


BMJ Open Factors associated with fear of hypoglycaemia among the T1D Exchange Glu population in a cross-sectional online survey

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ABSTRACT

Objectives Fear of hypoglycaemia (FoH) has been associated with suboptimal diabetes management and health outcomes. This study investigated factors associated with behavioural and emotional aspects of FoH among adults living with type 1 diabetes (T1D) mellitus.

Design Cross-sectional study.

Setting Online survey hosted on T1D Exchange Glu, an online community for patients living with T1D mellitus.

Measures The Hypoglycaemia Fear Survey II-short form and the Hypoglycaemic Attitudes and Behaviour Scale were used to assess FoH. Multivariable regressions were performed on assessment scores.

Results The study included 494 participants (mean±SD age 43.9±12.2 years, duration of T1D mellitus 16.6±16.8 years, self-reported glycosylated hemoglobin (HbA1c) 6.9%±0.8% (52±9 mmol/mol)), 63% men, 89% on insulin pump, 25% experienced a severe hypoglycaemic event in the last 6 months. Multivariable regression analyses showed higher anxiety, depression severity and diabetes distress were independently associated with FoH (all $p<0.01$). Longer diabetes duration was associated with lower FoH ($p<0.01$). Past experience with severe hypoglycaemia was associated with higher worry of hypoglycaemia ($p<0.01$) but not avoidance behaviour (ns).

Conclusions These results highlighted the multifaceted nature of FoH, which warrants further discussion between providers and patients to uncover drivers of and actions required to reduce FoH and improve patient care and outcomes.

INTRODUCTION

Diabetes mellitus is a serious health condition contributing to comorbidities in patients with diabetes. Hypoglycaemia is a major limiting factor in the glycaemic management of type 1 diabetes (T1D) and advanced type two diabetes mellitus.¹ Hypoglycaemia is more frequently experienced by patients being treated with insulin injection or infusion, but also in patients treated with insulin secretagogues.² Severe hypoglycaemia occurs about 2–3 times more frequently in patients with T1D mellitus than in patients with type two

Strengths and limitations of this study

- The study examined multiple components of fear of hypoglycaemia using a battery of validated patient-reported outcome instruments.
- The study sample was mostly white and highly educated and may not represent the type 1 diabetes population at large.
- Self-reported responses were not cross-checked with medical records.

diabetes mellitus treated with insulin, and the incidence increases with age and years of duration of diabetes.^{3–5} Symptoms of severe hypoglycaemia can include shakiness, anxiety, stupor or loss of consciousness, seizures, hypoglycaemia-induced coma and with recurrent hypoglycaemia, one can develop an impaired awareness of hypoglycaemia symptoms.^{6,7} A history of hypoglycaemia, especially severe hypoglycaemia, can lead to a fear of hypoglycaemia.⁸

Frequency of severe hypoglycaemia is one of the most important factors associated with fear of hypoglycaemia.^{9,10} Previous research has also shown fear of hypoglycaemia to be associated with severity of the worst hypoglycaemic event in the past 3 months, with greater severity associated with greater fear of hypoglycaemia as assessed by the Hypoglycaemia Fear Survey (HFS).^{8,11}

Fear of hypoglycaemia has been associated with suboptimal diabetes management and lower quality of life.¹² This fear may increase distress in patients and lead to behavioural changes to avoid hypoglycaemia. Fear of hypoglycaemia may be associated with behaviours including additional snacking, decreased physical activity and maintaining higher blood glucose levels to avoid hypoglycaemia.^{13–16} Patients may also experience stress-induced eating and bingeing, as well as

mismanagement of insulin doses in response to or anticipation of a future hypoglycaemic event.^{17–19} As a result, healthcare providers responding to unmet blood glucose goals may increase medication doses or add medications to treatment regimens to reduce blood glucose levels and not address the underlying fear of hypoglycaemia issues.

State and trait anxiety have been associated with fear of hypoglycaemia.²⁰ Polonsky *et al*²¹ observed that in patients with T1D mellitus and those with type 2 diabetes mellitus, higher scores on the worry scale of the HFS were correlated with higher levels of trait anxiety and general fearfulness. Patients with T1D mellitus who had higher scores on the worry scale also had difficulty discriminating between anxiety and initial symptoms of hypoglycaemia.²¹ This diminished ability to discriminate between anxiety and hypoglycaemia potentially delays or prevents patients from responding appropriately to hypoglycaemia, which can result in more severe hypoglycaemic episodes occurring.²¹ Additionally, difficulty in distinguishing between symptoms of anxiety, symptoms of hypoglycaemia and adverse effects associated with hypoglycaemia, complicates utilisation of psychological interventions that are routinely used to treat fears and phobias.²⁰ A single fear may be generalised as both anxiety and avoidant behaviour spread well beyond the initial triggering situation,²⁰ as evidenced by a case study of a man whose fear of hypoglycaemia led to the development of agoraphobia and panic disorder.²²

As studied by experts in the field, fear of hypoglycaemia consists of multiple behavioural and emotional aspects, including anxiety/worry around hypoglycaemia, confidence in managing hypoglycaemia and specific behaviours to avoid hypoglycaemia.^{23 24} Existing patient-reported outcome measures not only assess the overall level of fear of hypoglycaemia, but can also assess the aforementioned individual aspects of fear of hypoglycaemia. These existing measures are widely used in research, but not commonly used in clinical practice.

The American Diabetes Association (ADA) published a position statement on psychosocial care for patients with diabetes in 2016, which recommends assessment and monitoring of psychosocial factors impacting self-care, with referrals to a mental health provider for appropriate interventions. Specifically, the position statement recognised fear of hypoglycaemia and recommended assessment for it and referral if a positive screen for anxiety or fear of hypoglycaemia is presented.²⁵

In alignment with the ADA position statement and based on previous research, a closer examination of the different and complex emotional and behavioural aspects of fear of hypoglycaemia was the focus of the current study. The primary objectives of this study were (1) to describe experiences, emotional burdens and responses, and specific management behaviours with regard to hypoglycaemia among adults with T1D mellitus and (2) to investigate patient characteristics and demographics and experience with hypoglycaemia and hyperglycaemia in relation to the behavioural and

emotional aspects of fear of hypoglycaemia. Fear of hypoglycaemia still exists, although technology such as continuous glucose monitoring and mobile phone applications are moving quickly to help patients manage T1D mellitus and better understand key drivers of fear of hypoglycaemia in order to improve patient care and outcomes. This study adds to our understanding of the fear patients with T1D mellitus experience due to hypoglycaemic events, as well as the actions they take to prevent each of these events. A better understanding of the factors associated with the different aspects of fear of hypoglycaemia would facilitate further research on its aetiology and treatment, and improve clinical care for patients with fear of hypoglycaemia.

MATERIALS AND METHODS

Study design

A literature review was completed to better understand available literature regarding behaviours that result due to a fear of hypoglycaemia, and knowledge within the T1D mellitus community. The literature review was also conducted to identify fear of hypoglycaemia research areas that have been thoroughly covered and target areas with little to no attention in the literature. Ethnographic interviews and several patient focus groups were conducted to validate those elements related to the fear of hypoglycaemia and associated factors and behaviours identified in the literature review, and to elucidate those that were unidentified, but pose a real burden to the T1D mellitus community. The findings were in line with previous research, as people with current or history of fear of hypoglycaemia reported avoidant behaviours including conservative insulin dosing methods as well as proactive habits around eating.^{26 27} With the information generated from the literature review, ethnographic interviews and focus groups, an online survey was developed using the instruments discussed below.

This study was a cross-sectional online survey (see online supplementary file) hosted on T1D Exchange Glu, an online community for patients with T1D mellitus. People who registered on T1D Exchange Glu, and opted to receive research-related communications, were invited via email to participate in the study. Approximately 500 participants were enrolled by convenience sampling to provide a reasonable degree of precision for the point estimates. This study was approved by Quorum Institutional Review Board. Study participants completed informed consent forms prior to completing the survey. The online survey was active on T1D Exchange Glu 26 November 2018 to 13 December 2018. Eligible participants were those who were aged ≥ 18 years, diagnosed with T1D mellitus for at least 12 months, and had an HbA1c measurement within the last 6 months. Additional inclusion criteria were current US residency, fluency in written English, and not currently pregnant.

Measures

Participant characteristics and experience with diabetes

Participants self-reported on demographic and diabetes-related health information, including age, gender, race/ethnicity, insurance type, education, employment status, duration of disease, HbA1c measured within the past 6 months, current devices used, type of diabetes care providers, frequency of clinic visits, diabetes-related complications and comorbidities.

Experience with hypoglycaemia and hyperglycaemia

Participants self-reported on their experiences with past hypoglycaemia and hyperglycaemia, including frequency of mild, moderate and severe hypoglycaemia, diabetes management behaviour in response to hypoglycaemia, degrees of worry around mild, moderate and severe hypoglycaemia and hyperglycaemia, as well as their emotional experiences in response to hypoglycaemia.

HFS-II short form

The HFS-II short form is an 11-item patient-reported outcome measure derived from the 33-item HFS-II. The HFS-II short form assesses participants' behaviour (six items) and worry (five items) related to hypoglycaemia in the past 6 months. Items are rated on a 5-point Likert scale (0=never to 4=almost always). Mean item scores are calculated to produce HFS-behaviour (HFS-B) and HFS-worry subscale scores, and a total score. Higher scores indicate greater fear of hypoglycaemia.²⁸ Adequate Cronbach's α values have been reported for the avoidance subscale (0.76), maintain high subscale (0.83), worry subscale (0.78) and total scale (0.83).²⁸

Hypoglycaemia Attitudes and Behaviour Scale

The Hypoglycaemia Attitudes and Behaviour Scale (HABS) is a 14-item patient-reported outcome measure that assesses participants' hypoglycaemia-related anxiety (five items), avoidance (four items) and confidence (five items). Participants rated their current degree of agreement with each item on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). Individual domain scores (anxiety, avoidance and confidence) are calculated by taking the mean score of items in each domain, with higher scores indicating greater concern (anxiety and avoidance domains) or confidence (confidence domain). To produce a total score for the HABS, items in the confidence domain are first reverse scored, before the mean score of all 14-items is calculated. Higher total scores indicate greater hypoglycaemic concerns.²⁴ Adequate Cronbach's α values were reported for the anxiety subscale (0.71), avoidance subscale (0.75) and confidence subscale (0.80).²⁹

Generalised Anxiety Disorder

Generalised Anxiety Disorder (GAD-7) is a patient self-administered 7-item anxiety scale developed to diagnose GAD. Patients are asked to report the frequency at which they experienced seven symptoms of anxiety over the past 2 weeks on a 4-point scale (0=not at all to 3=nearly every

day). Responses to each item are summed to produce a total score (range: 0–21) with higher scores indicating more severe anxiety. Anxiety severity is classified into four categories based on the GAD-7 total score: minimal (0–4), mild (5–9), moderate (10–14) and severe.^{15–21 30} An excellent Cronbach's α value (0.92) was reported for the GAD-7.³⁰

Patient Health Questionnaire-8

The Patient Health Questionnaire-8 (PHQ-8) is a patient-reported outcome measure that is used both as a diagnostic and severity measure for depressive disorders in clinical studies. Patients are asked to report the frequency at which they experienced eight symptoms of depression over the past 2 weeks on a 4-point scale (0=not at all to 3=nearly every day). Responses to each item are summed to produce a total score (range: 0–24) with higher scores indicating more severe depression. Depression severity is classified into five categories based on the PHQ-8 total score: none (0–4), mild (5–9), moderate (10–14), moderately severe (15–19) and severe (20–24). A score ≥ 10 is indicative of major depression.³¹ An excellent Cronbach's α value (0.80) was reported for the PHQ-8.³¹

Problem Areas in Diabetes

The Problem Areas in Diabetes (PAID-5) is a 5-item patient-reported outcome measure that assesses diabetes-related emotional distress. Patients are asked to rate the diabetes issues that are currently a problem for them on a 5-point scale (0=not a problem to 4=serious problem). Item scores are summed to obtain a total score (range: 0–20), with scores ≥ 8 indicating possible diabetes-related emotional distress.³² A high Cronbach's α value (0.90) was reported for the total test.³²

Statistical analysis

Descriptive statistics were performed on survey items, demographics and patient-reported scores that assess generalised anxiety, depression, diabetes distress, worry/concern and fear around hypoglycaemia as well as specific avoidance behaviours around hypoglycaemia. Multivariable regressions were performed on assessment scores of worry/concern, fear and behaviours around hypoglycaemia by selecting covariates via a combination of clinically relevant criteria and model selection techniques. An initial list of covariates was selected based on literature review and clinical meaningfulness, including gender, past experience with hypoglycaemia, hypoglycaemia unawareness and general anxiety scores. The gradient boosting method³³ was used to help select additional potential covariates that are of high relative influence on the outcome variables. The gradient boosting method is an iterative algorithm that gradually builds strong prediction models for the outcome variable; in doing so, this method also identifies the relative influence of each covariate on the predictive power of the outcome variable. Covariates of high relative influence on the outcome measures included diabetes distress, depression, age,

Table 1 Participant characteristics and demographics

Variable	n=494
Age, years	43.9±12.2
Age of diagnosis, years	27.4±12.5
Duration of diabetes, years	16.6±16.8
Self-reported HbA1c, % (mmol/mol)	6.9±0.8 (52±9)
Men, n (%)	312 (63.0)
Race, n (%)	
American Indian/Alaskan Native	3 (0.6)
Asian	2 (0.4)
Black or African-American	6 (1.2)
White	488 (98.8)
Other	1 (0.2)
Ethnicity, n (%)	
Hispanic or Latino	6 (1.2)
Not Hispanic or Latino	487 (98.6)
NA	1 (0.2)
Highest level of education, n (%)	
Some high school	1 (0.2)
High school graduate/GED	12 (2.4)
Some college	103 (20.9)
Associates degree	124 (25.1)
Bachelor's degree	163 (33.0)
Master's degree	65 (13.2)
Doctoral degree	26 (5.3)
Employment status, n (%)	
Student	20 (4.0)
Working full time	353 (71.5)
Working part time	54 (10.9)
Unemployed, looking for work	8 (1.6)
Unemployed, not looking for work	5 (1.0)
Temporarily laid off or on leave from work	2 (0.4)
Disabled	20 (4.0)
Retired	47 (9.5)
Volunteer	8 (1.6)
Health Insurance, n (%)	
Private Health Insurance	282 (57.1)
Medicare	159 (32.2)
MediGap	16 (3.2)
Medicaid	58 (11.7)
Military healthcare	3 (0.6)
Affordable Care Act plan	15 (3.0)
Other state sponsored health coverage plan	7 (1.4)
Other government sponsored health coverage plan	3 (0.6)
Single service plan	15 (3.0)
None	1 (0.2)
Do not wish to answer	1 (0.2)
Don't know	2 (0.4)

Continued

Table 1 Continued

Variable	n=494
Data are mean±SD or n (%). NA=no answer. GED, General Education Development; HbA1c, glycosylated hemoglobin.	

duration of disease, self-reported HbA1c and number of diabetes-related comorbidities. All of the above selected covariates were entered into each regression model simultaneously. Each of the fear of hypoglycaemia subscale and total scores were analysed in a separate regression model, thus seven multivariable regression models were analysed on the HFS-II behaviour subscale, worry subscale, total score, HABS avoidance subscale, confidence subscale, anxiety subscale and total score, respectively.

Patient and public involvement

People with T1D mellitus were involved in the ethnographic interviews and focus groups in order to develop the final online survey as noted above.

RESULTS

Participant characteristics and demographics

A total of 519 participants from T1D Exchange Glu completed the online survey, of which 19 were excluded for not meeting the inclusion criteria. An additional six participants were excluded for unreliable responses, such as high amount of implausible responses (eg, self-reported high blood glucose <3 mg/dL) and/or duplicate submissions. The final sample for analyses included 494 adults with T1D mellitus (mean±SD age 43.9±12.2 years, duration of T1D mellitus 16.6±16.8 years, self-reported HbA1c 6.9%±0.8% (52±9 mmol/mol)), 98.8% white and 63% men. A summary of participant characteristics and demographics is provided in [table 1](#).

Diabetes management

Over 90% of participants visited diabetes-specific providers for their diabetes care, and about half of the participants visited providers every 6 months (49.6%) or every 2–3 months (38.5%) ([table 2](#)). Participants reported an average number of 1.7±1.3 diabetes-related comorbidities (median number of 2 (range 0–7)) and 2.0±1.8 mental health conditions (median number of 2, range 0–8). The most commonly reported diabetes-related comorbidities included joint issues (34.2%) and hypothyroidism (27.9%); most commonly reported mental health conditions included depression (36.0%) and fear of hypoglycaemia (31.4%). Insulin pumps were used by 88.5% of participants; blood glucose metres and continuous glucose monitors were common among participants (63.2% and 51.8%, respectively) ([table 2](#)). Less than 50% of participants reported ever receiving Blood Glucose Awareness Training (BGAT), an evidenced-based intervention to reduce fear of hypoglycaemia,³⁴ however, 94.2% of those who received training found it helpful

Table 2 Diabetes management

Variable	n=494
Diabetes healthcare provider, n (%)	
Adult endocrinologist	204 (41.3)
Paediatric endocrinologist	7 (1.4)
Diabetes nurse practitioner	88 (17.8)
Diabetes physician assistant (PA)	162 (32.8)
Primary care physician	27 (5.5)
Primary care—PA	1 (0.2)
Other, please specify	2 (0.4)
NA	3 (0.6)
Diabetes healthcare provider visit(s), n (%)	
Every month	19 (3.8)
Every 2–3 months	190 (38.5)
Every 6 months	245 (49.6)
Once a year	14 (2.8)
Once every 1–2 years	2 (0.4)
Other, please specify	22 (4.5)
NA	2 (0.4)
Insulin delivery method, n (%)	
Insulin pump	437 (88.5)
Multiple daily injections using vial/syringe	37 (7.5)
Multiple daily injections using an insulin pen	42 (8.5)
Inhalable insulin	6 (1.2)
Other	6 (1.2)
Current blood sugar monitoring, n (%)	
Blood glucose metre	312 (63.2)
Continuous glucose monitor	256 (51.8)
Flash glucose monitor	78 (15.8)
No of diabetes comorbidities	1.7±1.3
No of mental health conditions	2.0±1.8
Blood glucose awareness training, n (%)	
Yes	241 (48.8)
Was the training helpful in avoiding severe high and low blood sugar levels?	
Yes	227 (94.2)
No	5 (2.1)
Unsure	2 (0.8)
NA	7 (2.9)
No	193 (39.1)
Unsure	60 (12.1)

Data are n (%). NA=no answer.

Table 3 Worry or concern for hypoglycaemia and hyperglycaemia

Variable	n=494
Do you worry or are you concerned about hypoglycaemia or hyperglycaemia? (n(%))	
Yes, hypoglycaemia	56 (11.3)
Yes, hyperglycaemia	13 (2.6)
Yes, both hypoglycaemia and hyperglycaemia	394 (79.8)
If yes to both, which one worries you more?	
1-Extremely more worried about hypoglycaemia	22 (5.6)
2	85 (21.6)
3-Equally worried	34 (8.6)
4	245 (62.2)
5-Extremely more worried about hyperglycaemia	8 (2.0)
No	25 (5.1)
Unsure	6 (1.2)
Have you ever discussed your concerns or worry with your diabetes healthcare provider(s)? (n(%))	
Yes, hypoglycaemia	63 (12.8)
Yes, hyperglycaemia	13 (2.6)
Yes, both	335 (67.8)
No	81 (16.4)
Unsure	2 (0.4)
If yes, what did your provider recommend or say? (n(%))	
Provided diabetes education	223 (54.3)
Referred me to a mental health professional	211 (51.3)
Discuss my feelings	210 (51.1)
Recommended blood glucose awareness training	23 (5.6)
Other	35 (8.5)

Data are n (%).

in avoidance of severe high and low blood sugar levels ([table 2](#)).

Experience with hypoglycaemia and hyperglycaemia

Worry or concern for hypoglycaemia and hyperglycaemia

Most participants (67.8%) had discussed their worry or concern for both hypoglycaemia and hyperglycaemia with their diabetes healthcare providers ([table 3](#)). More participants (12.8%) reported they were worried or concerned for hypoglycaemia only versus merely 2.6% of participants reported they were worried or concerned for hyperglycaemia only ([table 3](#)). On a scale of 0–10 (0=no worried at all, 10=extremely worried), most participants reported seven or above when asked if worried about low

blood glucose levels of 54–70 mg/dL (3–4 mmol/L) or below 54 mg/dL (3 mmol/L). When asked about severe low blood glucose levels (requiring assistance), most participants reported five or above. Participants who had discussed worry or concern for hypoglycaemia or hyperglycaemia, reported their provider recommended diabetes education (54.3%), referral to a mental health professional (51.3%) or discussion of feelings (51.1%), but only 5.6% recommended BGAT (table 3).

Hypoglycaemia experience

The blood glucose-level participants began treating low blood glucose was 72.4±10.6 mg/dL (4±1 mmol/L) (table 4). Participants reported a mean lower blood sugar value of 85.8±14.9 mg/dL (5±1 mmol/L) and a mean higher blood sugar value of 126.9±29.8 mg/dL (7±2 mmol/L) for personal comfort levels (table 4). Commonly reported behaviours to avoid low blood glucose were decreasing basal insulin doses (46.8%), and checking continuous glucose monitor readings more frequently (44.7%). Fifty-five per cent (274) of participants reported having experienced a severe hypoglycaemic event during their lifetime. Of these participants, about 45% experienced a severe hypoglycaemic event within the last 6 months, and participants' lifetime severe low blood glucose events (median (Q1, Q3)) was 1 (0, 2) per participant (table 4). Of those participants who had ever experienced a severe low blood glucose event, 35.0% required glucagon, 54.4% called a paramedic, 31.0% visited an emergency department and 8.8% required overnight hospitalisation (table 4). Additionally, these participants reported avoiding future events by more frequent checking of blood glucose values via continuous glucose monitor readings (36.9%) or finger sticks (34.1%), purposely running higher blood glucose (33.0%) or trying to maintain a well-balanced balance diet (27.9%). Frustration (78.1%), embarrassment (59.5%), fear (45.1%) and worry (42.3%) were common emotions experienced by participants due to hypoglycaemia (table 4). About 34% of participants reported they were never aware of the onset of low blood glucose levels, 13.8% reported they were rarely aware, and 16.8% reported they were sometimes aware. A summary of hypoglycaemia experience results is provided in table 4.

Hypoglycaemia factors associated with fear of hypoglycaemia

Generalised anxiety, depression, diabetes distress (as measured by GAD-7, PHQ-8 and PAID-5, respectively), and prior severe low blood glucose events were consistently shown to be associated with fear of hypoglycaemia as measured by the HFS-II (avoidance behaviour and worry subscales) and HABS (avoidance subscale). A summary of all variables evaluated in the HFS-II and HABS is provided in table 5.

Higher levels of generalised anxiety as assessed by the GAD-7 (mild anxiety and moderate or severe anxiety compared with minimal anxiety) was shown to be associated with fear of hypoglycaemia as measured by the

Table 4 Hypoglycaemia experience

Variable	n=494
Blood glucose level began treating lows, mg/dL (mmol/L)	72.4±10.6 (4±1)
Comfortable low blood glucose level, mg/dL (mmol/L)	85.8±14.9 (5±1)
Comfortable high blood glucose level, mg/dL (mmol/L)	126.9±29.8 (7±2)
Lifetime severe low blood glucose rate, (events per participant (median (Q1, Q3))) [*]	1 (0, 2)
Required glucagon, n (%)	96 (35.0)
Called paramedic, n (%)	149 (54.4)
Visited emergency department, n (%)	85 (31.0)
Required overnight hospitalisation, n (%)	24 (8.8)
Most recent severe hypoglycaemic event, n (%) [*]	
Less than 1 month ago	19 (6.9)
1 month to less than 2 months ago	3 (1.1)
2 months to less than 3 months ago	43 (15.7)
3 months to less than 6 months ago	58 (21.2)
6 months to 1 year ago	55 (20.1)
1–2 years ago	28 (10.2)
2–5 years ago	20 (7.3)
More than 5 years ago	43 (15.7)
NA	5 (1.8)
Aware of low blood glucose, n (%)	
Never aware	169 (34.2)
Rarely aware	68 (13.8)
Sometimes aware	83 (16.8)
Often aware	122 (24.7)
Always aware	52 (10.5)
Emotions experienced due to hypoglycaemia, n (%)	
Fear	223 (45.1)
Frustration	386 (78.1)
Guilt	144 (29.1)
Embarrassment	294 (59.5)
Worry	209 (42.3)
Concern	161 (32.6)
Other	47 (9.5)

Data are mean±SD or n (%). NA=no answer.

^{*}Percentage calculated based on those who had experienced severe low blood glucose events, n=274.

HFS-II total scores and HABS total scores (p<0.001, both). Higher levels of generalised anxiety were also associated with lower confidence as measured by the HABS total scores (p<0.001, both).

Table 5 Regression coefficients for HFS and HABS subscale and total scores

	HFS-II			HABS			
	Avoidance behaviour	Worry	Total	Avoidance	Confidence	Anxiety	Total
Scale mean (SD)	1.6 (0.7)	1.8 (0.7)	1.7 (0.6)	2.7 (0.7)	3.4 (0.6)	2.6 (0.7)	2.6 (0.5)
Score range	0.0–3.6	0.0–4.0	0.0–3.8	1.0–4.2	1.0–5.0	1.0–5.0	1.1–4.3
Generalised Anxiety†							
Mild (0=minimal, 1=mild)	0.309**	0.474***	0.390***	0.114	−0.311***	0.394***	0.293***
Moderate or severe (0=minimal, 1=moderate/severe)	0.393***	0.613***	0.509***	0.241*	−0.469***	0.558***	0.459***
Depression‡§							
Mild (0=none, 1=mild)	0.145	0.456***	0.320***	0.230*	−0.159*	0.354***	0.231**
Moderate or more (0=none, 1=moderate or higher)	0.331***	0.618***	0.496***	0.384***	−0.532***	0.598***	0.527***
Diabetes distress¶ (0=low distress, 1=high distress)							
Duration of type 1 diabetes mellitus, years	−0.014***	−0.007*	−0.010***	−0.005	0.005*	−0.011***	−0.006**
Age, years	0.006*	0.005	0.005	0.000	−0.009**	0.012***	0.008***
Women** (0=men, 1=women)	−0.079	0.147*	0.042	−0.141*	−0.083	−0.124	−0.047
Hypoglycaemia unawareness†† (0=aware, 1=no awareness)							
Self-reported HbA1c, % (mmol/mol)	0.054	0.031	0.044	0.250***	−0.042	−0.010	0.081**
No of comorbidities							
Mild low BG, times per week	−0.008	0.009	0.001	−0.020*	0.005	−0.008	−0.016*
Moderate low BG, times per week	0.014	0.015	0.015	0.022	−0.023	0.018	0.034**
Severe low BG, lifetime	0.001	0.012**	0.007*	0.000	−0.009**	0.010**	0.006*

Higher scores for HFS and HABS indicate higher levels of concept measured. Reference groups for categorical variables.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

†Reference groups for categorical variables: GAD-7, minimal anxiety.

‡Reference groups for categorical variables: depression (PHQ-8), no depression.

§Reference groups for categorical variables: depression was analysed in separate regression models, replacing generalised anxiety, due to the extremely high correlation between depression and generalised anxiety ($r = 0.81$).

¶Reference groups for categorical variables: Diabetes Distress (PAID-5), low distress.

**Reference groups for categorical variables: gender, men.

††Reference groups for categorical variables: hypoglycaemia unawareness, awareness of the beginning of low blood sugar experience.

GAD-7, Generalised Anxiety Disorder; HABS, Hypoglycaemia Attitudes and Behaviour Scale; HbA1c, glycosylated hemoglobin; HFS, Hypoglycaemia Fear Survey; PAID-5, Problem Areas in Diabetes; PHQ-8, Patient Health Questionnaire-8.

Higher levels of depression as measured by the PHQ-8 (mild depression and moderate or more depression compared with no depression) was shown to be associated with fear of hypoglycaemia as measured by the HFS-II total scores ($p < 0.001$, both), and the HABS total scores (mild depression vs no depression; $p < 0.01$ and moderate or more depression vs no depression; $p < 0.001$). Higher PHQ-8 scores were associated with lower confidence as measured by the HABS confidence subscale scores ($p < 0.001$, both).

Greater diabetes distress as measured by the PAID-5 was shown to be associated with fear of hypoglycaemia as

measured by the HFS-II and HABS total scores ($p < 0.001$, both). Greater diabetes distress was associated with lower confidence in staying safe from hypoglycaemia problems as measured by the HABS confidence subscale score ($p < 0.001$).

History of severe low blood glucose was shown to be associated with fear of hypoglycaemia as measured by the HFS-II and HABS total scores ($p < 0.05$, both). Greater worry of hypoglycaemia was associated with history of severe low blood glucose as measured by both scales; however, there was no association with avoidance behaviour. History of severe low blood glucose was

associated with lower confidence as measured by the HABS confidence subscale score ($p < 0.01$).

Longer duration of diabetes in years was associated with lower fear of hypoglycaemia as measured by the HFS-II total score ($p < 0.001$) and HABS total score ($p < 0.01$). Longer duration of diabetes was associated with a higher confidence as measured by the HABS confidence subscale score ($p < 0.05$).

DISCUSSION

Participants enrolled in this study were generally well managed (mean HbA1c 6.9% (52 mmol/mol)), used insulin pumps (88.5%) and were predominantly white, non-Hispanic. Over 90% of participants were seen by diabetes-specific providers (eg, endocrinologist, diabetes physician assistant, diabetes nurse practitioner) for their diabetes care, and met with providers at least every 6 months or more often. Overall, the T1D Exchange Glu participants reported good diabetes management practices; however, fear of hypoglycaemia was evident in this cohort and was not uncommon. Moreover, 48% of participants were never or rarely aware of hypoglycaemia symptoms, putting them at risk for severe hypoglycaemic events. At the time of this study, thresholds for interpretation of scores for fear of hypoglycaemia instruments were not available, thus, the proportion of participants with clinically meaningful fear of hypoglycaemia could not be assessed. Of note, more than half of participants reported at least moderate mental health conditions (anxiety, depression and diabetes distress) as measured by the PHQ-8, GAD-7 and PAID-5 instruments, which further emphasises the need for mental health support (as recommended by the ADA) for this otherwise well-managed cohort with T1D mellitus.

In line with current literature, variables that were consistently associated with fear of hypoglycaemia across instruments and domains included generalised anxiety, depression and diabetes distress. Having anxiety or stress may contribute to fear and worry in general.³⁵ Furthermore, severity of fear of hypoglycaemia has been shown to increase in the presence of psychological factors such as anxiety and depression,³⁶ and has a negative impact on patients' self-management behaviour and health-related quality of life.^{16 37 38} We found that patients with higher generalised anxiety, depression or diabetes-related distress, showed higher worry around hypoglycaemia, more avoidance behaviour and lower confidence in managing hypoglycaemia. A history of severe hypoglycaemia has also been shown to be associated with worry,^{8 9 23 39} avoidance behaviour^{8 40} and lower confidence.^{41–43} In our study, those who experienced a severe hypoglycaemic event in their lifetime showed higher worry around hypoglycaemia and lower confidence in managing hypoglycaemia; however, they showed similar levels of avoidance behaviour compared with those who never experienced a severe hypoglycaemic event.

Our regression models did not show consistent gender differences in fear of hypoglycaemia, which is in contrast to some previous studies that suggest women are more likely to show fear of hypoglycaemia compared with men.^{44 45} Instead, our results show that women in this study may be more worried about hypoglycaemia than men (based on HFS-II worry subscale), but showed less avoidance behaviour compared with men (HABS avoidance subscale), and overall, there were no significant differences in total fear of hypoglycaemia scores by gender. This different finding may be due to the unique characteristics of this T1D Exchange Glu cohort, which have not been examined for fear of hypoglycaemia in previous studies. Nevertheless, our findings suggest that gender differences in fear of hypoglycaemia may not be as robust as previously thought and warrant further investigation in conjunction with other participant characteristics.

More avoidance behaviour, as measured by the HABS avoidance subscale, was associated with higher self-reported HbA1c; more avoidance behaviour, as measured by the HFS-behaviour subscale, was associated with more diabetes comorbidities. These findings suggest that poorer clinical outcomes are associated with the behavioural rather than the worry component of fear of hypoglycaemia. Since these results were not consistently observed across instruments, more studies are warranted to replicate these findings. However, health-related behaviours of people with diabetes have been shown to directly contribute to improved clinical outcomes and health-related quality of life,^{46 47} and patients will modify their diets or physical activity to avoid hypoglycaemia.^{44 48} As such, the findings on the potential associations between avoidance behaviours and poorer clinical outcomes may be particularly actionable, and thus worth further research for replication and possible approaches to mitigate these behaviours.

Commonly reported behaviours to avoid low blood glucose were decreasing basal insulin doses, and more frequent checking of continuous glucose monitor readings. Participants who experienced a severe hypoglycaemic event avoided future events by more frequent checking of blood glucose values using continuous glucose monitor readings or finger sticks, purposely running higher blood glucose, and trying to maintain a well-balanced diet including avoidance of certain foods. This is in alignment with prior reports that showed patients engage in hypoglycaemia-avoidance behaviours, but some of these behaviours long term can be detrimental and at the expense of disease management.^{8 49}

The ADA recommends screening for anxiety or fear of hypoglycaemia, and referral to mental healthcare providers if there is a positive screen.⁵⁰ Furthermore, the ADA also notes that hypoglycaemia unawareness often accompanies fear of hypoglycaemia, and should be treated with BGAT or some other intervention to reestablish hypoglycaemia awareness and reduce fear of hypoglycaemia.⁵⁰ Approximately one-third of study participants

reported being treated for fear of hypoglycaemia and very few reported a referral to BGAT.

Limitations

This T1D Exchange Glu study cohort was predominately white males with collegiate-level or higher education and good diabetes management, thus, the study results may not be generalisable to patients with T1D mellitus who do not meet these characteristics. At the time of the study, the HABS was not validated in adults with T1D mellitus. However, the relationships between HABS scores and other variables, such as depression, anxiety and diabetes distress, were in line with the literature and largely consistent with the findings on the HFS-II. These results demonstrate promising reliability and validity of the HABS in adults with T1D mellitus, and call for future studies to further validate the use of HABS in T1D mellitus.

CONCLUSION

This study highlighted the multifaceted nature of fear of hypoglycaemia, as distinctive factors and clinical outcomes were associated with the different behavioural and emotional aspects of fear of hypoglycaemia. These results call for more precise and comprehensive screening for fear of hypoglycaemia in diabetes clinical care. This study also supported the growing literature that anxiety, depression and diabetes distress were all associated with fear of hypoglycaemia. The clinical implication of this finding supports the relevance of screening for fear of hypoglycaemia and associated behavioural factors as part of quality clinical practice, to aid discussions between providers and patients and drive actions to improve health outcomes.

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