



# Impaired Awareness of Hypoglycemia and Severe Hypoglycemia in Drivers With Diabetes: Insights From the Association of British Clinical Diabetologists Nationwide Audit

*Diabetes Care* 2021;44:e190–e191 | <https://doi.org/10.2337/dc21-1181>

Harshal Deshmukh,<sup>1</sup>  
 Emma G. Wilmot,<sup>2,3</sup>  
 Pratik Choudhary,<sup>4</sup> Parth Narendran,<sup>5</sup>  
 Najeeb Shah,<sup>1</sup> Dennis Barnes,<sup>6</sup>  
 Shafie Kamruddin,<sup>7</sup>  
 Rumaisa Banatwalla,<sup>8</sup>  
 Peter Christian,<sup>9</sup> Simon Saunders,<sup>10</sup>  
 Alistair Lumb,<sup>11</sup> Roselle Herring,<sup>12</sup>  
 Jane Patmore,<sup>1</sup> Chris Walton,<sup>1</sup>  
 Robert E.J. Ryder,<sup>13</sup> and  
 Thozhukat Sathyapalan<sup>1</sup>

Hypoglycemia is an acute complication in people living with diabetes, with 83% of those with type 1 diabetes experiencing hypoglycemia at least once a month and even higher rates of 5 events per week recorded on continuous glucose monitoring (1). There are limited population-based data on the prevalence of impaired awareness of hypoglycemia (IAH) and severe hypoglycemia (SH) in drivers with diabetes in the U.K. and worldwide. The availability of these data can inform policy decisions and help optimize treatment options for people living with diabetes (2).

To understand the prevalence of IAH and SH in drivers with diabetes, we obtained data from the nationwide audit of FreeStyle Libre (FSL), conducted by the Association of British Clinical Diabetologists (ABCD). Baseline pre-FSL data included demographics, HbA<sub>1c</sub> values from the previous 12 months, Gold score (3) (to assess hypoglycemia awareness),

and SH. Rates of recurrent SH, defined as two or more episodes of hypoglycemia requiring third-party assistance in the 12 months prior to FSL initiation (4), were documented by clinicians.

The study consisted of 13,127 adults (aged  $\geq 17$  years) with diabetes, and information about driving was available for 4,262 (96% type 1 diabetes) of those (3,210 drivers and 1,052 nondrivers). Of those with a driving license, 3,182 had a group 1 driving license (a license to drive a motor car and a motorcycle), 25 had a group 2 driving license (a license for large goods vehicles [lorries or trucks], passenger-carrying vehicles [buses], and horse boxes), and 3 had a taxi license. Information about the Gold score was available for 2,849 people with either a group 1 or group 2 driving license. Overall, the prevalence of IAH was 21.8% (622/2,849), and the prevalence of complete loss of awareness of hypoglycemia, defined in this cohort as Gold = 7, was 1.4% (41/

2,849). In those with a group 1 license, 22% ( $n = 622/2,823$ ) had IAH (Gold  $\geq 4$ ); 1.4% (41/2,823) had a Gold score of 7, and 5% (147/2,823) had experienced more than 1 episode of SH in the preceding 12 months. None of the participants with a group 2 driving license or taxi license had complete loss of hypoglycemia awareness. One participant reported a single episode of SH; none experienced more than one episode of SH in the preceding year. Of the group 2 drivers, only 73% reported full awareness of hypoglycemia (defined as a Gold score of 1).

Drivers living with diabetes were slightly older (mean  $\pm$  SD 44.4  $\pm$  15.2 vs. 41.3  $\pm$  18.3 years;  $P < 0.00001$ ) and more likely to be male (54% vs. 44%;  $P < 0.0001$ ), with a shorter duration of diabetes (21.7  $\pm$  37.9 vs. 26.8  $\pm$  36 years;  $P < 0.0001$ ), than nondrivers. Drivers had a lower baseline HbA<sub>1c</sub> (70.6  $\pm$  19.4 [8.6%] vs. 75.06  $\pm$  19.14

<sup>1</sup>Hull University Teaching Hospitals NHS Trust and University of Hull, Hull, U.K.

<sup>2</sup>University Hospitals of Derby and Burton NHS Foundation Trust, Derby, U.K.

<sup>3</sup>University of Nottingham, Nottingham, U.K.

<sup>4</sup>Leicester Diabetes Centre, University of Leicester, Leicester General Hospital, Leicester, U.K.

<sup>5</sup>Queen Elizabeth Hospital Birmingham and University of Birmingham, Birmingham, U.K.

<sup>6</sup>Tunbridge Wells Hospital, Tunbridge Wells, U.K.

<sup>7</sup>Darlington Memorial Hospital, Darlington, U.K.

<sup>8</sup>St. Peter's Hospital, Chertsey, U.K.

<sup>9</sup>East Kent Hospitals University NHS Foundation Trust, Canterbury, U.K.

<sup>10</sup>Warrington and Halton Teaching Hospitals NHS Foundation Trust, Warrington, U.K.

<sup>11</sup>Oxford University Hospitals NHS Trust, Oxford, U.K.

<sup>12</sup>Royal Surrey County Hospital, Guildford, U.K.

<sup>13</sup>City Hospital, Birmingham, U.K.

Corresponding author: Thozhukat Sathyapalan, [thozhukat.sathyapalan@hyms.ac.uk](mailto:thozhukat.sathyapalan@hyms.ac.uk)

Received 4 June 2021 and accepted 31 July 2021

H.D. and E.G.W. are joint first authors.

© 2021 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <https://www.diabetesjournals.org/content/license>.

**Table 1—Demographic and clinical characteristics of people with diabetes with and without IAH**

Characteristic	Impaired awareness of hypoglycemia (Gold $\geq 4$ ) ( $n = 622$ )	Normal awareness of hypoglycemia (Gold $< 4$ ) ( $n = 2,227$ )	<i>P</i> value
Age (years)	49.2 $\pm$ 15.5	43.2 $\pm$ 15.0	<0.0001
Female sex, <i>n</i> (%)	287 (46)	991 (44)	0.85
Baseline BMI	26.7 $\pm$ 6.1	26.9 $\pm$ 5.6	0.5
Duration of diabetes (years)	24.9 $\pm$ 15.3	20.9 $\pm$ 44.4	0.0003
Insulin pump use, <i>n</i> (%)	110 (17)	394 (17)	0.45
Mean pre-FSL HbA <sub>1c</sub> , mmol/mol (%)	69.4 $\pm$ 20.1 (8.5)	71.2 $\pm$ 19.7 (8.7)	0.04
Frequent hypoglycemia as indication for FSL initiation, <i>n</i> (%)	231 (37)	391 (17)	<0.0001

Data are mean  $\pm$  SD unless otherwise indicated. *P* values are from *t* test or  $\chi^2$  test. <0.05 is statistically significant.

mmol/mol [9%];  $P < 0.0001$ ) and lower Gold score (2.35  $\pm$  1.5 vs. 3.30  $\pm$  1.96;  $P < 0.0001$ ) than nondrivers. In this population, the number of episodes of SH in the previous 12 months in nondrivers was 19% ( $n = 206$ ), while for group 1 driving license holders it was 8% ( $n = 287$ ) and for group 2 driving license holders it was 3% ( $n = 1$ ).

In the univariate analysis (Table 1), those with IAH were more likely to be older ( $P < 0.0001$ ), have a longer duration of diabetes ( $P = -0.00003$ ) and lower baseline HbA<sub>1c</sub> ( $P = 0.04$ ), and have “frequent hypoglycemia” as an indication for FSL initiation ( $P < 0.0001$ ). The regression analysis shows that higher age ( $\beta = 0.001$ ,  $P = 0.02$ ), longer duration of diabetes ( $\beta = 0.001$ ,  $P = 0.001$ ), and frequent hypoglycemia as indications for FSL initiation ( $\beta = 0.15$ ,  $P < 0.0001$ ) were significantly and independently associated with GOLD score in drivers.

Overall, 41 people who were group 1 drivers with diabetes were reported as having complete loss of hypoglycemia awareness (defined as a Gold score of 7), and 147 had experienced  $\geq 1$  SH episode in the previous 12 months. Of the group 2 drivers, only 73% had full awareness of hypoglycemia (defined as a Gold score of 1), and one participant had a reported SH episode in the preceding 12 months.

These data suggest that the impaired awareness of hypoglycemia is prevalent in drivers with diabetes but lower than the prevalence in nondrivers. Complete

loss of hypoglycemia awareness was rare. In keeping with previous data (5), impaired awareness of hypoglycemia was associated with increasing age, longer duration of diabetes, and frequent episodes of hypoglycemia. Less than one-tenth of drivers had experienced SH in the year prior to FSL initiation. Overall, these data provide useful insights into the prevalence of problematic hypoglycemia in people with diabetes who hold a driving license.

**Acknowledgments.** The authors thank all the clinicians and support staff who participated in the nationwide study, listed at <https://abcd.care/Resource/ABCD-Freestyle-Libre-Audit-Contributors>. **Funding.** The ABCD nationwide FSL audit is supported by a grant from Abbott Laboratories. H.D. is funded by a National Institute for Health Research clinical lectureship.

**Duality of Interest.** E.G.W. has received personal fees from Abbott Diabetes Care, Dexcom, Eli Lilly, Insulet, Medtronic, Novo Nordisk, and Sanofi. P.C. has received personal fees from Abbott Diabetes Care, Dexcom, Eli Lilly, Insulet, Medtronic, Novo Nordisk, and Sanofi. P.C. is also an honorary member of the Medical Advisory Panel on Diabetes to the Secretary of State for Transport. C.W. has a spouse/partner serving on the advisory panel for Celgene and on the speakers bureau for LEO Pharma and Novartis. R.E.J.R. serves on the advisory panel for Novo Nordisk A/S and on the speakers bureau for BioQuest. T.S. is on the speakers bureau for the Novo Nordisk Foundation and reports a relationship with Bristol-Myers Squibb, Eli Lilly and Company, and Sanofi. The FSL audit was independently initiated and performed by ABCD, and the authors remain

independent in the analysis and preparation of this report. No other potential conflicts of interest relevant to this article were reported.

**Author Contributions.** H.D., E.G.W., C.W., R.E.J.R., and T.S. conceived the presented idea. H.D., E.G.W., C.W., R.E.J.R., and T.S. contributed to the data analysis. H.D. wrote the first draft of the manuscript. All of the authors contributed to the writing of the manuscript and made extensive comments, criticisms, and changes to the final draft of the paper. All of the authors saw the final version of the manuscript. H.D. is the guarantor of this work and, as such, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

## References

1. Khunti K, Alsfiri S, Aronson R, et al.; HAT Investigator Group. Rates and predictors of hypoglycaemia in 27585 people from 24 countries with insulin-treated type 1 and type 2 diabetes: the global HAT study. *Diabetes Obes Metab* 2016;18:907–915
2. Stork AD, van Haeften TW, Veneman TF. Diabetes and driving: desired data, research methods and their pitfalls, current knowledge, and future research. *Diabetes Care* 2006;29:1942–1949
3. Gold AE, MacLeod KM, Frier BM. Frequency of severe hypoglycemia in patients with type 1 diabetes with impaired awareness of hypoglycemia. *Diabetes Care* 1994;17:697–703
4. International Hypoglycaemia Study Group. Glucose concentrations of less than 3.0 mmol/L (54 mg/dL) should be reported in clinical trials: a joint position statement of the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 2017;40:155–157
5. UK Hypoglycaemia Study Group. Risk of hypoglycaemia in types 1 and 2 diabetes: effects of treatment modalities and their duration. *Diabetologia* 2007;50:1140–1147