Conversations and Reactions Around Severe Hypoglycemia (CRASH) Study: Results From People With Diabetes and Caregivers in the United States

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A survey was conducted in eight countries to examine conversations around, and experiences and treatments during, severe hypoglycemia among people with diabetes and caregivers of people with diabetes. This article reports a subgroup analysis from the United States involving 219 people with diabetes and 210 caregivers. Most respondents (79.7%) did not use professional health care services during their most recent severe hypoglycemic event, and 40.3% did not report the event to their health care providers at a subsequent follow-up visit. Hypoglycemic events left respondents feeling scared (70.9%), unprepared (42.7%), and helpless (46.9%). These clinically important psychosocial impacts on people with diabetes and caregivers underscore the need for conversations about hypoglycemia prevention and management.

Diabetes affects more than 422 million people worldwide (1), and the International Diabetes Federation predicts that its prevalence will increase to affect ∼629 million people by 2045 (2). People with type 1 diabetes or insulin-treated type 2 diabetes are at an elevated risk of hypoglycemia because of glucose counterregulatory defects (3), and hypoglycemia is one of the most feared complications associated with insulin treatment (4).

According to the American Diabetes Association (ADA), level 1 hypoglycemia is defined as a glucose concentration <70 mg/dL (3.9 mmol/L) and ≥54 mg/dL (3.0 mmol/L), and level 2 hypoglycemia is defined as a glucose concentration <54 mg/dL (3.0 mmol/L) (5). Severe hypoglycemia (level 3) is not defined by a specific and measurable glucose value, but instead is characterized by altered mental and/or physical status requiring assistance from another person to recover. According to current guidelines, the preferred treatment for a conscious individual is to consume 15 g carbohydrates, check the glucose level 15 minutes later, and repeat this process, if necessary, until glucose is >70 mg/dL; if a person cannot safely swallow or tolerate oral carbohydrates, glucagon should be given (6). The ADA recommends that glucagon be prescribed and made readily available when needed for individuals at risk for level 2 or level 3 hypoglycemia (7).

The ADA *Standards of Medical Care in Diabetes* (7) states that "occurrence and risk for hypoglycemia should be reviewed at every encounter and investigated as indicated." Karter et al. (8) have shown that reporting health care resource utilization data (i.e., results from ambulance, emergency department, or hospital visits) alone can underestimate the occurrence of severe hypoglycemic events compared with the incorporation of self-reported data collected from people with diabetes. In that study, 0.8% of patients had documented hypoglycemia-related emergency department or hospital utilization, whereas 11.7% of patients reported having one or more severe hypoglycemia events annually (8). This gap shows that health care providers (HCPs) may be unaware of severe hypoglycemic events that have occurred outside of the health care system unless they have specific conversations with their patients.

The primary objective of the CRASH (Conversations and Reactions Around Severe Hypoglycemia) study was to enhance understanding about the conversations around, and experiences and treatments of, severe

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hypoglycemic events among people with type 1 or insulin-treated type 2 diabetes and caregivers of people with diabetes.

Research Design and Methods

Study Design and Patient Selection

The CRASH study was a multinational, cross-sectional, online survey conducted with people diagnosed with type 1 or type 2 diabetes and caregivers of people with diabetes from Canada, China, France, Germany, Japan, Spain, United Kingdom, and the United States (N = 2,625). Survey responses were reported by people with diabetes and caregivers who were recruited separately and considered independent respondents with no relationship to each other (no dyads). Here, we report results from the United States.

The study was conducted using purposive sampling from online research panels; we enrolled people with diabetes who were ≥18 years of age, self-reported either type 1 or type 2 diabetes treated with insulin via injection or pump, and experienced one or more severe hypoglycemic event in the past 3 years. Severe hypoglycemia was defined as a low blood glucose event that the person with diabetes could not treat by him- or herself.

The study population also included caregivers, defined as adults who were relied on during a severe hypoglycemic event of a person >4 years of age who was diagnosed with type 1 or type 2 diabetes and met the above criteria for severe hypoglycemia and treatment. Caregivers may have been living in the same household as a person with diabetes (e.g., family members, roommates, domestic helpers, or relatives) or may have been other people in the life of a person with diabetes (e.g., coworkers or teachers). Eligible respondents provided electronic consent through a Web survey interface before the administration of any study procedures. Exclusion criteria for this study included a diagnosis of schizophrenia, bipolar disorder, or gestational diabetes. Professionally trained and licensed HCPs were also excluded from participation. People with diabetes who were treated with insulin could also be treated with oral antihyperglycemic medications except for sulfonylureas. Exemption of ethics approval for the U.S. survey was requested and received from the Chesapeake Institutional Review Board (Columbia, MD).

Respondents completed the online survey, which included questions about demographics, diabetes management, recent medical history, and hypoglycemia awareness. Details of respondents' most recent severe hypoglycemic event were also recorded, including the setting, symptoms, actions taken, and emotional and life impacts (e.g., effects on physical activities, mood or emotional status, social or leisure activities, work or school, daily activities, relationships with friends and family, financial matters, or sleep). People with diabetes who were not conscious during the severe hypoglycemic event reported on what they were told about the event. As with the people with diabetes, caregivers' survey responses reflected a report of their experiences during or what they were told occurred at the time of the severe hypoglycemic event. Most caregivers' responses reported what had happened with the person with diabetes, but caregivers also reported their own experiences, conversations, feelings, and life impacts.

The survey included a standardized and validated self-reported measure of hypoglycemia awareness called the Gold score (9). Hypoglycemia awareness was reported by people with diabetes and caregivers based on the question, "Do you know when your hypoglycemia is commencing?" On a scale ranging from 1 (always aware) to 7 (never aware), impaired hypoglycemia awareness was defined as a score ≥4 (9). People with diabetes reported on whether they were aware of their own hypoglycemia commencing, whereas caregivers reported on awareness of hypoglycemia commencing for the person with diabetes for whom they cared.

Statistical Analysis

Analyses were conducted for both people with diabetes and caregivers by type of diabetes. Continuous variables were summarized as mean ± SD. Categorical variables were summarized as numbers and percentages. Overall differences on measures among the four study groups (type 1 or type 2 diabetes among people with diabetes or caregivers) were assessed using the Kruskal-Wallis test, a nonparametric test for continuous data, χ^2 test for binary categorical variables, and a two-way Cochran-Mantel-Haenszel test for general association between two nominal variables. If the P value from the omnibus test was significant, differences between type 1 and type 2 diabetes were assessed separately for people with diabetes and caregivers. Statistical significance was set at P <0.05. Statistical analyses were performed using SAS, v. 9.4, statistical software (SAS Institute, Cary NC).

Results

Demographics

In total, 429 individuals based in the United States responded to the survey, including 219 people with diabetes (110 with type 1 diabetes and 109 with type 2 diabetes) and 210 caregivers (110 caring for someone with type 1 diabetes and 100 caring for someone with type 2 diabetes) (Table 1). The mean age of people with diabetes was 54.0 ± 13.1 years (quartile 1 [Q1] 45, median 56, Q3 63) for those with type 1 diabetes and 58.4 ± 10.5 years (Q1 54, median 59, Q3 64) for those with type 2 diabetes. Sixty percent of the people with type 1 diabetes were female, whereas 60.6% of those with type 2 diabetes were male. Overall, the majority (54.3%) of caregivers were reported as being a spouse or partner of a person with diabetes. A small percentage of caregivers were parents or guardians caring for a minor (>4 and ≤17 years of age with type 1 diabetes [20.9%] or type 2 diabetes [1%]). The majority of respondents (76.7%) reported having a college or university degree.

Diabetes Management

A1C levels for people with diabetes were self-reported by all respondents: 41.8% reported levels ≤7% (≤53 mmol/mol); 34.5% reported levels between 7.1 and 8.0% (54 and 64 mmol/mol); 15.0% reported levels between 8.1 and 9.0% (65 and 75 mmol/mol); and 8.7% reported levels >9.1% (>76 mmol/mol). The majority of people with type 2 diabetes (59.6%) had used insulin for >5 years. As expected, insulin pump use at the time of the last severe hypoglycemic event was reported more often with type 1 diabetes than with type 2 diabetes (among all type 1 diabetes 30.9%, among all type 2 diabetes 2.9%, $P < 0.0001$). Impaired hypoglycemia awareness (Gold score ≥4) was reported significantly more often with type 1 diabetes than with type 2 diabetes (people with type 1 diabetes 36.4%, people with type 2 diabetes 20.2%, $P = 0.0079$).

History of Severe Hypoglycemia

The number of severe hypoglycemic events that occurred within the past 12 months (i.e., 0, 1, 2, ≥3 events) and within the past 3 years (i.e., 1, 2, ≥3 events) did not significantly differ between diabetes types, as reported by people with diabetes and caregivers (Table 1). Overall, 14.5% of respondents reported on their first severe hypoglycemic event.

Characteristics of the Most Recent Hypoglycemic Event

The majority of respondents (62.5%) reported being with a spouse/partner or caregiver during the most recent severe hypoglycemic event. The severe hypoglycemic events reported by respondents occurred primarily at home (80.7%). Severe hypoglycemia occurred in the afternoon for 21.0% of respondents, evening and before midnight for 25.4%, and after midnight (before morning) for 25.4%. Almost one-third of all respondents (32.6%) reported being asleep when the severe hypoglycemic event occurred.

The most commonly reported cause of the most recent severe hypoglycemic event was that the person with diabetes ate less than planned or usual (39.9%); this occurred significantly more often in those with type 2 diabetes than in those with type 1 diabetes (46.8 vs. 27.3%, $P = 0.0028$). Other perceived causes included that the person with diabetes exercised more than planned or realized (18.2%) or took an incorrect dose of insulin (12.1%).

Actions Taken During the Most Recent Severe Hypoglycemic Event

Glucagon injections were rarely used as rescue therapy (reported by 5.8% of respondents) (Table 2). A substantial minority of all respondents (40.4%) did not have a glucagon prescription, and, for people with diabetes, there was a statistically significant difference between those with type 1 diabetes and those with type 2 diabetes (38.0 vs. 65.4%, $P < 0.0001$) (Supplementary Table S1). In addition, significantly more caregivers of people with type 2 diabetes were unaware of the option to administer glucagon than caregivers of people with type 1 diabetes (38.3 vs. 9.7%, $P < 0.0001$). The proportion of respondents reporting any health care utilization during the most recent severe hypoglycemic event was low (20.3%). Receiving recommendations from HCPs before the most recent severe hypoglycemic event to use health care services (e.g., call ambulance, go to emergency department, or call HCP) in case of a severe hypoglycemic event was reported by a modest proportion of people with diabetes (type 1 diabetes 16.4% and type 2 diabetes 22.0%) and caregivers (of people with type 1 diabetes 29.1% and of people with type 2 diabetes 31.0%, $P = 0.0494$).

Impacts of the Most Recent Severe Hypoglycemic Event

The emotional impacts (emotions that arose at the time of the event) for each respondent type are reported in

TABLE 1 Baseline and Clinical Characteristics

	T1D PWD (*n* = 110)	T2D PWD (*n* = 109)	T1D CGs (*n* = 110)	T2D CGs (*n* = 100)	All T1D (*n* = 220)	All T2D (*n* = 209)	Total (*n* = 429)	*P*
Demographics								
Respondent age, years	54.0 ± 13.1	58.4 ± 10.5	52.3 ± 11.9	55.8 ± 12.9	53.2 ± 12.5	57.2 ± 11.8	55.1 ± 12.3	Omnibus: 0.0013 PWD†: 0.0151 CGs‡: 0.0172
Q1 | median | Q3	45 | 56 | 63	54 | 59 | 64	44 | 53 | 61	49 | 58 | 66	45 | 55 | 62	51 | 59 | 65	47 | 57 | 64	
PWD age, years	54.0 ± 13.1	58.4 ± 10.5	43.6 ± 23.4	63.2 ± 13.6	44.3 ± 23.1	62.6 ± 15.0	54.6 ± 17.5	Omnibus: <0.0001 PWD†: 0.7488 CGs‡: <0.0001
Q1 | median | Q3	45 | 56 | 63	54 | 59 | 64	20 | 44 | 64	58 | 64 | 70	32 | 53 | 64	55 | 62 | 67	45 | 59 | 66	
PWD aged 4–17 years§	N/A	N/A	23 (20.9)	1 (1.0)	23 (10.5)	1 (0.5)	24 (5.6)	Omnibus: <0.0001
Respondent, female sex	66 (60.0)	43 (39.4)	81 (73.6)	73 (73.0)	147 (66.8)	116 (55.5)	63 (61.3)	
Female PWD	66 (60.0)	43 (39.4)	39 (35.5)	41 (41.0)	105 (47.7)	84 (40.2)	189 (44.1)	Omnibus: 0.0012 PWD†: 0.0024 CGs‡: 0.4097
College/university degree	93 (84.5)	77 (70.6)	85 (77.3)	74 (74.0)	178 (80.9)	151 (72.2)	329 (76.7)	Omnibus: 0.0915
Years since diagnosis	30.5 ± 16.6	16.1 ± 8.7	24.1 ± 16.7	21.8 ± 16.8	27.3 ± 16.9	18.8 ± 13.5	23.2 ± 15.9	Omnibus: <0.0001 PWD†: <0.0001 CGs‡: 0.3169
Q1 | median | Q3	17 | 33 | 43	10 | 15 | 22	11 | 20 | 37	9 | 19 | 29	12 | 27 | 41	9 | 17 | 23	10 | 20 | 33	
Clinical characteristics								
Most recent A1C								Omnibus: 0.0138 PWD†: 0.6655 CGs‡: 0.0486
≤7% (≤53 mmol/mol)	45.0 (49)	42.3 (44)	35.2 (32)	44.7 (34)	40.5 (81)	43.3 (78)	41.8 (159)	
7.1–8.0% (54–64 mmol/mol)	39.4 (43)	39.4 (41)	24.2 (22)	32.9 (25)	32.5 (65)	36.7 (66)	34.5 (131)	
8.1–9.0% (65–75 mmol/mol)	11.0 (12)	16.3 (17)	22.0 (20)	10.5 (8)	16.0 (32)	13.9 (25)	15.0 (57)	
>9.1% (>76 mmol/mol)	4.6 (5)	1.9 (2)	18.7 (17)	11.8 (9)	11.0 (22)	6.1 (11)	8.7 (33)	

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TABLE 1 Baseline and Clinical Characteristics (Continued)

	T1D PWD (*n* = 110)	T2D PWD (*n* = 109)	T1D CGs (*n* = 110)	T2D CGs (*n* = 100)	All T1D (*n* = 220)	All T2D (*n* = 209)	Total (*n* = 429)	*P*
People using insulin for >5 years	N/A	65 (59.6)	N/A	72 (72.0)	N/A	137 (65.5)	137 (65.5)	Omnibus: 0.0602
Impaired hypoglycemia awareness¶	40 (36.4)	22 (20.2)	48 (43.6)	44 (44.0)	88 (40.0)	66 (31.6)	154 (35.9)	Omnibus: 0.0006 PWD†: 0.0079 CGs‡: 0.9577
SH events in the past 12 months								Omnibus: 0.2668
0	18 (16.4)	23 (21.1)	14 (12.7)	16 (16.0)	32 (14.5)	39 (18.7)	71 (16.6)	
1	40 (36.4)	36 (33.0)	36 (32.7)	37 (37.0)	76 (34.5)	73 (34.9)	149 (34.7)	
2	16 (14.5)	15 (13.8)	20 (18.2)	22 (22.0)	36 (16.4)	37 (17.7)	73 (17.0)	
≥3	36 (32.7)	35 (32.1)	40 (36.4)	25 (25.0)	76 (34.5)	60 (28.7)	136 (31.7)	
Reported on their first SH event	14 (12.7)	21 (19.3)	10 (9.1)	17 (17.0)	24 (10.9)	38 (18.2)	62 (14.5)	Omnibus: 0.1454
SH events in the past 3 years								Omnibus: 0.1925
1	32 (29.1)	29 (26.6)	23 (20.9)	20 (20.0)	55 (25.0)	49 (23.4)	104 (24.2)	
2	16 (14.5)	21 (19.3)	15 (13.6)	23 (23.0)	31 (14.1)	44 (21.1)	75 (17.5)	
≥3	62 (56.4)	59 (54.1)	72 (65.5)	57 (57.0)	134 (60.9)	116 (55.5)	250 (58.3)	
Characteristics of most recent SH event								
Insulin pump use at the time of most recent SH event	39 (35.5)	3 (2.8)	29 (26.4)	3 (3.0)	68 (30.9)	6 (2.9)	74 (17.2)	Omnibus: <0.0001 PWD†: <0.0001 CGs‡: <0.0001
Perceived cause(s) of most recent SH event								
Took too much insulin or incorrect dose	18 (16.4)	15 (13.8)	12 (10.9)	7 (7.0)	30 (13.6)	22 (10.5)	52 (12.1)	Omnibus: 0.1912
Ate less than planned or usual	30 (27.3)	51 (46.8)	42 (38.2)	48 (48.0)	72 (32.7)	99 (47.4)	171 (39.9)	Omnibus: 0.0063 PWD†: 0.0028 CGs‡: 0.1510
Exercised more than planned or realized	24 (21.8)	22 (20.2)	22 (20.0)	10 (10.0)	46 (20.9)	32 (15.3)	78 (18.2)	Omnibus: 0.1108
Do not know reason	18 (16.4)	15 (13.8)	22 (20.0)	29 (29.0)	40 (18.2)	44 (21.1)	84 (19.6)	Omnibus: 0.0333 PWD†: 0.5904 CGs‡: 0.1288
Other reason or do not remember	24 (21.8)	26 (23.9)	25 (22.7)	29 (29.0)	49 (22.3)	55 (26.3)	104 (24.2)	Omnibus: 0.6301

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TABLE 1 Baseline and Clinical Characteristics (Continued)

	T1D PWD (*n* = 110)	T2D PWD (*n* = 109)	T1D CGs (*n* = 110)	T2D CGs (*n* = 100)	All T1D (*n* = 220)	All T2D (*n* = 209)	Total (*n* = 429)	*P*
Company during most recent SH event								Omnibus: 0.2674
Alone	28 (25.5)	41 (37.6)	15 (13.6)	13 (13.0)	43 (19.5)	54 (25.8)	97 (22.6)	
Spouse/partner or CG	61 (55.5)	46 (42.2)	83 (75.5)	78 (78.0)	144 (65.5)	124 (59.3)	268 (62.5)	
Other	21 (19.1)	22 (20.2)	12 (10.9)	9 (9.0)	33 (15.0)	31 (14.8)	64 (14.9)	
CG's relationship to PWD								Omnibus: 0.0632
Spouse/partner	–	–	53 (48.2)	61 (61.0)	53 (48.2)	61 (61.0)	114 (54.3)	
Other	–	–	57 (51.8)	39 (39.0)	57 (51.8)	39 (39.0)	96 (45.7)	
Recovery time for most recent SH event								Omnibus: 0.0571
0–15 minutes	19 (18.1)	27 (25.0)	19 (17.3)	10 (10.2)	38 (17.7)	37 (18.0)	75 (17.8)	
15–30 minutes	38 (36.2)	46 (42.6)	43 (39.1)	43 (43.9)	81 (37.7)	89 (43.2)	170 (40.4)	
30 minutes to 1 hour	30 (28.6)	20 (18.5)	26 (23.6)	25 (25.5)	56 (26.0)	45 (21.8)	101 (24.0)	
>1 hour	18 (17.1)	15 (13.9)	22 (20.0)	20 (20.4)	40 (18.6)	35 (17.0)	75 (17.8)	
Time of most recent SH event								Omnibus: 0.1157
Morning	11 (10.0)	16 (14.7)	18 (16.4)	17 (17.0)	29 (13.2)	33 (15.8)	62 (14.5)	
Middle of day	10 (9.1)	13 (11.9)	11 (10.0)	17 (17.0)	21 (9.5)	30 (14.4)	51 (11.9)	
Afternoon	23 (20.9)	22 (20.2)	22 (20.0)	23 (23.0)	45 (20.5)	45 (21.5)	90 (21.0)	
Evening and before midnight	31 (28.2)	23 (21.1)	31 (28.2)	24 (24.0)	62 (28.2)	47 (22.5)	109 (25.4)	
After midnight	34 (30.9)	33 (30.3)	26 (23.6)	16 (16.0)	60 (27.3)	49 (23.4)	109 (25.4)	
Do not know	–	1 (0.9)	1 (0.9)	–	1 (0.5)	1 (0.5)	2 (0.5)	
Do not remember	1 (0.9)	1 (0.9)	1 (0.9)	3 (3.0)	2 (0.9)	4 (1.9)	6 (1.4)	
Sleeping when most recent SH event occurred?								Omnibus: 0.0107 PWD†: 0.1695 CGs‡: 0.2585
Yes	47 (42.7)	37 (33.9)	37 (33.6)	19 (19.0)	84 (38.2)	56 (26.8)	140 (32.6)	
No	61 (55.5)	69 (63.3)	66 (60.0)	77 (77.0)	127 (57.7)	146 (69.9)	273 (63.6)	
Do not know	1 (0.9)	1 (0.9)	2 (1.8)	2 (2.0)	3 (1.4)	3 (1.4)	6 (1.4)	
Do not remember	1 (0.9)	2 (1.8)	5 (4.5)	2 (2.0)	6 (2.7)	4 (1.9)	10 (2.3)	
Place of most recent SH event								Omnibus: 0.8459
Home	85 (77.3)	89 (81.7)	92 (83.6)	80 (80.0)	177 (80.5)	169 (80.9)	346 (80.7)	Omnibus: 0.6754
Work	8 (7.3)	6 (5.5)	2 (1.8)	4 (4.0)	10 (4.5)	10 (4.8)	20 (4.7)	
Other	17 (15.5)	14 (12.8)	16 (14.5)	16 (16.0)	33 (15.0)	30 (14.4)	63 (14.7)	

Data are mean ± SD or *n* (%) unless otherwise indicated. †PWD T1D versus T2D. ‡CGs T1D versus T2D. §Only reporting caregivers of this age-group. ¶Impaired awareness (Gold score) poses the question "Do you know when your hypoglycemia is commencing?" using a 7-point Likert scale, with 1 = "always aware" and 7 = "never aware." A score ≥4 defines impaired awareness of hypoglycemia (11). CG, caregiver; N/A, not applicable; PWD, people with diabetes; SH, severe hypoglycemic; T1D, type 1 diabetes; T2D, type 2 diabetes.

Table 3. Overall, experiencing or witnessing the severe hypoglycemic event made the majority of respondents (70.9%) feel scared. Just less than half of respondents reported that the most recent severe hypoglycemic event made them feel unprepared (42.7%) or helpless (46.9%). First-person reporting was completed by people with diabetes and caregivers on eight life domains in response to the impact of the most recent severe hypoglycemic event, as shown in Table 3.

Actions Taken After the Most Recent Severe Hypoglycemic Event

Several different actions (not mutually exclusive) were taken in response to the most recent severe hypoglycemic event (Table 4), including respondents starting to carry glucose-containing candy or sweet foods/drinks and/or adjusting their meal plan (60.8%), measuring blood glucose more often (43.8%), changing the insulin regimen or timing or dosing of insulin (35.0%), and wearing a continuous glucose monitoring (CGM) device (9.3%). A very small proportion of respondents obtained glucagon or kept glucagon close (3.7%) and/or kept glucagon kits in areas that are frequented or carried glucagon (2.8%). The actions of carrying candy or sweet foods/drinks and/or adjusting the meal plan ($P = 0.0013$) and wearing a CGM device were significantly different between groups ($P < 0.0001$). All participants with type 2 diabetes reported carrying candy, foods/drinks, or adjusting their meal plan more than all participants with type 1 diabetes (68.9 vs. 53.2%). All participants with type 1 diabetes reported that they were more likely to start wearing a CGM device than those with type 2 diabetes (16.4 vs. 1.9%).

Conversations About Severe Hypoglycemia

Respondents were surveyed on recommendations and discussions that occurred before their most recent severe hypoglycemic event. Approximately one-third of people with diabetes (type 1 diabetes 38.2%, type 2 diabetes 38.5%) reported having a discussion about severe hypoglycemia at every visit with their HCP (Table 5). Half of the respondents (50.6%) reported having conversations about severe hypoglycemia with their HCP at some visits. A small proportion of respondents (17.7%) reported never having a discussion with their HCP before their most recent severe hypoglycemic event.

The majority of people with diabetes (type 1 diabetes 81.8%, type 2 diabetes 84.4%) and caregivers (for someone with type 1 diabetes 72.7%, for someone with type 2 diabetes 65.0%) reported that consumption of

TABLE 2 Actions Taken During Most Recent Severe Hypoglycemic Event

Action†	T1D PWD (*n* = 110)	T2D PWD (*n* = 109)	T1D CGs (*n* = 110)	T2D CGs (*n* = 100)	All T1D (*n* = 220)	All T2D (*n* = 209)	Total (*n* = 429)	*P*
Ate or drank sugars	93 (84.5)	101 (92.7)	94 (85.5)	87 (87.0)	187 (85.0)	188 (90.0)	375 (87.4)	Omnibus: 0.2670
Injected glucagon	9 (8.2)	4 (3.7)	7 (6.4)	5 (5.0)	16 (7.3)	9 (4.3)	25 (5.8)	Omnibus: 0.5284
Health care resource use‡	15 (13.6)	15 (13.8)	30 (27.3)	27 (27.0)	45 (20.5)	42 (20.1)	87 (20.3)	Omnibus: 0.0074
Admitted overnight§								
Denominator for %	4	10	16	14	20	24	44	
Admitted overnight	1 (25.0)	4 (40.0)	3 (18.8)	9 (64.3)	4 (20.0)	13 (54.2)	17 (38.6)	Omnibus: 0.0814
Admitted to ED	4	10	16	14	20	24	44	
Of which, admitted overnight§	1 (25.0)	4 (40.0)	3 (18.8)	9 (64.3)	4 (20.0)	13 (54.2)	17 (38.6)	Omnibus: 0.0814

Data are *n* (%). †Actions are not mutually exclusive. ‡Called ambulance, called HCP, or went to the emergency department. §Data reflect respondents who arrived at the emergency department (by or not by ambulance) and who were then admitted overnight. CG, caregiver; ED, emergency department; PWD, people with diabetes; T1D, type 1 diabetes; T2D, type 2 diabetes.

TABLE 3 Impacts (Emotions and Affected Life Domains) of Most Recent Severe Hypoglycemic Event on Respondents

Impacts	T1D PWD (*n* = 110)	T2D PWD (*n* = 109)	T1D CGs (*n* = 110)	T2D CGs (*n* = 100)	All T1D (*n* = 220)	All T2D (*n* = 209)	Total (*n* = 429)	*P*
Emotions								
Scared, agree/strongly agree	68 (61.8)	69 (63.3)	94 (85.5)	73 (73.0)	162 (73.6)	142 (67.9)	304 (70.9)	Omnibus: 0.0003 CGs†: 0.0255
Unprepared, agree/strongly agree	39 (35.5)	54 (49.5)	45 (40.9)	45 (45.0)	84 (38.2)	99 (47.4)	183 (42.7)	Omnibus: 0.1865
Helpless, agree/strongly agree	51 (46.4)	50 (45.9)	56 (50.9)	44 (44.0)	107 (48.6)	94 (45.0)	201 (46.9)	Omnibus: 0.7755
Affected life domains								
Physical activities	20 (18.2)‡	13 (11.9)‡	10 (9.1)§	10 (10.0)§	N/A	N/A	N/A	PWD¶: 0.1957 CGs†: 0.8226
Mood or emotional status	22 (20.0)‡	19 (17.4)‡	29 (26.4)§	28 (28.0)§	N/A	N/A	N/A	PWD¶: 0.6261 CGs†: 0.7900
Social or leisure activities	7 (6.4)‡	10 (9.2)‡	8 (7.3)§	8 (8.0)§	N/A	N/A	N/A	PWD¶: 0.4370 CGs†: 0.8427
Work or school	3 (2.7)‡	7 (6.4)‡	8 (7.3)§	7 (7.0)§	N/A	N/A	N/A	PWD¶: 0.1903 CGs†: 0.9389
Daily activities	17 (15.5)‡	19 (17.4)‡	13 (11.8)§	16 (16.0)§	N/A	N/A	N/A	PWD¶: 0.6931 CGs†: 0.3803
Relationships with friends and family	6 (5.5)‡	3 (2.8)‡	10 (9.1)§	4 (4.0)§	N/A	N/A	N/A	PWD¶: 0.3138 CGs† 0.1396
Financial matters	2 (1.8)‡	3 (2.8)‡	4 (3.6)§	1 (1.0)§	N/A	N/A	N/A	PWD¶: 0.6435 CGs†: 2107
Sleep	16 (14.5)‡	16 (14.7)‡	23 (20.9)§	10 (10.0)§	N/A	N/A	N/A	PWD¶: 0.9777 CGs†: 0.0300
Respondent reported ≥1 life domains	46 (41.8)‡	40 (36.7)‡	53 (48.2)§	48 (48.0)§	N/A	N/A	N/A	PWD¶: 0.4378 CGs†: 0.9790

Data are *n* (%). Answers are not mutually exclusive. †CGs T1D versus T2D. ‡PWD first-person survey question: "My most recent severe low blood sugar (hypoglycemia) has affected my [insert life domain]." §Caregiver first-person survey question: "The most recent severe low blood sugar (hypoglycemia) of the person with diabetes I care for has affected my [insert life domain]." ¶PWD T1D versus T2D. CG, caregiver; PWD, people with diabetes; T1D, type 1 diabetes; T2D, type 2 diabetes.

TABLE 4 Actions Taken After Most Recent Severe Hypoglycemic Event

Actions	T1D PWD (n = 110)	T2D PWD (n = 109)	T1D CGs (n = 110)	T2D CGs (n = 100)	All T1D (n = 220)	All T2D (n = 209)	Total (n = 429)	P
Changed insulin regimen or timing or dosing of insulin	33 (30.0)	35 (32.1)	47 (42.7)	35 (35.0)	80 (36.4)	70 (33.5)	150 (35.0)	Omnibus: 0.2125
Wore a CGM device	16 (14.5)	2 (1.8)	20 (18.2)	2 (2.0)	36 (16.4)	4 (1.9)	40 (9.3)	Omnibus: <0.0001 PWD†: 0.0006 CGs‡: 0.0001
Measured blood glucose more often	45 (40.9)	52 (47.7)	47 (42.7)	44 (44.0)	92 (41.8)	96 (45.9)	188 (43.8)	Omnibus: 0.7766
Carried glucose candy, food, or drink or adjusted meal plan	52 (47.3)	71 (65.1)	65 (59.1)	73 (73.0)	117 (53.2)	144 (68.9)	261 (60.8)	Omnibus: 0.0013 PWD†: 0.0077 CGs‡: 0.0339
Obtained glucagon or kept glucagon close	5 (4.5)	4 (3.7)	7 (6.4)	0 (0.0)	12 (5.5)	4 (1.9)	16 (3.7)	Omnibus: 0.1021
Kept glucagon kits in areas frequented; carried kit	3 (2.7)	1 (0.9)	6 (5.5)	2 (2.0)	9 (4.1)	3 (1.4)	12 (2.8)	Omnibus: 0.2115

Data are *n* (%). Answers are not mutually exclusive. *P* values are from χ^2 test. †PWD T1D vs. T2D. ‡CGs T1D vs. T2D. CG, caregiver; T1D, type 1 diabetes; T2D, type 2 diabetes.

carbohydrates and/or a form of glucose was advised to treat hypoglycemia during a discussion with an HCP before the patient's most recent severe hypoglycemic event. Approximately one-fourth of respondents reported that their HCP recommended glucagon injection as a treatment option and, of these respondents, there was a significantly larger proportion with type 1 diabetes than with type 2 diabetes (44.1 vs. 7.2%, P <0.0001).

A substantial proportion of all respondents (40.3%) reported not having had a discussion with their HCP after the most recent severe hypoglycemic event occurred. The primary reasons reported as to why hypoglycemia was not discussed with an HCP included "knew cause of the severe hypoglycemia event" (62.4%), "no big deal" (24.2%), "did not think it would happen again" (9.6%), and "did not want to talk about it" (9.6%).

Actions for preventing or preparing for future severe hypoglycemic events that were recommended by HCPs after the most recent severe hypoglycemic event included (not mutually exclusive) changing the insulin regimen or timing or dosing of insulin (33.8%), more intensive glucose monitoring (28.2%), carrying sweets or some form of glucose (27.5%), adjusting meal plans (timing of meals, snack more, or amount of food intake) (18.6%), and increasing the availability of glucagon (obtain glucagon or keep it closer) for recovery from severe hypoglycemia (7.7%).

Discussion

The CRASH study examined important aspects associated with severe hypoglycemia in people with type 1 or insulin-treated type 2 diabetes and caregivers of people with diabetes, including situational contexts, psychological experiences, and discussions with HCPs about prevention and treatment strategies. Communication and shared decision-making between people with diabetes and their HCPs are important for successfully managing diabetes and promoting quality of life. Results from the U.S. CRASH survey indicate that conversations are not taking place as often as recommended by ADA guidelines, which is consistent with a recent publication from Pilla et al. (10) who found that communication about hypoglycemia occurred in only 24% of health care visits. Of the respondents who did not have any conversation with their HCP regarding the most recent hypoglycemia event (40.3%), nearly two-thirds reported that the reason they did not discuss it was because they knew the cause of the event.

TABLE 5 Recommendations and Discussions With HCP Before and After Most Recent Severe Hypoglycemic Event

	T1D PWD (n = 110)	T2D PWD (n = 109)	T1D CGs (n = 110)	T2D CGs (n = 100)	All T1D (n = 220)	All T2D (n = 209)	Total (n = 429)	P
Frequency of SH discussions with HCP before most recent SH event								Omnibus:<0.0001 PWD†: 0.7017 CGs‡: 0.0008
Every visit	42 (38.2)	42 (38.5)	36 (32.7)	16 (16.0)	78 (35.5)	58 (27.8)	136 (31.7)	
Some visits	57 (51.8)	52 (47.7)	56 (50.9)	52 (52.0)	113 (51.4)	104 (49.8)	217 (50.6)	
Never	11 (10.0)	15 (13.8)	18 (16.4)	32 (32.0)	29 (13.2)	47 (22.5)	76 (17.7)	
HCP recommendations before most recent SH event								
Consume carbohydrates/sugar	90 (81.8)	92 (84.4)	80 (72.7)	65 (65.0)	170 (77.3)	157 (75.1)	327 (76.2)	Omnibus: 0.0035 PWD†: 0.6097 CGs‡: 0.2264
Inject glucagon	47 (42.7)	12 (11.0)	50 (45.5)	3 (3.0)	97 (44.1)	15 (7.2)	112 (26.1)	Omnibus: <0.0001 PWD†: <0.0001 CGs‡: <0.0001
Use health care services (call ambulance, visit emergency department, contact HCP)	18 (16.4)	24 (22.0)	32 (29.1)	31 (31.0)	50 (22.7)	55 (26.3)	105 (24.5)	Omnibus: 0.0494 PWD†: 0.2879 CGs‡: 0.7630
Most recent SH event was not discussed later with HCP	49 (44.5)	39 (35.8)	44 (40.0)	41 (41.0)	93 (42.3)	80 (38.3)	173 (40.3)	Omnibus: 0.6207
Reasons SH event was not discussed with HCP								
Denominator for %	47	38	39	33	86	71	157	
Knew cause of the SH event	31 (66.0)	21 (55.3)	25 (64.1)	21 (63.6)	56 (65.1)	42 (59.2)	98 (62.4)	Omnibus: 0.7654
No big deal	14 (29.8)	9 (23.7)	10 (25.6)	5 (15.2)	24 (27.9)	14 (19.7)	38 (24.2)	Omnibus: 0.5083
Did not think it would happen again	5 (10.6)	5 (13.2)	1 (2.6)	4 (12.1)	6 (7.0)	9 (12.7)	15 (9.6)	Omnibus: 0.3777
Did not want to talk about it	5 (10.6)	1 (2.6)	5 (12.8)	4 (12.1)	10 (11.6)	5 (7.0)	15 (9.6)	Omnibus: 0.4066
HCP recommendations after most recent SH event								
Change insulin regimen	34 (30.9)	36 (33.0)	38 (34.5)	37 (37.0)	72 (32.7)	73 (34.9)	145 (33.8)	Omnibus: 0.8194
Change meal plan	13 (11.8)	30 (27.5)	20 (18.2)	17 (17.0)	33 (15.0)	47 (22.5)	80 (18.6)	Omnibus: 0.0263 PWD†: 0.0034 CGs‡: 0.8224
Measure blood glucose more often or get CGM device	29 (26.4)	31 (28.4)	34 (30.9)	27 (27.0)	63 (28.6)	58 (27.8)	121 (28.2)	Omnibus: 0.8835
Started carrying sweets or sugar	17 (15.5)	41 (37.6)	23 (20.9)	37 (37.0)	40 (18.2)	78 (37.3)	118 (27.5)	Omnibus: 0.0001 PWD†: 0.0002 CGs‡: 0.0099
Obtain glucagon or kept it closer	10 (9.1)	9 (8.3)	10 (9.1)	4 (4.0)	20 (9.1)	13 (6.2)	33 (7.7)	Omnibus: 0.4619

Data are n (%) unless otherwise noted. Answers are not mutually exclusive. P values are from χ^2 test. †PWD T1D vs. T2D. ‡CGs T1D vs. T2D. CG, caregiver; PWD, people with diabetes; SH, severe hypoglycemic; T1D, type 1 diabetes; T2D, type 2 diabetes.

Clearly, the most recent severe hypoglycemic event had an acute impact on respondents' emotions (i.e., feelings of being scared, helpless, and/or unprepared). Our survey did not assess whether discussions with HCPs dealt with these issues, but more attention to the psychological impact seems warranted. In addition, our survey did not examine the precise nature of enduring life impacts, although some impacts seem to involve lifestyle changes that attempt to prevent future hypoglycemia (e.g., impacts to physical, social, work/school, and daily activities), and some impacts are negative consequences of the events themselves (e.g., impacts to mood/emotions, family/social relationships, sleep, and finances). Fulcher et al. (11) reported similar results from their survey, in which individuals with type 1 or type 2 diabetes reported a large financial and psychosocial impact resulting from experiencing a nocturnal or daytime nonsevere hypoglycemic event. Again, HCP assessments of such psychosocial impacts are essential to identify any need for additional attention, whether through counseling by diabetes care providers or mental health specialists. It is important to note that negative consequences were common among caregivers as well as people with diabetes.

Glucagon is used to treat severe hypoglycemia when a person with diabetes can no longer safely swallow oral carbohydrates or cannot tolerate carbohydrates because of nausea or vomiting. Specifically, the ADA recommends that glucagon should be prescribed for all individuals at increased risk of level 2 hypoglycemia, which is defined as blood glucose <54 mg/dL (<3.0 mmol/L), or level 3 (severe) hypoglycemia (7) to ensure that glucagon is available when needed. Results from this study demonstrate that a low percentage of people with diabetes and caregivers reported glucagon use for their most recent severe hypoglycemic event, and a low percentage of respondents obtained glucagon or made sure to keep it close even after the most recent event. Instead, eating or drinking a form of glucose was the most common first response at the time of the severe hypoglycemic event (6).

The assessment by a caregiver regarding the safety of giving food or drink by mouth is made at a panicked time, when emotions can be intense and decision-making may be impaired. In interviewing caregivers of people with diabetes, Stuckey-Peyrot et al. (12) found that caregivers felt a rising sense of panic and questioned their actions during severe hypoglycemic events. Some caregivers described needing to "encourage them along" or urging the person with diabetes to "please drink more," while some said they had to take the lead on administering the carbohydrates, which one caregiver described as "dumping" soda down the person's throat. If administering oral carbohydrates did not resolve severe hypoglycemia, then caregivers sometimes felt helpless and said that at a "certain point" it seemed that the "only option [was] to call for emergency help" (12).

Since the CRASH study was completed, new innovations in glucagon delivery for the treatment of severe hypoglycemia have been approved in the United States and elsewhere (13–15). New, ready-to-use drug/device combinations do not require a user to reconstitute the glucagon, thus allowing for more successful administration of a full dose of glucagon, and are easier to use than conventional injectable glucagon emergency kits (12,16–18). Certainly, after a severe hypoglycemic event, conversations among people with diabetes, caregivers, and HCPs should include assessment of unexpired glucagon ownership and review of when and how to use it.

Strengths of this study are the relatively large numbers of people in each group (people with type 1 or type 2 diabetes and caregivers of people with type 1 or type 2 diabetes) who reported on their experience of severe hypoglycemia. Reports by caregivers of a severe hypoglycemic event, which by definition requires help from another person for recovery, provide additional insight and remind us of the need to support caregivers' burden. The study was also comprehensive, focusing on activities taking place before, during, and after the most recent hypoglycemic event.

Limitations of the CRASH study include the self-reported nature of the data, as potential biases may have affected responses. Information discussed with HCPs was also not available to the investigators. For example, HCPs may have discussed severe hypoglycemia or recommended seeking emergency health care, but respondents may not have recognized or remembered such discussions. In addition, because this study was an online survey requiring internet access, only members of a medical research panel were eligible to participate. Survey respondents were highly educated, with 76.7% reporting having a college/university degree. The sample population was therefore unlikely to be representative of all adults experiencing recent severe hypoglycemia. Although respondents were asked to respond about events that met the formal criterion for severe hypoglycemia, they were not required to demonstrate that these events met those criteria.

The CRASH study results can be used to improve the preparedness of people with diabetes and caregivers and increase their understanding of the medical importance of risk and avoidance of severe hypoglycemia. The actions that people with diabetes and caregivers take are influenced by conversations about severe hypoglycemia that occur with HCPs; therefore, it is important that HCPs consider these findings and apply them to their practice.

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DUALITY OF INTEREST

F.J.S. served as consultant and is on an advisory board for Eli Lilly and Company. E.S., C.J.C., S.B., and B.D.M. were employees and shareholders of Eli Lilly and Company when the CRASH survey was conducted and analyzed. B.A.N. is an employee at Syneos Health. Z.B., D.M.B., and R.P. are employees at Evidera. No other potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

F.J.S. and B.D.M. contributed to the conceptualization. F.J.S., B.A.N., and B.D.M. wrote the original draft. E.S., B.A.N., Z.B., D.M.B., R.P., and B.D.M. were involved in data curation. E.S., Z.B., D.M.B., and B.D.M. devised the methodology. E.S., B.A.N., and B.D.M. supervised the crafting of the manuscript. E.S., Z.B., D.M.B., and R.P. were responsible for validation. B.A.N. led the project administration. C.J.N., D.M.B., and B.D.M. helped with the investigation of the manuscript. Z.B. and B.D.M. contributed resources to the development of the manuscript. All authors contributed to the formal analysis and reviewed and edited the manuscript. B.D.M. is the guarantor of this work and, as such, takes responsibility for the integrity of the data and the accuracy of the data analysis.

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