

James Lind Alliance Research Priorities

The cognitive and psychological effects of living with type 1 diabetes: a narrative review

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Abstract

Across the lifespan, type 1 diabetes mellitus has a profound (neuro)psychological impact. In young people, type 1 diabetes can interfere with psychosocial development and hamper school performance. In adulthood, it can interfere with work life, relationships and parenting. A substantial minority of adults with type 1 diabetes experience coping difficulties and high diabetes-related distress. In youth and adulthood, type 1 diabetes is related to mild cognitive decrements as well as affective disorders, such as depression and anxiety. There is limited literature available that explores the interaction between cognitive and psychological comorbidity and underlying mechanisms. The aims of the present narrative review were to summarize the current state of the literature regarding both cognitive and psychological comorbidities in type 1 diabetes across the lifespan, and to explore potential links between the two domains of interest to make suggestions for future research and clinical practice.

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Introduction

This review is part of a series on the James Lind Alliance Research Priorities in Diabetes. Type 1 diabetes mellitus is primarily diagnosed during childhood and adolescence [1], although many cases are diagnosed during adulthood [2]. Despite significant improvements in its medical treatment, type 1 diabetes carries an increased risk of developing micro- and macrovascular complications [3]. It is well recognized that living with and self-managing type 1 diabetes, with and without complications, is psychologically challenging, impacting on emotional health and social functioning [4]. There is also evidence that type 1 diabetes is associated with mild to moderate cognitive deficits, also called decrements, during childhood [5] and adulthood [6]. Less is known about the impact of type 1 diabetes on cognition in the elderly (age >65 years) or about their risk of dementia.

Type 1 diabetes and related acute and long-term complications can have a profound effect on cognitive, emotional and social functioning of the person living with diabetes. In this narrative review, we present selected review and overview

papers, where possible combined with original research articles, to highlight the most recent advances in research on cognitive and psychological, i.e. emotional and behavioural, problems across the lifespan of type 1 diabetes. A systematic search of the literature was not performed. These two domains of interest encompass a broad range of functions that are most often researched separately rather than in interaction. We explore the limited research to date on the complex relationship between psychological and cognitive functions in the ageing population of people with type 1 diabetes and discuss potential implications for future research.

Type 1 diabetes-related cognitive sequelae

In this section we discuss the current state of cognitive findings in type 1 diabetes across the lifespan. Most neurocognitive tests used to measure domains such as memory, attention and executive functions are similar throughout adolescence to older age. For younger children, adapted versions of the tests are sometimes used.

Childhood/adolescence

One meta-analysis of 19 studies in young people has shown that type 1 diabetes-related cognitive decrements are characterized by slightly lower overall cognitive performance and moderately lower memory skills, attention and executive

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What's new?

- Cognitive decrements are found in people with type 1 diabetes across the lifespan in functions such as attention, information processing speed, and executive functions. Also across the lifespan, type 1 diabetes is related to a higher prevalence of depression, anxiety and distress, and a lower quality of life.
- This narrative review summarizes current knowledge and discusses studies that have linked cognitive decrements with psychological comorbidities, including the possible effect on diabetes self-care.
- This study shows the gaps in our knowledge and provides suggestions for clinical research and how clinical practice can be improved by including cognitive and psychological screening.

functions. These small to moderate effects were mainly found in those with an early disease onset, i.e. at <7 years of age [5]. Another meta-analysis, summarizing 24 studies, found moderate, in terms of effect size, deficits in visuospatial abilities, reading and writing, and motor speed, with smaller effects on intelligence [7]. Negative effects of type 1 diabetes on cognition have been found in pre-school children [8], and as early as 2 years after diagnosis [9]. To test whether these deficits increase over the years, a series of longitudinal studies has been performed 2, 6 and 12 years after diagnosis in 124 children aged 3–14 years at inclusion [9–11]. It was found that, at inclusion, directly after type 1 diabetes onset, there were no differences between groups [12], but after 2 years, intelligence, learning and memory, and processing speed had moderately declined [9]. Interestingly, at year 6 and 12, cognitive decrements remained stable. A more recent study including children aged <10 years with a mean disease duration of 2.9 years failed to show baseline cognitive deficits or decline after 18 months compared to controls, but only after stringently controlling for multiple comparisons [13]. Within the type 1 diabetes group, however, those with moderate to severe diabetic ketoacidosis at onset did show pronounced baseline and follow-up cognitive deficits relative to their peers without diabetic ketoacidosis at onset [14]. Collectively, these studies identified early disease onset, higher HbA_{1c}, hypoglycaemic events and diabetic ketoacidosis around onset as major contributors to cognitive decrements, but observed no or limited decline in cognitive abilities. It is hypothesized that these diabetes-related factors provide an ‘initial strike’, after which the brain adapts to the new situation of fluctuating glucose levels [15].

Young and middle adulthood

Despite the extensive literature showing cognitive decrements soon after diagnosis in childhood, there is a limited

number of longitudinal studies available in adults with type 1 diabetes. A meta-analysis of 33 cross-sectional studies indicated generally lower cognitive performance, which was mainly characterized by slowing of processing speed, and attentional and executive functions deficits [6]. Across studies, hyperglycaemia, but not hypoglycaemia, was related to these decrements, in contrast to the findings of paediatric studies. The effect sizes of these decrements were, however, similar to the ones found in paediatric samples.

The Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) is by far the largest longitudinal study on cognition, with an 18-year follow-up. In the absence of a healthy control group, the DCCT/EDIC demonstrated minor, but clinically significant, declining processing speed and visuospatial processing in those with an HbA_{1c} of ≥ 7.2 mmol/mol (8.8%) [16]. Again, hypoglycaemic events did not affect cognitive performance [16,17]. The results were similar when only including people with type 1 diabetes who were adolescents at study entry [18].

Two other smaller longitudinal studies with matched controls have been published. One showed an accelerated decline in processing speed over a 7-year period, which was related to pre-existing micro- and macroangiopathy, systolic blood pressure and type 1 diabetes duration [19]. The other study compared 25 people with type 1 diabetes with proliferative retinopathy to 25 matched controls. At baseline, people with type 1 diabetes had worse information processing speed and (psycho)motor speed [20]. After a 3.5-year follow-up, the type 1 diabetes group showed accelerated decline on executive functions, which was related to higher HbA_{1c}, but (again) not to hypoglycaemic events [20].

Late adulthood

With the increasing life expectancy of people living with type 1 diabetes, it is surprising to see that only a few cognitive studies focusing on older age have been published. Brands *et al.* [21] demonstrated lower processing speed abilities, with comparable rates of atrophy and brain lesions, in people with type 1 diabetes with an average age of 61 years and, on average, 34 years of diabetes, compared with controls. After 4 years of follow-up, this group, relative to controls, did not show accelerated cognitive decline [22]. Interestingly, however, those who had either experienced at least one severe hypoglycaemic episode within the follow-up period and those with cardiovascular disease did demonstrate declining processing speed and overall cognitive performance, respectively [22]. This possibly indicates that cognition of elderly people living with type 1 diabetes is vulnerable to hypoglycaemia and macroangiopathy.

A recent cross-sectional study in older people with type 1 diabetes confirmed that hypoglycaemia, in addition to pre-existing microangiopathy was associated with cognitive decrements [23]. The role of hypoglycaemia in type 1

diabetes-related cognitive deficits in the elderly was further supported by a study assessing clinically significant cognitive impairment (≥ 2 cognitive tests ≥ 1.5 SD below normative data) in 201 people with type 1 diabetes [24].

Again, the effects found in these studies were not larger than those found in paediatric and adult samples, suggesting that with advancing age the decrements deteriorate slowly, if they deteriorate at all.

Type 1 diabetes and dementia

In the general population, the risk of dementia increases substantially with ageing. An often-postulated hypothesis is that, because of microstructural cerebral alterations and cognitive deficits, people with diabetes are at an increased risk of developing dementia, such as vascular dementia and Alzheimer's disease [25]; however, compelling evidence for this hypothesis is currently lacking for type 1 diabetes.

The previously mentioned study quantifying clinically significant cognitive impairment, also known as mild cognitive impairment [26], found that 48% of the 201 elderly people with type 1 diabetes met these criteria [24], which is substantially higher than the 16% found in the general population aged > 60 years [26]. Of the 48% of people meeting mild cognitive impairment criteria, 12% were characterized as having amnesic, 44% as non-amnesic, and another 44% as multiple-domain mild cognitive impairment [24]. Amnesic mild cognitive impairment is known to have the highest conversion rate to dementia compared with the other forms of this condition [26].

There are only few studies that have included type 1 diabetes in assessing the link between diabetes and dementia. Smolina *et al.* [27] did include type 1 diabetes in a cohort study conducted in England based on medical records. In total 10 786 people with type 1 diabetes with a dementia diagnosis were identified and classified as: any dementia, Alzheimer's disease, and vascular dementia. The overall adjusted relative risks were 1.65 (95% CI 1.61–1.68) for any dementia, 1.10 (95% CI 1.05–1.15) for Alzheimer's disease, and 2.21 (95% CI 2.13–2.28) for vascular dementia [27]. Given the increased risk of macrovascular events, the elevated risk of vascular dementia was to be expected. The risk for Alzheimer's disease was only slightly increased in type 1 diabetes but statistically significant. This, combined with the low number of amnesic mild cognitive impairment cases found in type 1 diabetes [24], indicates that Alzheimer's disease is not the main dementia to be concerned about.

This study was not able to identify underlying mechanisms. A recent study, using the Kaiser Permanente Diabetes Registry data, showed a direct link between any dementia and higher long-term HbA_{1c} values specifically in people with type 1 diabetes [28]. Using data from the same registry, a study by Rodill *et al.* [29] did not demonstrate a relationship between proliferative retinopathy and any

dementia, suggesting that the link between glycaemic control and dementia is not mediated by this form of microangiopathy.

Emotional effects of living with type 1 diabetes

Children and adolescents

Being diagnosed with type 1 diabetes in childhood or adolescence can interfere with developmental changes and cause psychological distress [30,31]. Reynolds *et al.* (2011) [30], Johnson *et al.* (2013) [32] and Buchberger *et al.* (2016) [33] reviewed symptoms of depression and anxiety in children with type 1 diabetes. Reynolds *et al.* included 22 studies in their meta-analysis, and showed that young people with diabetes reported significantly more depressive symptoms and more clinical depression compared to peers, with fixed moderate effect sizes [30]. Looking at the descriptive results of the review by Johnson *et al.* [32], 11 out of their 23 included studies compared young people with diabetes and their peers without diabetes. Of those studies, eight found higher prevalence rates of depressive symptoms vs control or reference groups. The remaining three studies found no differences [32]. Buchberger *et al.* [33] updated the search of Reynolds *et al.* from 2008 to 2015 and included 14 studies in their review and meta-analysis. They found a pooled prevalence of self-reported depressive symptoms of 30%, with high heterogeneity. Prevalence rates ranged from 17% to 63%, depending on population, design and diagnostic tool [33].

Anxiety symptoms are less well studied. Reynolds *et al.* [30] included six studies, showing that anxiety symptoms are slightly elevated in young people with type 1 diabetes compared to peers, with a minor effect size. Buchberger *et al.* [33] identified seven studies reporting prevalence rates of elevated anxiety levels up to 32%, but not all studies showed differences between young people with diabetes and control groups [33]. One study even found that young people with diabetes reported less anxiety compared to their peers [34].

In addition to depressive and anxiety symptoms, Reynolds *et al.* [30] included other variables in their review, including psychological distress, self-esteem, peer difficulties and psychopathology. Of those constructs, only psychological distress was found to be elevated (minor effect size) compared to healthy peers [30]. An important component of psychological distress is diabetes-specific distress, referring to the negative emotions arising from living with diabetes and the burden of daily self-management. Hagger *et al.* [35] in their systematic review included 16 studies assessing diabetes-specific distress, or simply diabetes distress, and found that it was reported by one in three adolescents [35], with great heterogeneity among studies. Fewer studies on diabetes distress have been conducted in emerging adults specifically, and reviews are lacking. Across studies, prevalence rates of

psychological (diabetes) distress vary from 12% to 60% [36–39]. It should be kept in mind that both anxiety and diabetes distress are strongly correlated with depressive symptoms, so those with depressive symptoms are likely to experience symptoms of anxiety or distress as well [30,33,35].

It is not yet clear how different emotional difficulties impact on diabetes self-management and glycaemic control [30,33,35,40,41]. Reynolds *et al.* [30] found that children with poorer glycaemic control differed more from their healthy peers with regard to anxiety and psychological distress levels, but not for depressive symptoms. Johnson *et al.* [32] found that cross-sectional studies examining the relationship between more depressive symptoms and poor glycaemic control found a significant association, while results from prospective studies showed mixed results. Buchberger *et al.* [33] found that most studies reported a small to moderate relationship between more depressive and anxiety symptoms and poor glycaemic control, but not all. Hagger *et al.* [35] found more diabetes distress to be related to poorer glycaemic control in eight of 12 studies, with small to moderate effect sizes. Whether diabetes distress is more strongly related to glycaemic control and self-management than depression and anxiety (as has been found in adults) is unclear and warrants further investigation [35].

Young people with type 1 diabetes seem to be at an increased risk of eating problems, which may be related to the need to focus on food and energy intake as part of the treatment. Disordered eating behaviour is prevalent in teenagers and young adults with type 1 diabetes, with prevalence rates up to 40% [42]. Diagnosed eating disorders are less common, with prevalence rates of ~7% [42], but detrimental to health, with an increased risk of poorer glycaemic control, earlier complications and mortality [43]. Skipping insulin injections and under-dosing of insulin are unhealthy weight loss strategies unique to people with insulin-treated diabetes. Insulin manipulation is not uncommon among young women with type 1 diabetes, and is referred to as ‘diabulimia’. This term is inaccurate, as binge-eating is not necessarily part of the problematic ‘purging’ behaviour [44].

Recent large population-based cohort studies from Denmark and Sweden showed that young people with type 1 diabetes are around two times as likely to be diagnosed with a psychiatric disorder compared to peers without diabetes [45,46], with incident rates of ~15%. The same trend was found in young adults with childhood onset of diabetes in Australia [47]. In all three population-based studies prevalence rates of eating, mood, anxiety and behavioural disorders differed most from peers [45–47].

Adults

Living with and managing type 1 diabetes during adulthood and older age, whether diagnosed early or later in life can be stressful. As noted by the sociologists Corbin and Strauss

(1985) [48], living with a chronic condition such as diabetes demands ‘three lines of work’: medical, psychological and social, and balancing a normal life with adequate self-management can be challenging [49]. Not surprisingly, adults with type 1 diabetes commonly experience coping difficulties and psychosocial problems [50,51], although overall the perceived quality of life appears not to be lower than that of the general population [52]. About one-third of adults with type 1 diabetes report high levels of diabetes distress that can translate into ‘diabetes burnout’, a vicious cycle of feeling frustrated and ‘giving in’, with further deterioration of glycaemic control and increasing emotional distress [53]. Acute blood glucose excursions, and in particular hypoglycaemic events, are found to be disruptive and burdensome, negatively impacting work performance, relationships and emotional health [54]. Approximately 20% of people with longstanding type 1 diabetes have impaired hypoglycaemia awareness, putting them at increased risk of severe hypoglycaemia, particularly in older adults [55]. Fear of hypoglycaemia is common and can seriously impair normal functioning in people with diabetes as well as family members [56]. During adulthood, debilitating microvascular complications can develop and progress, negatively impacting physical health, social and psychological functioning. Worrying about complications and loss of functional abilities is one of the major sources of distress in people with type 1 diabetes [57]. Diabetes and its complications can negatively impact on sexual functioning in both men and women, with ~25% reporting sexual dysfunction [58]. In women, but not in men, sexual dysfunction has been found to be related to depression and the quality of the relationship [59]. Pregnancy in type 1 diabetes can be extra stressful, given the need to maintain strict glycaemic control and uncertainties around possible birth defects and neonatal complications [60].

As in young people, psychological distress (anxiety and depression) appears common in adults with type 1 diabetes [61]. Prevalence of anxiety has been studied almost exclusively in adults with type 2 diabetes, or a mix of both disease types, leaving uncertainty about the prevalence of anxiety and depression and its correlates in type 1 diabetes [62]. Recently, Nefs *et al.* [63] published the findings of a cross-national questionnaire study on anxiety and depression in adults with diabetes with a relatively large subsample of type 1 diabetes aged 33–56 years ($n=2782$). They found anxiety rates in type 1 diabetes not to be elevated (point prevalence 2%). Interestingly, participants with elevated symptoms of anxiety and depression were found to have shorter diabetes duration. A Spanish diagnostic interview study conducted in 339 adults with type 1 diabetes from a tertiary clinic, found the prevalence of anxiety and depression to be 19.5% and 24%, respectively, and highest for women [64]. The authors distinguished between three age groups: early adulthood (18–25 years), midlife (26–45 years) and mature adults (46–65 years). Interestingly, they found the highest levels of anxiety in the midlife group, and the highest depression levels in

mature adults, with microvascular complications predicting anxiety and depression across age groups.

Depression has been found to be more prevalent in adults with type 1 diabetes, relative to the general population, and associated with poorer self-care, glycaemic control and increased risk of complications [65,66]. Most studies have measured depressive symptoms based on self-report questionnaires. Fisher *et al.* [67] point to the problem of possible overdiagnosis of depression when using self-report measures, referring to their data in a cross-sectional study in adults with type 1 diabetes (mean age 43 years), comparing findings from a psychiatric diagnostic interview with a short depression screener (Patient Health Questionnaire-8). Moreover, they found high levels of diabetes distress that may at least partly overlap with depressive symptomatology, although depression and diabetes-related distress are two separate constructs [68].

Eating disorders are less well studied in adults than in young people with type 1 diabetes, but a recent prevalence study from Norway showed that in a sample of 282 adults with type 1 diabetes (age range 18–79 years), a total of 20.3% (13.3% of men and 24.8% of women) scored above the threshold of a validated screener for disordered eating behaviours (DEPS-R). HbA_{1c} level was significantly associated with DEPS-R total score ($P < 0.01$) among women, but not with depression and anxiety. Mean DEPS-R score decreased with increasing age [44].

Mechanisms

The aetiology of depression in young people and adults with diabetes is still poorly understood. Multiple pathways are likely to be involved. One explanation may be the emotional and behavioural burden of type 1 diabetes and the continuing, and intrinsically unpleasant self-care demands that get in the way of a 'normal life'. Young people with type 1 diabetes may be particularly vulnerable to social pressure, discrimination and stigma, increasing the risk of psychological and behavioural problems. In adults, diabetes can interfere with work, relationships and parenting. Next to illness intrusiveness, biomedical factors may play a role. For example, hyperglycaemia and hypoglycaemia are known to directly impact on mood and cognitive performance, further adding to stress and the risk of demoralization and depression. Given the prevalence and consequences, guidelines recommend to screen for mental health problems in young people with type 1 diabetes [31], and interventions are available for healthcare teams to offer to their patients [69].

In addition to this 'hardship' hypothesis, biological risk factors may be involved. A history of poor glycaemic control throughout childhood is found to be a risk factor for anxiety, mood and eating disorders in young adulthood [47]. In more recent studies, young people with diabetes seem to differ less from their peers, possibly because of advances in treatment in the last decades [30,46]. In adults, a possible link with

cerebral microvascular disease [70], and neuroinflammation [71] has been postulated.

Linking cognition and emotional effects

The interaction between cognitive and emotional effects, and its effects on diabetes self-care are poorly studied. Yet there are good reasons why this is an important topic. Firstly, in type 1 diabetes, states such as depression and anxiety are more prevalent [72], and secondly, are linked to worse self-care, and cognitive decline [73]. Furthermore, there might be indications for biochemical disturbances in the brain regions affected by diabetes that might also affect emotional states.

Perez *et al.* (2017) [74] looked at the relationship between executive functioning and depressive symptoms, and diabetes-specific quality of life in young people with type 1 diabetes. In this sample, no executive functioning problems were reported in the clinical range, nor an association between executive functioning and depressive symptoms; however, more executive functioning problems were associated with poorer diabetes-specific quality of life, clearly highlighting that psychological well-being and cognitive functioning are linked. In older adults with type 1 diabetes, higher depression scores were independently related to poorer diabetes self-care and instrumental activities of daily living (IADL) scores [75]. Univariately, but independent of age, education and depressive symptoms, lower memory and complex attentional functioning were related to poorer diabetes self-care. Moreover, in a multivariate model, more overall cognitive impairment was independently related to worse diabetes self-care, with the model explaining 30% of the variance. Worse IADL score was univariately and independently related to lower executive functions, processing speed, and complex attentional functioning scores, whereas more overall cognitive impairment was independently related to lower IADL scores, with the model explaining 28% of the variance [75].

Besides the behavioural pathway, brain functioning may be directly affected by diabetes. McIntyre *et al.* [76] note that brain regions subserving affective functions, such as the prefrontal cortex and limbic structures, are affected in neuroimaging studies in type 1 diabetes. This suggests that diabetes-associated structural and biochemical disturbances in the brain might also influence emotional well-being, leaving people with diabetes more susceptible to mood disturbances and mental health difficulties. This hypothesis was supported by a report of elevated prefrontal glutamate-glutamine- γ -aminobutyric acid levels related to both poorer cognition and higher depressive symptoms [77]. Further support comes from a resting-state functional magnetic resonance imaging study in adults with and without retinopathy. In that study, higher levels of depressive symptoms moderately exacerbated general cognitive performance and processing speed decrements [78]. The study also showed that higher levels of depressive symptoms in these people with diabetes were related to a brain state in which there was more attention for the internal

than the external environment, alterations that are commonly seen in people with major depression as well [78].

Discussion

In this section we review our findings, to identify gaps in the literature and make suggestions as to how research can help us going forward.

Cognition

Cognitive decrements are seen as early as pre-school age and as soon as 2 years after diagnosis. Contrary to what might be expected, we do not see a progressive decline in cognitive deficits. Rather, effect sizes remain relatively stable over time. Although there is sufficient novel literature on cognitive functioning, the available meta-analyses are relatively old. It is of particular interest to conduct meta-analyses that include recent studies that have applied modern treatment options, such as continuous glucose monitoring. This might help us identify the impact of glucose fluctuations, and not just of severe hyper- or hypoglycaemic events or HbA_{1c} on cognition.

Not surprisingly, the focus of many studies has been on the effect of early-onset age on cognition; however, with the identification of many people, especially genetic cases, with adulthood onset [2], we need to know if such individuals are more vulnerable to cognitive decrements or not.

Independent of age, large longitudinal studies are missing. With only a few covering childhood and early to middle adulthood and one covering older adulthood, it is pivotal to invest in such studies. It will increase our insight into trajectories of cognitive decline over time and provide stronger evidence for associations between biomedical variables and cognition. Ultimately, this should lead to ways that could help prevent or ameliorate cognitive decrements, something that, with increasing life expectancy and thus increasing risk of dementia, is important and necessary.

With an ageing population of people with type 1 diabetes, knowledge of the cognitive profile of older people and the risk of dementia is important. There is an almost total lack of cross-sectional and longitudinal studies. As one study pointed out, cognitive decrements have a direct effect on diabetes self-care [75]. The participants in that study were free of dementia, but another study identified the risk of dementia, in particular vascular dementia, to be strongly elevated [27]. From a self-care point of view, older adults with type 1 diabetes are those to whom particular attention should be paid. Future studies therefore need to identify the magnitude of cognitive decrements, risk of dementia, and their underlying pathophysiology.

Psychological effects

Type 1 diabetes has traditionally been studied as a chronic illness of childhood; however, young adulthood is a critical

time for the development and integration of lifelong diabetes management skills. Most young adults experience multiple transitions during this unstable developmental period, including changes in lifestyle and healthcare, and shifting social relationships with family members, friends and intimate others. More longitudinal research is needed to track the psychosocial development into young adulthood and beyond to identify key factors that influence diabetes management and health outcomes. Here again, those young adults diagnosed after the age of 18 years warrant special attention as very little is known about this group. Besides changes over time in the long run, changes over time on a daily level are of interest. With the increasing knowledge of the importance of time in range and glucose variability, the impact of this variability on psychological well-being seems understudied. Better insight into these more direct relationships and potential moderators and mediators could be helpful to guide intensified diabetes management.

Where literature on the cognitive effect of type 1 diabetes in older adults is lacking, the same can be concluded for the psychological impact. Studies suggest that levels of diabetes-specific distress decline with older age; however, research into the psychological status of elderly patients is limited and requires more attention. More so, elderly are more likely to have invalidating comorbidities and complications as well as an increased risk of hypoglycaemia, negatively impacting both cognitive and emotional functioning. More research into the complex interaction between cognitive, emotional and behavioural problems in older people with type 1 diabetes is warranted.

Linking cognitive and psychological effects

The studies mentioned in the present review highlight the cognitive and emotional states in type 1 diabetes that might independently, or through their interaction, have negative consequences for diabetes self-care and health outcomes. From a cognitive research perspective, the emotional effects of type 1 diabetes are commonly treated as a confounder rather than a factor of interest. This might be opportune during early and middle adulthood, where the brain is in a stable period and cognitive deficits influencing self-care are less expected. In young people with type 1 diabetes, however, the interaction between cognition and emotional state is important, as it is during this period that they gradually become responsible for their own diabetes management, and the basis for their academic and professional future is created. The interaction becomes even more important in elderly people with type 1 diabetes. In this period of natural cognitive decline, the complex and non-routine nature of diabetes self-care may put individuals at risk of severe glucose fluctuations, potentially resulting in severe hypoglycaemic events or diabetic ketoacidosis. Depression in elderly people with type 1 diabetes may further increase this risk, as depression alone is related to poorer self-care [73]. It is

therefore important that research focuses on the interaction between type 1 diabetes-related cognitive decrements and emotional status, especially in young people and the elderly.

Clinical implications

Clinically, healthcare providers should be aware that emotional status and cognitive decrements can interact with each other and put patients at a higher risk of glucose fluctuations and its subsequent consequences. For young people with type 1 diabetes, both International Society for Paediatric and Adolescent Diabetes (ISPAD) consensus guidelines and the American Diabetes Association (ADA) position statement state that psychological well-being should be assessed on a routine basis [34,79]. The ISPAD adds screening of cognitive development, especially if there is a background of early diabetes onset, severe hypoglycaemia or chronic hyperglycaemia. However, implementation of these guidelines in routine care is difficult [80]. For young people with diabetes, the Diabetes-Related Executive Functioning Scale has been developed to provide information about specific executive functioning and related behaviour problems that are clinically relevant and important to optimizing diabetes management [81]. With early identification of executive functioning difficulties, parental involvement in diabetes self-care could be adjusted to maintain or reach optimal glycaemic outcomes [82]. It is recommended that this questionnaire be administered in tandem with psychological well-being measures to obtain a complete picture and discuss possible interactions [83]. When indicated, a more extensive neuropsychological or psychological evaluation should be provided.

For adults, the ADA position statement on psychosocial care for people with diabetes states that: 'Providers should consider an assessment of symptoms of diabetes distress, depression, anxiety, and disordered eating and of cognitive capacities using patient-appropriate standardized/validated tools at the initial visit, at periodic intervals, and when there is a change in disease, treatment, or life circumstance' [84]. Especially in older adults, annual screening for early detection of mild cognitive impairment or dementia and depression is recommended [85].

This means that both the paediatric and adult type 1 diabetes healthcare teams should be aware of the possibilities of cognitive decrements, psychological problems, and its potential interaction. Brief cognitive screenings for type 1 diabetes that have yet to be developed could be applied during childhood and older adulthood. When indicated, a more extensive neuropsychological evaluation should be provided. Similarly, brief psychological evaluations should be incorporated into routine type 1 diabetes care. When screening indicates potential problematic areas, people with type 1 diabetes should be offered a referral to a clinical (neuro)psychologist for further diagnostics and psychological treatment if needed. A priority for research should be to

provide clinicians with validated tools and to incorporate comprehensive psychological screening into clinical practice.

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Competing interests

None declared.

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