

RESEARCH ARTICLE

Perceptions of hypoglycemia and self-monitoring of blood glucose in insulin-treated diabetes patients: results from a European online survey



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Practice Points

- Hypoglycemia is a frequent and potentially fatal complication in patients with Type 1 or 2 diabetes receiving insulin treatment or oral antidiabetes drugs (e.g., sulfonylureas and meglitinides).
- The potential for hypoglycemic episodes can create fear among many patients with diabetes, resulting in poor adherence to treatment regimens that are specifically designed to attain tight glycemic control.
- This online survey evaluated the effects of hypoglycemia on the lives of 1848 patients with diabetes (in France, Germany and the UK), and determined whether self-monitoring of blood glucose to prevent hypoglycemic episodes is an appealing and widely accepted concept.
- Approximately a third of all patients surveyed did not always recognize the symptoms of hypoglycemia when they were having an episode and approximately a quarter had no warning signs (hypoglycemia-associated autonomic failure).
- Approximately 40% of patients said they tended to maintain their blood glucose levels above physician-recommended values to help avoid hypoglycemia.
- The vast majority of patients (80%) would value a meter that provides high or low blood glucose warnings at specific timepoints during the day.
- Insulin-treated patients with diabetes are particularly worried about potential hypoglycemia; however, patients have a positive perception about, and are specifically motivated to adopt tools, such as self-monitoring of blood glucose, that are designed to facilitate the identification, management and prevention of hypoglycemia.

SUMMARY **Aim:** Tight glycemic control is important for reducing diabetic complications but increases the risk of hypoglycemia. The online survey aimed to evaluate the effects of hypoglycemia on the lives of patients with diabetes and determine whether self-monitoring of blood glucose to prevent hypoglycemic episodes is an appealing and widely accepted concept. **Materials & methods:** A total of 1848 individuals with insulin-treated diabetes in Europe were included in a 10-min online survey to determine perceptions about hypoglycemia and self-monitoring of blood glucose as a tool to prevent

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hypoglycemia. **Results:** Approximately a third of patients were not always able to recognize the symptoms of hypoglycemia when they were having an episode and approximately a quarter experienced no warning signs (hypoglycemia-associated autonomic failure). Out of the patients surveyed, 37% said they tended to maintain their blood glucose levels above physician-recommended values to help avoid hypoglycemia, and 80% said they would value a meter that provides high or low blood glucose warnings at specific timepoints during the day. **Conclusion:** Overall, individuals with insulin-treated diabetes have a positive perception about and are keen to adopt tools designed to facilitate the identification, management and prevention of hypoglycemia, while helping to avoid hyperglycemia and an increased risk of diabetic complications.

It is widely recognized in patients with diabetes mellitus that efforts to attain tight glycemic control are essential [1–3]. Such efforts primarily comprise striving for a glycosylated hemoglobin level of less than 7% through strict control of fasting, and maintaining pre- and post-prandial blood glucose concentrations at normal or near-normal values, thereby reducing the risk of diabetic complications [4].

In 1993, the Diabetes Control and Complications Trial (DCCT) Research Group documented that intensive insulin therapy markedly delayed the onset and slowed the progression of microvascular complications in patients with Type 1 diabetes [1]. In 1998, the UK Prospective Diabetes Study (UKPDS) reported that intensive intervention with sulfonylureas or insulin significantly reduced the risks of microvascular complications and any diabetes-related end points in patients with Type 2 diabetes. Moreover, for each 1% decrease in glycosylated hemoglobin level, relative risk reductions were 37% for microvascular complications and 21% for diabetes-related end points and death [2].

Importantly, in the DCCT, a key aspect of the intensive treatment approach was self-monitoring of blood glucose (SMBG), and data clearly indicate that SMBG is a useful tool to assist in improving glycemic control in individuals with insulin-treated diabetes [5]. As a tool, SMBG also helps to substantially reduce the risks of, and prevent, ‘asymptomatic’ hypoglycemia and asymptomatic hyperglycemia in patients with diabetes [6]. Thus, the American Diabetes Association (ADA) advocates that patients with diabetes using multiple daily insulin injections should conduct SMBG at least three-times daily; the ADA also regards SMBG, including after meals, as appropriate for facilitating the attainment of glycemic goals in patients using less frequent insulin therapy, those treated with oral antidiabetic therapy and those receiving dietary therapy alone [7].

Clinical strategies that target tight glycemic control in patients with diabetes carry an attendant risk of hypoglycemia: clearly, the tighter the glycemic control, the greater the risks of hypoglycemic episodes. The DCCT, for example, reported that intensive insulin therapy in patients with Type 1 diabetes was associated with a two- to three-fold increase in the risk of severe hypoglycemia [1], and approximately 90% of all individuals with insulin-treated diabetes have had hypoglycemic episodes at some stage [8]. Although there is currently no consensus or standardized definition of hypoglycemia, the ADA definition of hypoglycemia (plasma glucose <3.9 mmol/l/ <70 mg/dl) is widely accepted [5,7]. The potential for such hypoglycemic episodes creates fear among many patients with diabetes, and many patients may, therefore, adhere poorly to treatment regimens specifically designed to attain tight glycemic control. This situation creates a ‘double-edged sword’: on the one hand, patient fear drives avoidance of the well-known, deleterious consequences of severe hypoglycemia (i.e., mental impairment – confusion and disorientation – seizures and coma); and on the other hand, poor adherence to antidiabetic therapy, as a result of concern about possible hypoglycemia, prevents attainment of the unequivocal benefits of antidiabetic therapy in reducing end-organ diabetic complications [1,2,6]. Indeed, the psychological consequences of hypoglycemia include subsequent fear of hypoglycemia, guilt relating to fear of hypoglycemia, failure to comply with therapeutic regimens, high levels of anxiety, and low levels of patient satisfaction and happiness. Fear of hypoglycemia is a particularly important problem and it is becoming almost as much of a barrier to glycemic control as hypoglycemia itself. The Hypoglycemia Fear Survey (HFS), first published in 1987, and its more recent counterpart (HFS-II), are used to measure behaviors (HFS-B) and worries (HFS-W)

associated with hypoglycemia in adults with Type 1 diabetes. They describe behaviors that patients may engage in to avoid hypoglycemia, such as maintaining higher blood glucose levels than recommended, avoiding being alone, and limiting exercise or physical activity, or concerns they may have about hypoglycemic episodes, such as nocturnal episodes. HFS-B and HFS-W scores have been shown to be significantly higher in women than men, and among patients who have previously experienced severe hypoglycemic episodes compared with those who have not [8,9].

Against this backdrop of potentially major harm from hypoglycemia, SMBG is especially important in patients with a history of frequent hypoglycemic episodes; in particular, SMBG should be performed before pivotal aspects of daily life such as driving [10]. However, no data are available about patient beliefs, concepts and feelings around the specific use of SMBG to prevent hypoglycemic episodes during diabetes treatment. The current survey was, therefore, undertaken to evaluate the explicit effects of hypoglycemia on the lives of patients with diabetes, and to determine whether specific SMBG to prevent hypoglycemic episodes is an appealing and widely accepted concept.

Materials & methods

During a 3-week period between May and June 2011, patients diagnosed with Type 1 (50% of patients) and 2 (50%) diabetes in the LifeScan (a division of Ortho Clinical Diagnostics, High Wycombe, UK) patient database were selected for inclusion in a 10-min, online, market research survey. Initial contact with patients was via e-mail with a link to the online survey. Eligibility criteria included patient authorization to be contacted via their supplied e-mail address, patients had to be receiving insulin treatment (or oral therapy and insulin), 50% of patients needed to have Type 1 diabetes and the other 50% Type 2 diabetes. Patients were selected from the UK ($n = 480$), France ($n = 564$) and Germany ($n = 804$). Patients were asked to respond to a total of 11 key questions (the complete questionnaire is available as [Supplementary Material](#); see online at www.futuremedicine.com/doi/suppl/10.2217/dmt.12.66) about their understanding, perceptions and daily experiences of hypoglycemia and SMBG. Regarding 'understanding of hypoglycemia', for example, patients were asked: "Do

you agree or disagree with the following statements about your experience of hypoglycemia?" The responses comprised: "Understand what it is", "Do not always recognize signs" and "Body does not give warning".

Descriptive statistics were applied to responses for each question, and 95% CIs were calculated using a standard two-sample test.

Results

■ Patient awareness of hypoglycemia

In all three countries, 97–100% of respondents were able to correctly identify the accepted glycemic cut-off value that met the ADA definition of hypoglycemia. However, across all countries, approximately a third of patients (32–37%) did not always recognize the signs of a hypoglycemic episode when they were having one.

As shown in [Figure 1](#), in each country, this 'nonrecognition' percentage was significantly greater ($p < 0.05$) in patients with Type 1 than 2 diabetes: overall, 43% of patients with Type 1 versus 29% of patients with Type 2 diabetes reported that they do not always recognize the signs of hypoglycemia. In addition, a total 22% of patients responded that they had no warning of hypoglycemia. This response was generally similar in patients with Type 1 versus 2 diabetes (15–27 vs 14–24% of patients across the three countries), although fewer patients overall in the UK (14%) than France (23%) and Germany (25%) said that they had no warning of hypoglycemia.

The pattern of patient responses regarding the understanding of hypoglycemia was generally similar when analyzed according to treatment type: intensive insulin treatment (IIT; patients treated with three or more insulin injections per day) versus patients treated with conventional insulin therapy (CIT; patients treated with one or two insulin injections per day). No significant difference was noted for nonrecognition of hypoglycemic signs in IIT versus CIT recipients (32–38 vs 25–39% of patients). More CIT patients in France (39%) than the UK and Germany (25–27%) were 'nonrecognizers'.

■ Patient experience of hypoglycemia

Across the three countries surveyed, approximately a third to a half of patients admitted to being "... very worried about hypoglycemia" ([Figure 2](#)). As shown in [Figure 2](#), such concern

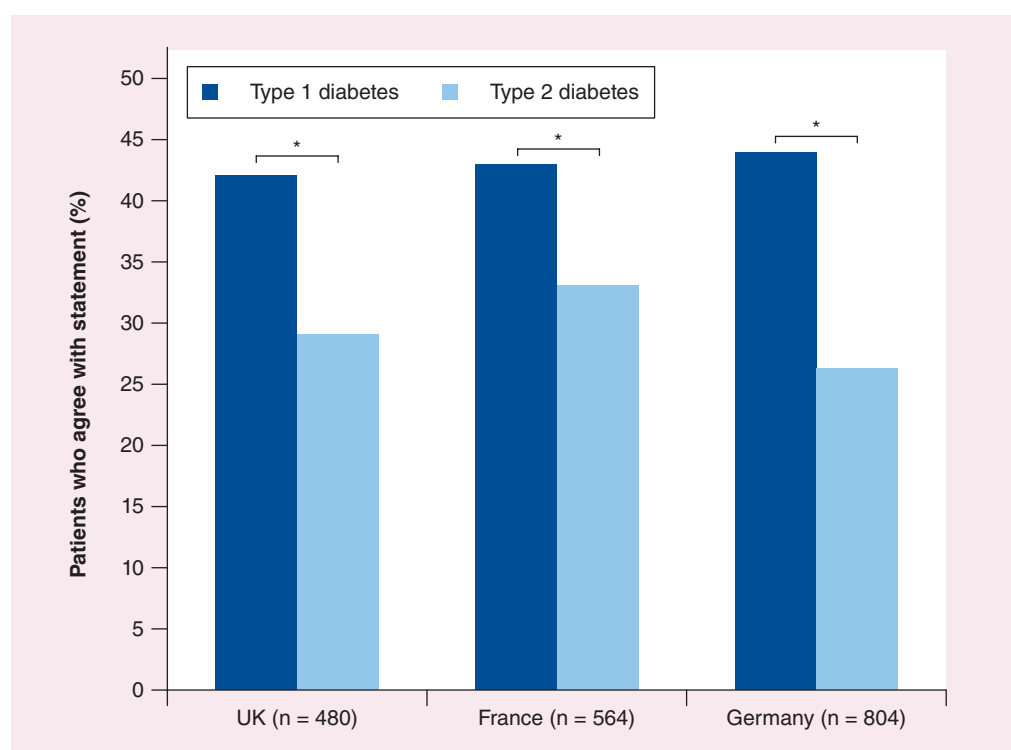


Figure 1. ‘Nonrecognition’ of hypoglycemic symptoms by insulin-treated patients with Type 1 or Type 2 diabetes. Patients were asked: “Do you agree or disagree with the following statement about your experience of hypoglycemia? – Do not always recognize signs”. Values shown are the proportions of patients who agreed with the statement.

*All differences between patients with Type 1 and 2 diabetes were statistically significant ($p < 0.05$).

was greater in France (33% of patients) than in the UK (15%) and Germany (19%). A similar pattern was evident when patients responded to the statement “I tend to keep my blood glucose levels a little higher than I should to help avoid hypoglycemia”: 46% of patients in France, 36% in the UK and 31% in Germany (overall 37%) (Figure 2). The corresponding proportions of patients who “... find it difficult to balance the risk of hypoglycemia and good blood glucose control” were 48, 32 and 20%, respectively (overall 32%) (Figure 2).

As shown in Table 1, more patients with Type 1 than Type 2 diabetes found it difficult to balance the risk of hypoglycemia against good glycaemic control in the UK (40 vs 28% of patients), France (53 vs 46%) and Germany (29 vs 15%); differences were statistically significant ($p < 0.05$) in the UK and Germany. In the UK, significantly more patients with Type 1 than 2 diabetes stated that: “My fear of hypoglycemia affects my overall quality of life” (21 vs 10%) or “Hypoglycemia or fear of hypoglycemia affects my relationships” (14 vs 7%). However, no

statistically significant differences in responses to these questions were evident in France and Germany, except for the second question in Germany, where approximately twice as many patients with Type 1 compared with Type 2 diabetes (11 vs 5%) considered hypoglycemia to affect their relationships.

Generally, similar findings were evident for IIT users versus CIT recipients (UK: 41 vs 18%; France: 55 vs 37%; and Germany: 21 vs 15%; differences were statistically significant in the UK and France: $p < 0.05$) (Table 1). In all three countries, IIT users had a greater, and in many cases statistically significantly greater ($p < 0.05$), tendency to keep blood glucose levels slightly elevated to help avoid hypoglycemia (33–50 vs 18–39% of patients; overall 39 vs 30%) and to be very worried about hypoglycemia (19–35 vs 7–29%; overall 24 vs 15%) (Table 1). In the UK, significantly more IIT than CIT users stated that hypoglycemia, or fear of hypoglycemia, affects their overall quality of life (18 vs 10% of patients) and their relationships (13 vs 6%). As shown in Table 1, in the

UK and Germany, approximately three times as many IIT as CIT users were “... very worried about hypoglycemia” (19–21 vs 7–8% of patients; $p < 0.05$).

In the UK and Germany, but not France, difficulties in striking a balance between hypoglycemic risk and good glycemic control manifested more frequently in younger patients with diabetes; in other words, those aged 16–44 years rather than those aged ≥ 45 years (32–44 vs 14–31% of patients).

■ Patient acceptance of SMBG as a tool for the management of hypoglycemia

As part of the current survey, patients answered a series of questions relating to their perception and experience with SMBG in the management of hypoglycemia.

Overall, as shown in **Figure 3**, approximately three-quarters of patients in the three countries surveyed agreed with the following statements: “I would value a meter that told me

when my blood glucose is getting high or low at a particular time of day” (80% of patients) and “My meter giving me an advanced warning of a potential hypoglycemic event would be useful” (74%). The tendency for agreement with these statements was lower in Germany than in France and the UK, although no major differences between countries were evident (**Figure 3**).

In addition, 60% of patients responded that a blood glucose meter that warned of low blood glucose levels or ‘patterns’ would facilitate maintenance of glycemic control at levels recommended by their doctor (i.e., avoiding the tendency to keep blood glucose levels at higher than recommended values to help prevent hypoglycemia). Half of all patients with diabetes overall stated that “A more accurate meter would give me greater confidence in self-managing my diabetes” and half believed that “A more accurate meter (at low blood glucose levels) would help me better manage the risk

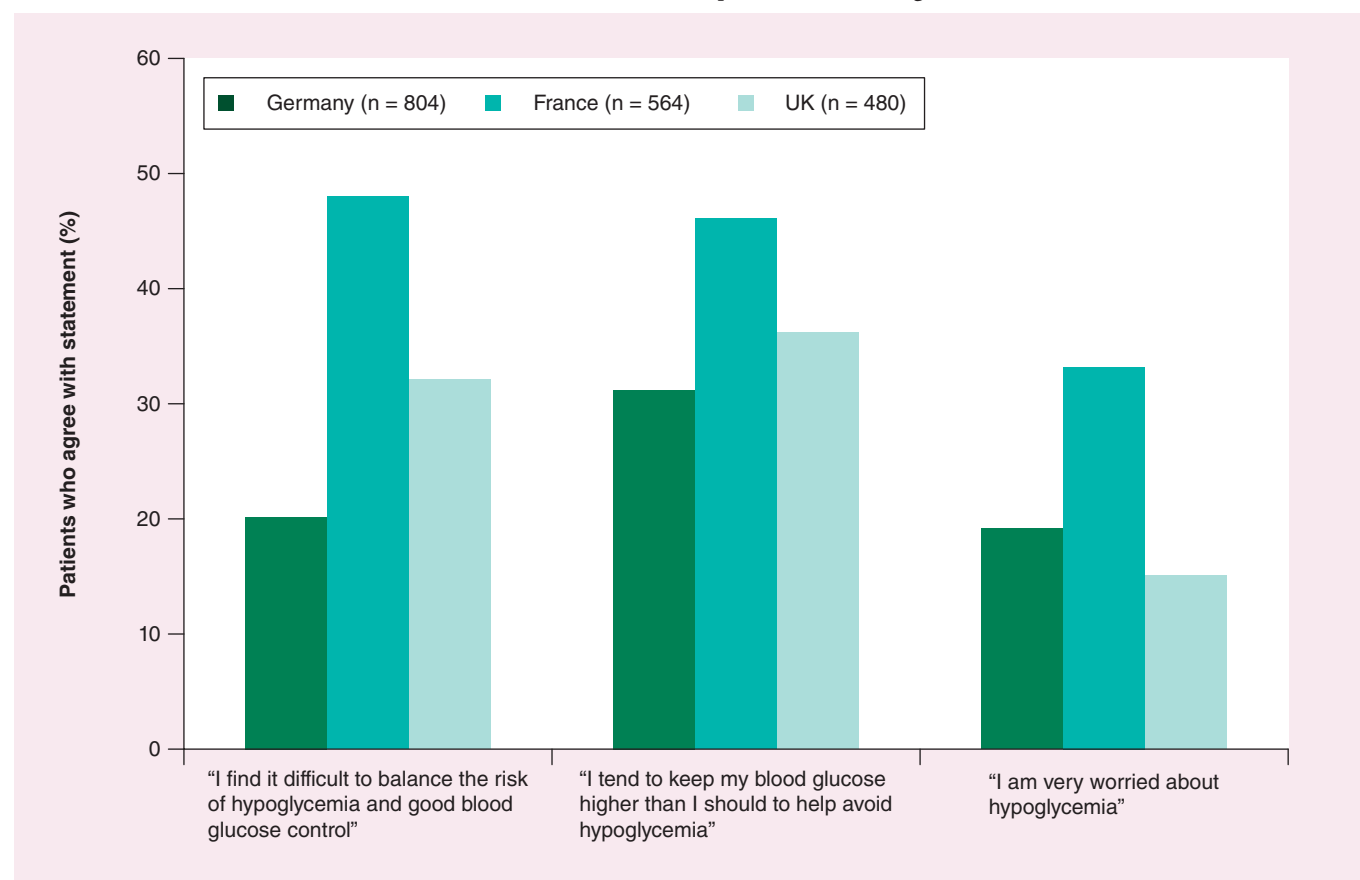


Figure 2. Proportions of individuals with insulin-treated diabetes who were apprehensive about hypoglycemia and who, to avoid hypoglycemia, deliberately maintained their blood glucose at higher levels than they should. Statements shown on the x-axis are in response to: “Do you agree with the following statements about your experience of hypoglycemia?”

Table 1. Proportions of insulin-treated patients with diabetes with specific anxieties and problems associated with hypoglycemia.

Do you agree or disagree with the following statements about your experience of hypoglycemia? [†]	UK (n = 480)				France (n = 564)				Germany (n = 804)				Overall (n = 1848)			
	Diabetes type		Treatment		Diabetes type		Treatment		Diabetes type		Treatment		Diabetes type		Treatment	
	1	2	IIT	CIT	1	2	IIT	CIT	1	2	IIT	CIT	1	2	IIT	CIT
I am very worried about hypoglycemia	17	13	19*	7	32	34	35	29	20	19	21*	8	22	22	24*	15
I find it difficult to balance the risk of hypoglycemia and good blood glucose control	40*	28	41*	18	53	46	55*	37	29*	15	21	15	39*	28	34*	24
I tend to keep my blood glucose levels a little higher than I should to help avoid hypoglycemia	35	37	42*	28	44	47	50*	39	33	30	33*	18	37	37	39*	30

[†]Values shown are percentages of patients agreeing with each statement.
 *Statistically significant difference ($p < 0.05$) versus comparator group.
 CIT: Conventional insulin treatment (one or two insulin injections per day); IIT: Intensive insulin treatment (three or more insulin injections per day).

of hypoglycemia". The tendency for agreement with these three statements was lower in Germany than in France and the UK.

Significantly more ($p < 0.05$) patients with Type 1 (92%) than Type 2 diabetes (82%) in France agreed that they would value a meter that told them when their blood glucose was getting high or low at a particular time of day. In Germany, significantly more ($p < 0.05$) patients with Type 1 (49%) than Type 2 diabetes (41%) agreed that "Better understanding when my blood glucose goes low would improve my quality of life", whereas more ($p < 0.05$) patients with Type 2 (57%) than Type 1 (46%) diabetes agreed that their current meter helps them to better manage their risk of hypoglycemia. In the UK, there were no significant differences between patients with Type 1 or 2 diabetes.

In the UK, significantly more IIT patients than conventional insulin users valued a meter that would indicate when blood glucose is getting high or low at a particular time of day (84 vs 75% of patients; $p < 0.05$). Significantly more IIT patients also valued, in terms of improved glycemic control, a meter that would warn of hypoglycemic patterns (76 vs 66%; $p < 0.05$). In France, a significantly more positive perception was held about a meter providing a high or low warning at a specific timepoint during the day, by IIT compared with CIT users (88 vs 79%; $p < 0.05$).

In all three countries, patients in the younger age groups were less satisfied that their current meter was helping their hypoglycemia. Moreover, in Germany, more patients with diabetes aged younger than 55 years compared with older than 55 years valued a meter that would

provide an advance warning of hypoglycemia (72 vs 63–65% of patients).

Discussion

This large-scale, online survey clearly identified that, although all patients have some awareness of what hypoglycemia actually is, approximately a third fail to recognize the symptoms of hypoglycemia when they are having a hypoglycemic episode. Moreover, notwithstanding some marked intercountry differences in responses, approximately one in four patients with diabetes overall admitted to having no warning of an impending hypoglycemic episode. This is a rather alarming figure, since, without monitoring their blood glucose, such patients will be unable to prevent hypoglycemic episodes or treat them early. It is also of interest to note that, as reported by others [11], a patient's ability to perceive hypoglycemia diminishes in both Type 1 and 2 diabetes with disease duration (i.e., a patient is more likely to develop hypoglycemia-associated autonomic failure the longer one has diabetes).

In all three countries surveyed, a third of patients were very worried about hypoglycemia and 37% overall admitted to keeping blood glucose levels a little higher than they should to help avoid hypoglycemia. The potential for deleterious consequences with such an approach is not difficult to envision, given the previously mentioned, unequivocal benefits of tight glycemic control: definitive data from the DCCT and UKPDS in the 1990s showed that tight glycemic control significantly reduced the risks of microvascular complications and diabetes-related end points in patients [1,2].

Generally, the current survey also revealed that anxieties and problems associated with hypoglycemia may be more prevalent in the following subgroups:

- Patients with Type 1 rather than Type 2 diabetes (e.g., they have greater difficulties in balancing hypoglycemic risk against good glycemic control);
- Younger versus older patients (aged <45 vs ≥45 years; e.g., they also have greater difficulties in balancing hypoglycemic risk against good glycemic control). This is a logical extension or ‘mirror’ of the first bullet point, since the prevalence of Type 1 diabetes is usually greater in younger than older patients;
- IIT patients rather than CIT users (e.g., they have increased worry about hypoglycemia and an increased tendency to maintain blood glucose at higher levels).

However, these apparent trends would benefit from confirmation in further studies.

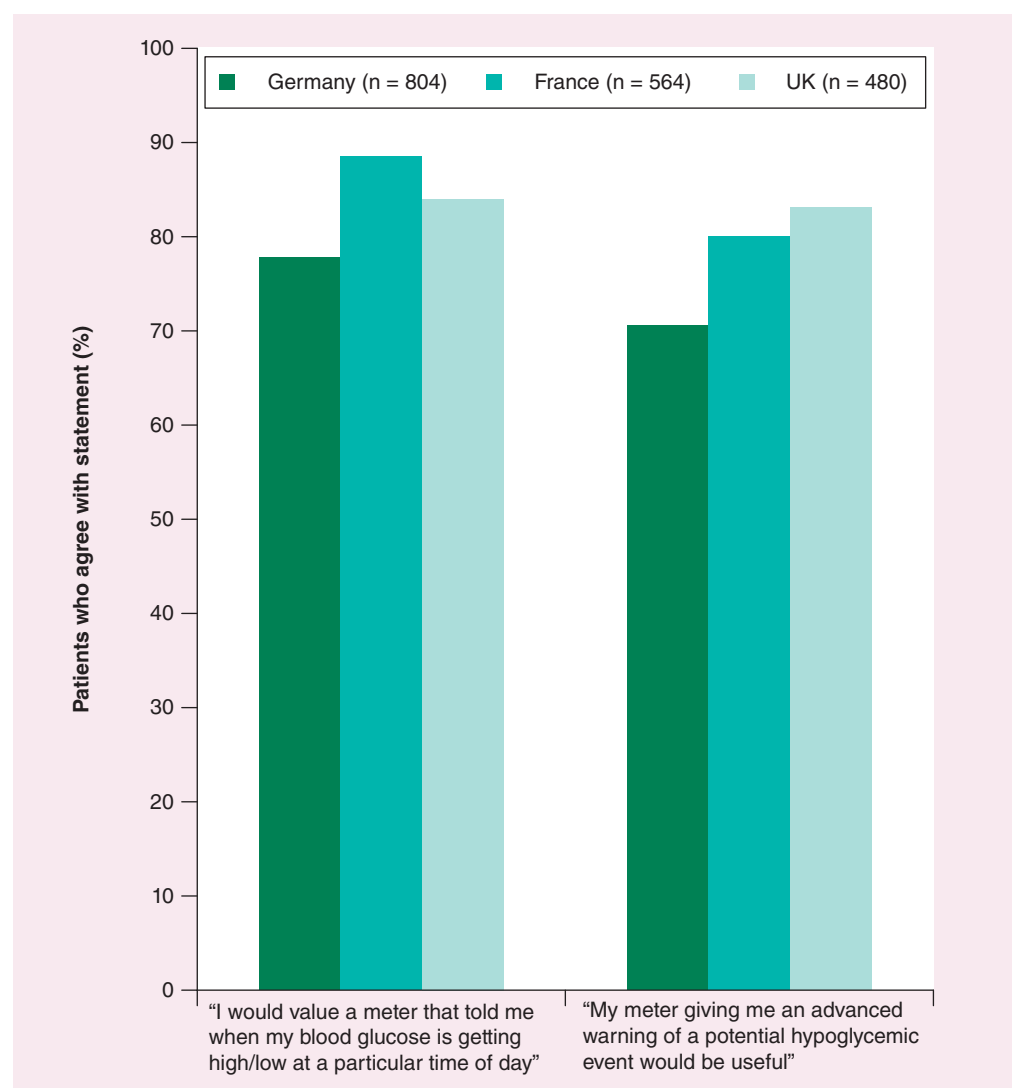


Figure 3. Proportions of individuals with insulin-treated diabetes with positive perceptions about a new blood glucose meter that would indicate when blood glucose is getting high or low at a particular time of day and give an advanced warning of a potential hypoglycemic event. Statements shown in the figures are in response to: “Do you agree or disagree with the following statements about your blood glucose meter and your experience of hypoglycemia?” Values shown are the proportions of patients who agreed with the statements.

All the above-mentioned findings distinctly highlight the need for insulin-treated patients with diabetes to have appropriate tools to facilitate the prevention, identification and early treatment of hypoglycemic episodes while avoiding hyperglycemia and an increased risk of diabetic complications. In this regard, SMBG with novel blood glucose meters for specific identification of low blood glucose levels may be particularly pertinent. Indeed, the current survey revealed that 80% of patients overall would value a meter that provided information about high or low blood glucose levels at a particular time of day, and 74% considered a meter that provided an advance warning of a possible hypoglycemic event to be desirable. Various intercountry differences in responses to questions about SMBG were noted, but in the UK and France especially, IIT rather than CIT users highly regarded high and low blood glucose warnings at specific timepoints during the day. In Germany, agreement with several statements about the use of blood glucose meters was generally less common than in the other two countries, but this may be attributable, in part, to limitations in maintaining question uniformity (e.g., cultural and language differences) from one country to the next. It must also be noted that between-country differences may reflect inherent biases (e.g., differences in marketing practices or healthcare system management factors across the three countries) of the proprietary database sample used in the survey. Furthermore, given the self-selected patient group and the descriptive nature of our survey, the overall generalizability of our survey results may be somewhat limited.

This survey provides detailed and clinically relevant data regarding patient perceptions about hypoglycemia, SMBG and meter features as tools for its management. Future surveys could perhaps also be designed to quantify the effects of anxiety about potential hypoglycemia, and conversely, to accurately assess the effects of SMBG with novel blood glucose meters designed to prevent hypoglycemia, on specific aspects of quality of life in patients with diabetes. In the future it might be interesting to obtain responses from patients with Type 2 diabetes only receiving oral therapy (e.g., insulin sensitizers or DPP-4 inhibitors) since the patients in the current survey were also receiving insulin.

The current data clearly indicate that SMBG is a useful tool to assist in improving glycemic

control in individuals with insulin-treated diabetes [5] and, in clear recognition of the merits of SMBG in patients with diabetes, the ADA recommends regular SMBG in individuals with insulin-treated diabetes, and in patients treated with other antidiabetic agents or dietary therapy alone [7]. UK NICE guidelines for Type 2 diabetes also highlight the integral role of SMBG in patient education and in facilitating the effective use of various antidiabetic treatments and lifestyle interventions [101].

Conclusion

Overall, this survey specifically defines that insulin-treated patients with diabetes, especially those who are IIT rather than CIT users, are particularly worried about potential hypoglycemia. Patients have a positive perception about and appear specifically motivated to adopt tools designed to facilitate the identification, management and prevention of hypoglycemia. Clearly, such tools include SMBG with blood glucose meters that provide an advance warning of possible hypoglycemia, and indications of high or low blood glucose levels at specific timepoints during the day in patients with Type 1 or Type 2 diabetes treated with insulin. Future studies may also assist us in understanding the utility of such ‘antihypoglycemic tools’ in patients with diabetes not being treated with insulin.

Financial & competing interests disclosure

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Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

References

Papers of special note have been highlighted as:

- of interest
 - ■ of considerable interest
- 1 The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N. Engl. J. Med.* 329, 977–986 (1993).
 - 2 UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with Type 2 diabetes (UKPDS 33). *Lancet* 352, 837–853 (1998).
 - 3 Coutinho M, Gerstein HC, Wang Y, Yusuf S. The relationship between glucose and incident cardiovascular events. A metaregression analysis of published data from 20 studies of 95,783 individuals followed for 12.4 years. *Diabetes Care* 22, 233–240 (1999).
 - Extensive analysis of published data showing that the relationship between glucose levels and cardiovascular risk extends below the diabetic threshold.
 - 4 Poolsup N, Suksomboon N, Jiamsathit W. Systematic review of the benefits of self-monitoring of blood glucose on glycemic control in Type 2 diabetes patients. *Diabetes Technol. Ther.* 10(Suppl. 1), 51–66 (2008).
 - ■ Evaluation of the evidence of benefit of self-monitoring of blood glucose (SMBG) on glycemic control in non-insulin-treated Type 2 diabetes, showing that SMBG proved to be useful for improving metabolic control (glycosylated hemoglobin reduction) when the results were used to adjust therapeutic regimens.
 - 5 American Diabetes Association. Standards of medical care in diabetes – 2008. *Diabetes Care* 31(Suppl. 1), S12–S54 (2008).
 - 6 Monnier L, Colette C, Lapinski H, Boniface H. Self-monitoring of blood glucose in diabetic patients: from the least common denominator to the greatest common multiple. *Diabetes Metab.* 30, 113–119 (2004).
 - ■ Analysis of the frequency of SMBG in different patients, showing that the frequency and timing of SMBG depends on the type of diabetes, and should be a compromise between optimal and minimal regimens.
 - 7 American Diabetes Association. Standards of medical care in diabetes – 2012. *Diabetes Care* 35(Suppl. 1), S11–S63 (2012).
 - 8 Wild D, von Maltzahn R, Brohan E, Christensen T, Clauson P, Gonder-Frederick L. A critical review of the literature on fear of hypoglycemia in diabetes: implications for diabetes management and patient education. *Patient Educ. Couns.* 68, 10–15 (2007).
 - ■ Critical review of the literature that integrates existing research on the fear of hypoglycemia and discusses its implications for diabetes management and patient education.
 - 9 Gonder-Frederick LA, Schmidt KM, Vajda KA *et al.* Psychometric properties of the Hypoglycemia Fear Survey-II for adults with Type 1 diabetes. *Diabetes Care* 34, 801–806 (2011).
 - 10 Briscoe VJ, Davis SN. Hypoglycemia in Type 1 and Type 2 diabetes: physiology, pathophysiology, and management. *Clin. Diabetes* 24, 115–121 (2006).
 - ■ As hypoglycemia is the major limiting factor in intensive glycemic control for both Type 1 and 2 diabetes, this article reviews the physiology of the normal counter-regulatory responses to hypoglycemia and the deficient counter-regulatory defenses that occur in patients with diabetes, and also discusses treatment paradigms for establishing good glycemic control while limiting hypoglycemia.
 - 11 Cryer PE. Hypoglycemia: still the limiting factor in the glycemic management of diabetes. *Endocr. Pract.* 14, 750–756 (2008).
 - Review of the prevalence of risk factors for and prevention of hypoglycemia, from the perspective of the pathophysiologic aspects of glucose counter-regulation in diabetes, showing that by practicing hypoglycemia risk reduction it is possible both to improve glycemic control and to minimize the risk of hypoglycemia in many patients.
 - Website
 - 101 National Collaborating Centre for Chronic Conditions. Type 2 diabetes. National clinical guideline for management in primary and secondary care (update) (2008). www.nice.org.uk/nicemedia/live/11983/40803/40803.pdf (Accessed 13 December 2011)