienced through the interaction with other people living with T1D [55]. Therefore, group interventions may add some benefits regarding improvements in DD, as shown in different trials evaluating the effectiveness of virtual group appointments in the treatment of DD [74]. Besides, addressing DD through these interventions might be linked to reductions in HbA1c via the improvement of self-care [56]. On the other hand, a significant, sustained decline in DD was reported in the Supporting Teens Problem Solving Program study (a randomized controlled trial comparing a distress/depression program with a diabetes education program in 264 adolescents with T1D) in the Penn Resilience Program arm (based on the promotion of resilience by 4 key constructs: a sense of hopefulness, an optimistic explanatory style, coping strategies, and problem-solving skills) compared with advanced diabetes education [75,76]. Besides, important dimensions of DD (e.g., fear of hypoglycemia) may be addressed by specific programs [77].

It also should be noted that telemedicine/virtual approaches may be useful strategies in reducing DD in people living with T1D, including virtual group appointments [74]. Additionally, video-based telehealth leads to reductions in emotional distress (including fear of hypoglycemia) in parents of children with T1D [78]. Remote sessions regarding specific problems in T1D (e.g., sleep disturbances), might also help to improve DD [79].

Stepped diabetes care approaches in the management of DD have also been tested. A randomized controlled trial performed in 260 people living with diabetes (63.8 % with T1D) with elevated depressive symptoms and/or DD showed that the stepped approach (i.e., 5 sessions of cognitive-behavioral therapy group treatment -Step 1-; 6–12 sessions of single cognitive-behavioral therapy in case of non-response to Step 1 -Step 2-, and referral for outpatient depression treatment in case of non-response to Step 2– Step 3-) further improved depression (primary outcome), well-being and acceptance, although did no improve DD, compared with treatment-as-usual [80]. This fact highlights that depression and DD are different problems which may require different approaches.

Notably, ongoing trials might help to shed light on the benefits of novel specific interventions to improve DD. Therefore, the multi-center randomized controlled trial THR1VE! will evaluate the effectiveness of diabetes education, together with a text message-based positive psychology intervention in reducing DD in adolescents living with T1D [81].

### *5.2. Impact of diabetes technology on type 1 diabetes-related distress*

In recent years, significant innovations in management of T1D have been developed. On the one hand, these advances have permitted to improve glycemic control and decrease the risk of hypoglycemia in people living with T1D [82,83]. Moreover, new technologies in the management of T1D reduce self-care burden associated with the disease and improve the quality of life of life of people living with T1D and their families [82,83]. Therefore, diabetes technology may have positive effects on DD in this population.

Notably, the implementation of continuous glucose monitoring (CGM) devices has led to significant improvements in glycemic control and quality of life in people living with T1D [84,85] and, consequently, may also result in reductions in DD in this population. Accordingly, results from the DIAMOND randomized trial, which assessed CGM versus self-monitoring of blood glucose in 158 adults with MDI and poorly controlled T1D, showed that CGM was associated with improvements in DD (especially in regimen and interpersonal distress) [86]. In the SILVER extension of the GOLD trial, those participants with T1D who continued with CGM over a year ($n = 107$) presented a higher overall well-being, treatment satisfaction and hypoglycemia confidence, whereas fear of hypoglycemia decreased, and DD tended to decrease [87]. However, conflicting results regarding this issue may be found in the literature [88,89]. On the other hand, use of intermittently scanned CGM is also associated with reductions in DD in people living with T1D [90,91]. Moreover, different technologies in DD, such as smart insulin pens, might also decrease DD (NCT05036343), although further research is needed.

Use of automated insulin delivery (AID) technologies is associated with increases in time in target glucose range with similar or even improved risk of hypoglycemia, as well as with improvements in quality of life and reduced self-care burden in people living with T1D [83]. Despite the fact that no fully AID systems are currently available, controller algorithms provide closed-loop insulin delivery to adjust glycemic target range between meals [83]. Of note, although studies that evaluate specific psychosocial-related outcomes regarding the use of AID are lacking, some clinical trials demonstrated significant improvements in DD in people living with T1D through the use of these technologies [92,93]. These results have also been confirmed in real-world settings [94]. Improvements in parental DD are expected following the use of advanced hybrid closed loop systems in children with T1D [95,96], although the impact of this intervention might be lower in terms of DD reductions in children/adolescents [97]. Additionally, AID may also reduce DD in specific subpopulations, such as older adults with T1D [98].

Notably, less advanced insulin delivery systems, such as sensor-augmented insulin pumps could also improve DD in people with T1D [99]. However, it should be noted that advanced hybrid closed-loop insulin delivery systems may be more effective in reducing DD than sensor-augmented pumps [100]. Indeed, recent real-world evidence shows that switching from sensor-augmented pumps to hybrid closed-loops systems improves glycemic outcomes and reduces neuropsychological burden and DD in people living with T1D [101].

It is important to bear in mind that there are several barriers and disparities in AID access and diabetes education/training for AID utilization, which are key factors to avoid burnout and optimize use of AID systems or different diabetes technologies [83]. In this regard, disparities related to gender, geographic location, social status, or ethnic identity may constitute important barriers to the use of AID, as previously reported [102,103]. Moreover, other factors such as costs, alarm fatigue, physical discomfort/unwanted social attention may constitute important barriers to use these technologies [83,104–106]. Additionally, people living with T1D may benefit from choosing their preferred insulin delivery method [107].

## 6. Conclusion

DD is a frequent but overlooked issue in people living with T1D, with important implications in health. Person-centered, holistic approaches are recommended to address this problem, and specific behavioral/psychosocial interventions may also be needed in its management. Novel technologies in diabetes, such as CGM or AID systems may have a decisive role in reducing DD in people living with T1D, although further research is warranted.

## CRediT authorship contribution statement

**Alba Rodríguez-Muñoz:** Writing – original draft, Writing – review & editing. **María José Picón-César:** Writing – review & editing. **Francisco J. Tinahones:** Writing – review & editing, Supervision. **José Ignacio Martínez-Montoro:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision.

## Declaration of competing interest

The authors declare that no competing interests exist.

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