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ASSESSMENT OF KNOWLEDGE AND ATTITUDES OF DIABETIC PATIENTS AND THEIR HEALTHCARE PROVIDERS TOWARD THE IMPACT OF HYPOGLYCEMIA ON SAFE DRIVING: A CROSS-SECTIONAL STUDY

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Abstract

Background: Evidences derived from numerous studies revealed that diabetes mellites (DM) may impair driving fitness in a number of ways, including hypoglycemia, hyperglycemia, visual impairment, and other diabetic symptoms. Investigating the link between hypoglycemia and motor-vehicle collisions (MVCs) is necessary to lower morbidity and mortality in diabetic patients. The aims of the study were to assess the awareness and knowledge about the impact of hypoglycemia on driving among insulin-treated diabetic patients, those treated with insulin secretagogues who are visiting King Fahd Military Hospital in Asir region, Saudi Arabia, and healthcare providers in Asir region.

Methods: An online questionnaire-based cross-sectional observational study that intended to involve at least 385 participants (diabetic patients and healthcare providers) at King Fahd Armed Forces Hospital in Asir region, Saudi Arabia. Two separate questionnaires will be used to assess the level of awareness and knowledge among the participants toward diabetes and driving; the first is specified for diabetic patients, and the second is specified for HCPs.

Results: A total of 416 diabetic patients, and 23 physician in Aseer region were surveyed. 30.8% of patient participants aged 60 years or above. Moreover, Good level of knowledge about hypoglycemia and its effect on safe driving was reported in 56% of the patients and 56.5 of

physicians. Factors associated with better knowledge included younger age ((p = 0.003), being female (p = 0.003), having type 1 diabetes (p = 0.001), shorter diabetes duration (p = 0.014), and using insulin (p = 0.001). Among physicians, endocrinologists/diabetologists had better knowledge compared to other specialties.

Conclusion: The results revealed a gap in awareness and preventive strategies among both patients and healthcare providers. This highlights the need for targeted educational interventions to improve understanding and encourage proactive management of hypoglycemia, especially in driving situations.

Keywords: Driving, Diabetes, Hypoglycemia, Insulin, Insulin secretagogues, Road traffic accidents.

INTRODUCTION

In most nations, driving is a necessary form of transportation for individuals. It is a regular, necessary daily work that calls for visual, motor, and cognitive abilities to be properly completed. Because it has a significant impact on people's health, social, and financial pleasure, safe driving has always been a top priority worldwide and has drawn medical study attention [1]. Road traffic accidents (RTAs) are the ninth most common cause of death worldwide, accounting for 2.2% of all deaths worldwide. An estimated 1.3 million people every year, or 3287 per day, pass away in RTAs. It is one of the main causes of death for adolescents between the ages of 15 and 29. Moreover, 20 to 50 million individuals are incapacitated or injured. Globally, RTAs cost USD$518 billion, with costs ranging from 1% to 2% of each country's annual gross domestic product (GDP) [2].

In KSA, the primary mode of transportation both inside and between cities is the motor car. A recent estimate places the number of cars on Saudi Arabia's highways at above 6 million [3]. 20% of hospital beds are occupied by RTA victims, and RTAs are responsible for 81% of hospital deaths, per records of morbidity and mortality in Ministry of Health (MOH) hospitals [4]. In the past 20 years, RTAs have resulted in 86,000 deaths, 611,000 injuries, and 7% lifelong disability in KSA [5]. The economic repercussions of RTAs, in terms of potential productive years life lost (PPYLL), were examined in a study that revealed a 31.6% rise in deaths due to RTAs among males in 1997-2002 compared to a 1.3% increase in deaths due to RTAs among females [6]. In Saudi Arabia, there are 19 deaths daily, and 4 injuries every hour due to RTAs. The age groups that are economically active and young are most impacted [7]. In industrialized nations, the gross loss from accidents accounts for 1 ± 2% of the country's GDP; in the KSA, this loss is thought to be between 2.2 and 9% [4,8].

The number of accidents may rise as a result of a driver's age and certain medical problems, such as diabetes mellitus (DM), which both decrease driving safety [9]. The majority of people with DM can operate a vehicle safely. Yet, the disease's signs or complications might occasionally make it difficult to drive safely [10]. DM is one of the most prevalent chronic diseases in almost every nation in the globe. DM is anticipated to impact 285 million adults worldwide (6.4%), and by 2030, its prevalence is predicted to rise to 7.7%, affecting 439 million people [11]. DM is one of the most prevalent diseases in Saudi Arabia. The countries of the Arabian Gulf (Saudi Arabia, Kuwait, UAE, Bahrain, Oman, and Qatar) are thought to have some of the highest rates of DM in the world when compared to other regions of the world [12].

The World Health Organization (WHO) reports that Saudi Arabia ranks the 7th highest rate of diabetes worldwide and the 2nd highest rate in the Middle East, with an estimated 7 million people having diabetes and more than 3 million having pre-diabetes. Furthermore, over the past three years in Saudi Arabia, the prevalence of DM has increased by roughly a factor of 10 [13]. In Saudi Arabia, appropriate awareness remains a significant difficulty despite the high prevalence of DM. To reduce the risk of developing complications related to the condition, early detection and increased awareness of people with DM are essential [14].

Evidences derived from numerous studies revealed that DM may impair driving fitness in a number of ways, including hypoglycemia, hyperglycemia, visual impairment, and other diabetic symptoms [9,15]. People with DM frequently experience hypoglycemia, which increases their risk of injury and occasionally even death [16]. Those with insulin-treated DM (ITDM), and those using insulin secretagogues (sulphonylureas [e.g., glibenclamide/glyburide, glipizide and gliclazide] and meglitinide analogues [nateglinide and repaglinide]) [17] are more likely to have hypoglycemia since insulin can increase the risk of hypoglycemia [18]. Motor vehicle collisions (MVCs) may be caused by a number of issues that can arise from hypoglycemia in people with diabetes (DM), such as decreased eyesight, altered consciousness levels, or fainting [19].

Investigating the link between hypoglycemia and MVCs is necessary to lower morbidity and mortality in DM patients. Furthermore, it is crucial to evaluate the proportion of people with ITDM, and those treated with insulin secretagogues who have talked with their healthcare providers (HCPs) about diabetes while driving and how that relates to an elevated risk of MVCs. Additionally, implementing prophylactic recommendations and guidelines requires an evaluation of healthcare providers' awareness and knowledge of the problems related to diabetes and driving. Therefore, the aims of the study were to assess the awareness and knowledge about the impact of hypoglycemia on driving among insulin-treated diabetic patients, and those treated with insulin secretagogues who are visiting King Fahd Military Hospital in Asir region, Saudi Arabia as well as healthcare providers.

METHODOLOGY:

This study adopted a questionnaire-based, cross-sectional observational design to explore knowledge and awareness related to diabetes and driving among diabetic patients and healthcare providers (HCPs). The research was conducted at the Department of Diabetology, King Fahd Armed Forces Hospital, located in the Asir region of the Kingdom of Saudi Arabia, over a six-month period from July to December 2023.

The required sample size was determined using the standard formula for unknown population sizes, assuming a confidence level of 95%, a margin of error of 5%, a Z-score of 1.96, and a standard deviation of 0.5. Based on these parameters, the minimum required sample size was calculated to be 385 participants. A convenience sampling technique was utilized to recruit eligible participants, which included both diabetic patients and practicing physicians with relevant experience.

The inclusion criteria for diabetic patients required participants to be adults aged 18 years or older, holding a valid driving license, currently driving, and using insulin or insulin secretagogues for glycemic control. Patients were excluded if they were under 18 years of age, not driving or lacking a valid driving license, using non-insulin-based medications for diabetes management, or having comorbidities that could impair driving performance. Physicians were eligible if they had direct experience managing patients with diabetes, while those lacking such experience were excluded.

Two structured and previously validated questionnaires [20,21], tailored separately for diabetic patients and physicians, were utilized for data collection. The diabetic patient questionnaire was adapted from a prior study and modified by the research team to fit the current objectives. It was administered through direct interviews using paper-based forms in the Arabic language to ensure participant comprehension. The questionnaire included two sections: the first covered demographic data such as age, gender, diabetes type, disease duration, and therapeutic regimen, while the second comprised eight items assessing knowledge and awareness about diabetes and driving. Similarly, the physician questionnaire was based on a previously validated tool, modified for the current study, and developed in English using Google Forms. It was distributed electronically via the mobile messaging platform WhatsApp, accompanied by an explanatory message outlining the survey's purpose. This questionnaire also consisted of two parts: the first gathered demographic and professional data, including age, gender, nationality, specialty, job title, years of experience, and exposure to diabetes-related cases. It also assessed whether the physician was aware of driving recommendations for diabetic patients or had managed cases involving hypoglycemia-induced driving accidents. The second section used multiple-choice questions to evaluate the physicians' knowledge regarding diabetes and its implications for safe driving.

To ensure the validity and reliability of the adapted questionnaires, a pilot study was conducted with a small group of 10 participants. The internal consistency of the tool was evaluated using the Kuder–Richardson Formula 20 (KR-20) for dichotomous data, yielding a Cronbach's alpha of 0.71. The analysis indicated that none of the items, if removed, would enhance reliability, suggesting that all items were essential and retained.

Content validity was established through expert review. Three field specialists independently assessed the questionnaire items for relevance and clarity in relation to the study's objectives. Differences in interpretation were discussed until consensus was reached, and necessary modifications were applied to finalize the instruments. Construct validity was assessed through convergent and discriminant analyses. Factor analysis with Orthomax rotation revealed item loadings between 0.39 and 0.79, exceeding the minimum acceptable threshold of 0.3, indicating adequate convergent validity. Discriminant validity was supported by a statistically significant difference in knowledge scores between participants in the first and third quartiles ($Q1 = 3.1$, $Q3 = 8.6$, $p = 0.024$).

All data analyses were carried out using the Statistical Package for the Social Sciences (SPSS) software, version 26. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were applied to summarize the data. For the patient data, categorical variables were compared using chi-square tests. For the physician data, knowledge was assessed through 12 questions, with each correct answer receiving one point. The overall knowledge score was calculated as a percentage, with scores ranging from 0 to 100. Inferential analyses included independent t-tests and one-way ANOVA to compare mean knowledge scores across categorical variables, while Pearson correlation coefficients were used to assess associations between knowledge scores and continuous variables. A p-value less than 0.05 was considered statistically significant.

The study protocol received ethical approval from the Institutional Review Board of King Fahd Armed Forces Hospital. Informed consent was implied through voluntary completion of the questionnaire, and a brief explanation was provided at the beginning of each questionnaire to clarify the study's purpose and ensure voluntary participation.

RESULTS:

Bio-Demographic Data

As shown in table 1, a total of 416 diabetic patients and 23 physicians were surveyed in Aseer region of Saudi Arabia. The mean age of the patients and physicians was 49.4 (17.8) years and 42.1 (9.3) years respectively, the majority of the two groups were male (71.2%, 56.5%), and the majority of the patients had Type II diabetes (68.5%). Moreover, 32.2% had diabetes for less than 5 years with mean duration of diabetes of 11.4 years (SD = 8.3). When considering antidiabetic medications, 37.7% of patients were on insulin, 38.0% were taking oral hypoglycemic drugs (OHGDs), and 24.3% were on both. Among those taking OHGDs, the most commonly used

medications were Glucophage (47.9%), Dimicron (35.1%), and Regulator (34.0%). In addition, most of the physicians specialized in endocrinology or diabetology (82.6%) and 47.8 % were registrars with 60.9 % had more than 10 years of experience.

Table 1. Bio-demographic data of study diabetic cases and physicians, Aseer region, Saudi Arabia.

Diabetic patients (N=416)			**Healthcare providers (N=23)**		
Bio-demographic data	**No**	**%**	**Bio-demographic data**	**No**	**%**
Age in years			**Age in years**		
< 30	83	20.0%	< 40 years	12	52.2%
30-39	46	11.1%	> 40 years	11	47.8%
40-49	62	14.9%	Mean ± SD	42.1 ± 9.3	
50-59	97	23.3%	**Gender**		
60+	128	30.8%	Male	13	56.5%
Mean ± SD	49.4 ± 17.8		Female	10	43.5%
Gender			**Nationality**		
Male	296	71.2%	Non-Saudi	10	43.5%
Female	120	28.8%	Saudi	13	56.5%
Type of DM			**Specialty**		
Type I DM	131	31.5%	Endocrinologist/Diabetologist	19	82.6%
Type II DM	285	68.5%	Internist	2	8.7%
Diabetes duration in years			Diabetes Educator	1	4.3%
< 5 years	134	32.2%	Family Physician	1	4.3%
5-10 years	76	18.3%	**Job title**		
11-20 years	118	28.4%	Consultant	10	43.5%
> 20 years	88	21.2%	Registrar	11	47.8%
Mean ± SD	11.4 ± 8.3		Diabetes Educator	1	4.3%
Antidiabetic drugs			Resident	1	4.3%
Insulin	157	37.7%	**How many years have you been in practice since completing your medical college?**		
OHGDs	158	38.0%	< 10 years	9	39.1%
Both of them	101	24.3%	> 10 years	14	60.9%
Types of OHGDs			**Approximately, how many diabetic patients in outpatient setting do you see in a week?**		
Glucophage	124	47.9%	< 40 patients	10	43.5%
Dimicron	91	35.1%	40-80 patients	7	30.4%
Regulator	88	34.0%	> 80 patients	6	26.1%
Metformin	61	23.6%	**Approximately, what is the proportion of patients with diabetes among all patients seen?**		
Gliclazide	19	7.3%	< 30%	3	13.0%
Novorapid	19	7.3%	30-50%	6	26.1%
NoVo Mix	18	6.9%	> 50%	14	60.9%
Dapagliflozin	13	5.0%			
Linagliptin	5	1.9%			
Gliclazide	5	1.9%			
Empagliflozin	1	.4%			

As shown in table 2, 55.3% of the patients reported having discussed diabetes and its impact on driving with their doctor. A significant majority (85.3%) had received education about the symptoms of hypoglycemia from their diabetes specialist. Regarding the impact of hypoglycemia on driving, 60.8% of the patients were educated about it and 88.0% received education about preventive measures for hypoglycemia, and 79.3% believed that having diabetes posed a danger while driving. Furthermore, 74.3% acknowledged that there is a blood glucose level below which it is unsafe to drive.

Considering physicians, most of them (95.7%) were aware of the recommendations for insulin-treated patients regarding safe driving, and an equal proportion (22, 95.7%) agreed that insulin-treated patients should be evaluated for their ability to drive. Additionally, 20 physicians (87.0%) believed insulin-treated patients should check their blood glucose before driving. When asked about the safe blood glucose level for driving, 13 (56.5%) reported it should be over 5 mmol/L (>90 mg/dL). Regarding the timing of blood glucose checks before driving, 11 (47.8%) advised checking just before driving, while 5 (21.7%) suggested checking 30 minutes before.

When treating mild to moderate hypoglycemia, 12 physicians (52.2%) believed patients should wait 30–45 minutes before resuming driving. For long trips, 10 physicians (43.5%) recommended checking blood glucose every two hours. Additionally, 19 physicians (82.6%) agreed that Type 1 diabetes is associated with a higher incidence of driving mishaps compared to Type 2 diabetes.

Table 2. Patients' and physicians' knowledge and awareness about hypoglycemia and its effect on safe driving (n=416)

Knowledge and awareness of patients			**Knowledge and awareness of physicians**		
Knowledge and awareness	**No**	**%**	**Knowledge and awareness**	**No**	**%**
Previously discussed with you doctor about diabetes disease and its effect on driving?			**Are you aware to the recommendations for insulin-treated patients with diabetes and safe driving?**		
Yes	230	55.3%	Yes	22	95.7%
No	186	44.7%	No	1	4.3%
Have you been educated by your diabetes specialist about the symptoms of hypoglycemia?			**Insulin-treated patients with diabetes require evaluation for their ability to drive?**		
Yes	355	85.3%	Yes	22	95.7%
No	61	14.7%	No	0	0.0%
Have you been educated by a diabetes specialist about the effect of hypoglycemia on driving?			Don't know	1	4.3%
Yes	253	60.8%	**Insulin-treated patients with diabetes need to check their blood glucose before driving.**		
No	163	39.2%	Yes	20	87.0%
Have you been educated by a diabetes specialist about the preventive measures for hypoglycemia?			No	1	4.3%
Yes	366	88.0%	Don't know	2	8.7%
No	50	12.0%	**The level of blood glucose which is safe for the patient to drive is:**		
Do you think there is any danger in driving because you have diabetes?			> 4 mmol/L (> 72 mg/dL)	2	8.7%
Yes	330	79.3%	> 5 mmol/L (> 90 mg/dL)	13	56.5%
No	86	20.7%	> 6 mmol/L (> 108 mg/dL)	6	26.1%
Is there a blood glucose level that is not safe to drive?			> 7 mmol/L (> 126 mg/dL)	2	8.7%
Yes	309	74.3%	**The recommended time for checking blood glucose before driving is:**		
No	107	25.7%	Just before driving	11	47.8%
If, yes, what is that level? (n=309)			30 minutes before	5	21.7%
< 60 mg/ dl	47	15.3%	60 minutes before	2	8.7%
< 90 mg /dl	212	69.1%	Don't know	5	21.7%
< 110 mg / dl	46	15.0%	**Persons with diabetes should not drive after effective treatment of mild to moderate hypoglycemia until at least ..... minutes.**		
< 130 mg / dl	2	.7%	15 to 20 min	8	34.8%
			30 to 45 min	12	52.2%
			Don't know	3	13.0%
			During long-time trip, the recommended time for rechecking blood glucose is:		
			Every hour	2	8.7%
			Every 2 hours	10	43.5%

	Every 3 hours	3	13.0%
	Every 4 hours	4	17.4%
	Don't know	4	17.4%
	Which type of diabetes associated with higher incidence of driving mishaps?		
	Type I DM	19	82.6%
	Type II DM	2	8.7%
	Don't know	2	8.7%

Figure 1 illustrates the overall knowledge and awareness of hypoglycemia and its effect on safe driving among diabetic patients. The results showed varied levels of awareness and knowledge, where 233 (56%) of the patients demonstrated good level of knowledge while 56.4% of the physicians demonstrated good level of knowledge

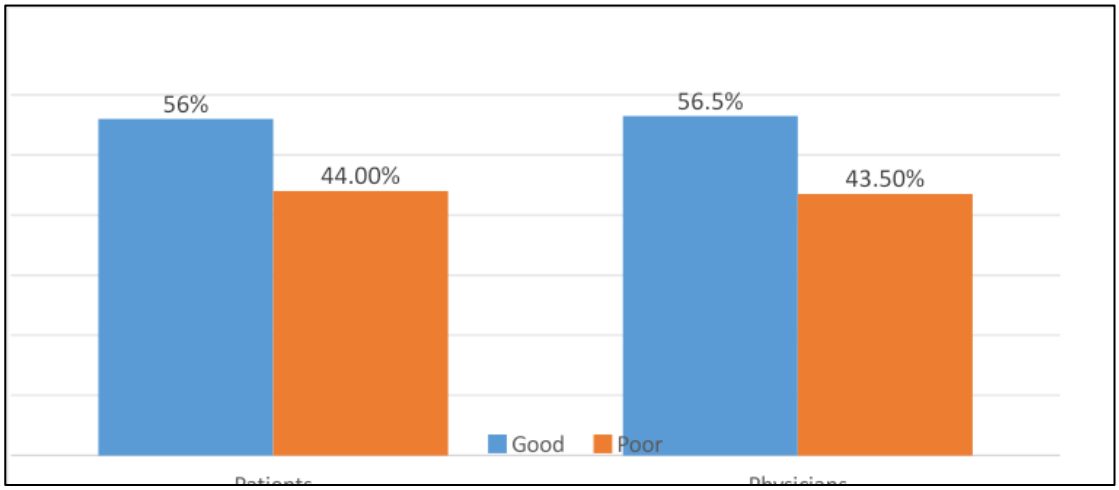

Figure 1. The patients' and physicians overall knowledge and awareness about hypoglycemia and its effect on safe driving (n=416).

Practice regarding Hypoglycemia and Its Consequences

When it comes to their practices regarding hypoglycemia, as shown in table 3, only 28.8% of the patients always measured their blood sugar before driving. About 31.7% rarely checked their blood sugar before driving. Additionally, 62.3% reported keeping a source of sugar in their car in case of hypoglycemia. Regarding their experiences, 39.2% of the patients had experienced symptoms of low blood sugar while driving in the past two years. Of these, 21.9% reported having had a car accident or a traffic violation due to low blood sugar.

Table 3. Diabetic patients' practice regarding hypoglycemia and its consequences (n=416).

Practice and consequences	**No**	**%**
How many times do you measure your blood sugar before driving?		
Never	59	14.2%
Rarely	132	31.7%
Often	105	25.2%
Always	120	28.8%
Do you have a source of sugar in your car?		
Yes	259	62.3%
No	157	37.7%

Have you experienced symptoms of low blood sugar while driving in the past two years?		
Yes	163	39.2%
No	253	60.8%
Have you a car accident or any traffic violation due to low blood sugar in the past two years?		
Yes	91	21.9%
No	325	78.1%

Factors Associated with Overall Knowledge about Hypoglycemia and Safe Driving

As shown in table 4, several factors were significantly associated with the patients' overall knowledge about hypoglycemia and its effect on safe driving. Age was one of these factors in the current study where younger patients (<30 years) had a significantly higher proportion of good knowledge (72.3%) compared to older patients (p = 0.003). Regarding to gender, female patients were more likely to have good knowledge (75.8%) compared to males (48.0%) (p = 0.001).

The type of diabetes, another significant factor where patients with Type I diabetes demonstrated higher proportion of good knowledge (67.9%) compared to those with Type II diabetes (50.5%) (p = 0.001). Similarly, the duration of diabetes impacted the level of knowledge. Patients with a shorter duration of diabetes (<5 years) were more likely to have good knowledge (59.7%) than those with longer disease durations (p = 0.014). Finally, the differences in type of a antidiabetic drugs were associated with differences in the level of knowledge where patients using insulin demonstrated better knowledge (68.8%) than those using oral hypoglycemic drugs (50.6%) or both insulin and oral drugs (44.6%) (p = 0.001).

Table 4. Factors associated with patients' overall knowledge about hypoglycemia and its effect on safe driving.

Factors	**Overall knowledge level**				**p-value**
	Poor		**Good**		
	No	**%**	**No**	**%**	
Age in years					
< 30	23	27.7%	60	72.3%	.003*^
30-39	20	43.5%	26	56.5%	
40-49	24	38.7%	38	61.3%	
50-59	46	47.4%	51	52.6%	
60+	70	54.7%	58	45.3%	
Gender					
Male	154	52.0%	142	48.0%	.001*
Female	29	24.2%	91	75.8%	
Type of DM					
Type I DM	42	32.1%	89	67.9%	.001*
Type II DM	141	49.5%	144	50.5%	
Diabetes duration in years					
< 5 years	54	40.3%	80	59.7%	.014*
5-10 years	37	48.7%	39	51.3%	
11-20 years	42	35.6%	76	64.4%	

> 20 years	50	56.8%	38	43.2%	
Antidiabetic drugs					
Insulin	49	31.2%	108	68.8%	.001*
OHGDs	78	49.4%	80	50.6%	
Both of them	56	55.4%	45	44.6%	

P: Pearson X^2 test ^: Exact probability test
* P < 0.05 (significant)

Relationship between Knowledge about Hypoglycemia and Practice
As shown in table 5, the knowledge level of the patients significantly influenced their practices. Patients with good knowledge were more likely to always measure their blood sugar before driving (42.1%) compared to those with poor knowledge (12.0%) (p = 0.001). Similarly, patients with good knowledge were significantly more likely to have a source of sugar in their car (77.7%) compared to those with poor knowledge (42.6%) (p = 0.001). In addition, patients with good knowledge were more likely to have experienced symptoms of low blood sugar while driving in the past two years (47.6%) compared to those with poor knowledge (28.4%) (p = 0.001).On the other hand, there was no significant association between knowledge level and experiencing a car accident or traffic violation due to low blood sugar (p = 0.478).

Table 5. Relation between diabetic patients' knowledge about hypoglycemia and their practice.

	Overall knowledge level				**p-value**
	Poor		**Good**		
	No	**%**	**No**	**%**	
How many times do you measure your blood sugar before driving?					
Never	32	17.5%	27	11.6%	
Rarely	86	47.0%	46	19.7%	.001*
Often	43	23.5%	62	26.6%	
Always	22	12.0%	98	42.1%	
Do you have a source of sugar in your car?					
Yes	78	42.6%	181	77.7%	.001*
No	105	57.4%	52	22.3%	
Have you experienced symptoms of low blood sugar while driving in the past two years?					
Yes	52	28.4%	111	47.6%	.001*
No	131	71.6%	122	52.4%	
Have you a car accident or any traffic violation due to low blood sugar in the past two years?					
Yes	43	23.5%	48	20.6%	.478
No	140	76.5%	185	79.4%	

P: Pearson X^2 test
* P < 0.05 (significant)

Attitude and Perception of physicians toward Hypoglycemia and Safe Driving

In terms of attitude, 22 physicians (95.7%) believed drivers should stop driving immediately and treat themselves if hypoglycemia or impaired driving is suspected, and an equal percentage disagreed with the notion that insulin-treated patients should not drive. Furthermore, 20 physicians (87.0%) agreed that insulin-treated patients should carry fast-acting carbohydrates while driving, while all 23 physicians (100%) believed that insulin-treated patients should carry a glucose meter while driving. A majority (22, 95.7%) also believed insulin-treated patients should carry identification indicating that they have diabetes.

Practice towards Diabetic Patients for Safe Driving among Diabetic Patients

As illustrated in figure 2, the results indicate the extent of educational interventions provided by healthcare professionals to diabetic patients regarding the risks of hypoglycemia and safe driving practices. Specifically, all healthcare professionals (100%) reported providing education to diabetic patients about the symptoms of hypoglycemia. A slightly lower percentage, 87%, indicated that they educated patients about the impact of hypoglycemia on driving. Furthermore, 78.3% of respondents stated that they discussed the recommendations for safe driving with their diabetic patients. Lastly, 47.8% of the professionals reported having encountered at least one diabetic patient who had experienced driving mishaps due to diabetes.

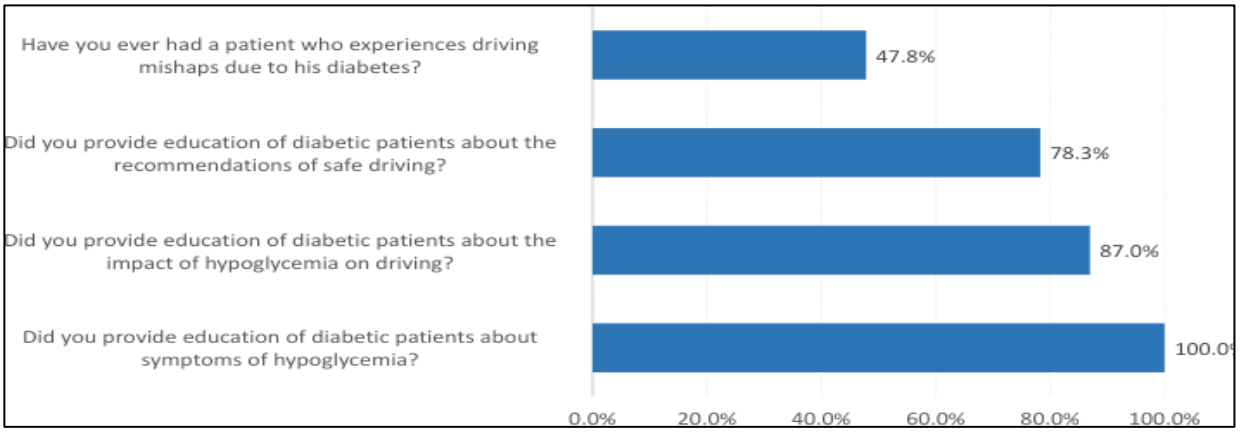

Figure 2. Physicians practice towards diabetic patients for safe driving among diabetic patients, Aseer region, Saudi Arabia.

Factors Associated with Knowledge about Hypoglycemia and Safe Driving

Several factors were analyzed for their association with physicians' knowledge about hypoglycemia and safe driving. As shown in table 6, specialty was significantly associated with knowledge levels (p = 0.048); endocrinologists/diabetologists had better knowledge compared to other specialties. However, no significant associations were observed for age (p = 0.528), gender (p = 0.529), nationality (p = 0.612), job title (p = 0.364), or years of practice (p = 0.237). Additionally, the number of diabetic patients seen per week (p = 0.182) and the proportion of diabetic patients seen among all patients (p = 0.265) were not significantly associated with knowledge, though those seeing a higher proportion of diabetic patients tended to have better knowledge.

Table 6. Factors associated with study physician's knowledge about hypoglycemia and its effect on safe driving among diabetic patients.

Factors	Overall knowledge level				p-value
	Poor		Good		
	No	%	No	%	
Age in years					
< 40 years	6	50.0%	6	50.0%	.510
> 40 years	4	36.4%	7	63.6%	
Gender					
Male	6	46.2%	7	53.8%	.768
Female	4	40.0%	6	60.0%	
Nationality					
Non-Saudi	3	30.0%	7	70.0%	.253
Saudi	7	53.8%	6	46.2%	
Specialty					
Diabetes Educator	1	100.0%	0	0.0%	.048*

Endocrinologist/Diabetologist	7	36.8%	12	63.2%	
Family Physician	0	0.0%	1	100.0%	
Internist	2	100.0%	0	0.0%	
Job title					
Consultant	4	40.0%	6	60.0%	
Diabetes Educator	1	100.0%	0	0.0%	.545
Registrar	5	45.5%	6	54.5%	
Resident	0	0.0%	1	100.0%	
How many years have you been in practice since completing your medical college?					
< 10 years	5	55.6%	4	44.4%	.349
> 10 years	5	35.7%	9	64.3%	
Approximately, how many diabetic patients in outpatient setting do you see in a week?					
< 40 patients	5	50.0%	5	50.0%	.808
40-80 patients	3	42.9%	4	57.1%	
> 80 patients	2	33.3%	4	66.7%	
Approximately, what is the proportion of patients with diabetes among all patients seen?					
< 30%	0	0.0%	3	100.0%	.163
30-50%	4	66.7%	2	33.3%	
> 50%	6	42.9%	8	57.1%	
Have you ever had a patient who experiences driving mishaps due to his diabetes?					
Yes	5	45.5%	6	54.5%	.855
No	5	41.7%	7	58.3%	

P: Pearson X^2 test
* P < 0.05 (significant)

Relation between Knowledge and Practice

As shown in table 7, physicians' knowledge of hypoglycemia and safe driving was not significantly associated with their practice of educating diabetic patients about hypoglycemia symptoms (p = 0.186), the impact of hypoglycemia on driving (p = 0.211), or recommendations for safe driving (p = 0.196). Although all physicians (23, 100%) reported that they provided education about hypoglycemia symptoms, no significant difference in knowledge was found between those who provided education on the impact of hypoglycemia on driving and those who did not (p = 0.328). Similarly, attitudes towards stopping to treat hypoglycemia (p = 0.293) and the need for carrying fast-acting carbohydrates (p = 0.184), glucose meters (p = 0.223), and identification (p = 0.229) were not significantly associated with knowledge levels.

Table 7. Relation between physician knowledge about hypoglycemia and safe driving with their knowledge and attitude.

Practice & attitude	**Overall knowledge level**				**p-value**
	Poor		**Good**		
	No	**%**	**No**	**%**	
Did you provide education of diabetic patients about symptoms of hypoglycemia?					-
Yes	10	100.0%	13	100.0%	
No	0	0.0%	0	0.0%	
Did you provide education of diabetic patients about the impact of hypoglycemia on driving?					0.385
Yes	8	80.0%	12	92.3%	
No	2	20.0%	1	7.7%	
Did you provide education of diabetic patients about the recommendations of safe driving?					0.400
Yes	7	70.0%	11	84.6%	
No	3	30.0%	2	15.4%	
Drivers should stop and treat themselves as soon as hypoglycemia and/or impaired driving is suspected?					0.244

Agree	9	90.0%	13	100.0%	
Disagree	0	0.0%	0	0.0%	
Not sure	1	10.0%	0	0.0%	
Do you think that insulin-treated patients with diabetes shouldn't drive?					0.244
Agree	0	0.0%	0	0.0%	
Disagree	9	90.0%	13	100.0%	
Not sure	1	10.0%	0	0.0%	
Insulin-treated patients who have diabetes need to carry fast acting carbs during driving?					0.488
Agree	8	80.0%	12	92.3%	
Disagree	1	10.0%	1	7.7%	
Not sure	1	10.0%	0	0.0%	
Insulin-treated patients who have diabetes need to carry their glucose meters during driving?					-
Agree	10	100.0%	13	100.0%	
Disagree	0	0.0%	0	0.0%	
Not sure	0	0.0%	0	0.0%	
Insulin-treated patients who have diabetes need to carry ID that says they have diabetes.					.244
Agree	9	90.0%	13	100.0%	
Disagree	0	0.0%	0	0.0%	
Not sure	1	10.0%	0	0.0%	

P: Pearson X^2 test

DISCUSSION

The findings of this cross-sectional study, which aimed to assess the knowledge and attitudes of diabetic patients and their healthcare providers toward the impact of hypoglycemia on safe driving, provide valuable insights into this critical issue. Hypoglycemia, a frequent complication in diabetes management [22], poses a significant risk to road safety by impairing judgment, reaction time, and even causing loss of consciousness while driving [23]. Despite the known dangers, the results reveal a gap in awareness and preventive strategies among both patients and healthcare providers. This highlights the need for targeted educational interventions to improve understanding and encourage proactive management of hypoglycemia, especially in driving situations. Addressing these gaps is essential to reduce hypoglycemia-related accidents and enhance patient safety.

Ma et al. (2020), conducted a retrospective study that modeled the effects of Ontario's medical fitness-to-drive policy on traffic safety. The authors estimated the losses to road safety spent while medically at-risk drivers were subject to review, as well as the savings to road safety that resulted from licensing decisions made following the review process, using data from 2005 to 2014. The results revealed that drivers with medical conditions had the same age- and sex-standardized collision rate as the general driving population during the study period, indicating no reductions in traffic safety [21].

In the present study, nearly half of the patients had not discussed diabetes and driving with their doctors. This finding is consistent with a previous study in Saudi Arabia that reported the majority of the participants never discussed driving and diabetes with their HCPs [24]. Healthcare providers should be encouraged to routinely incorporate discussions about the impact of diabetes on driving during patient consultations to raise awareness and ensure safety. The results also indicated that a slight majority (56%) of the patients demonstrated a good level of knowledge about hypoglycemia and its impact on safe driving, while a significant minority (44%) exhibited poor knowledge on this topic. This division highlights a concerning gap in awareness among diabetic patients regarding the dangers of hypoglycemia, especially in relation to driving safety. While it is encouraging that over half of the patients are well-informed, the 44% with poor knowledge presents a potential risk, as insufficient understanding of hypoglycemia could lead to unsafe driving behaviors, increasing the risk of accidents.

This gap in awareness about the impact of hypoglycemia could be attributed in part due to lack of relevant advice from healthcare providers. It is reported that patients with diabetes often receive little to no advice on how to ensure safety on the road [20]. In this regard, approximately one-third of the participants in the study by Batais et al., were unaware of the recommendations for drivers with insulin-treated diabetes and safe driving [25]. A previous study in Saudi Arabia revealed that more than half of the primary care physicians in Saudi Arabia did not consider diabetes to be a fitness-to-drive risk [26].

The fact that 43.5% of physicians in our study have poor knowledge highlights the need for continuous education and professional development on hypoglycemia management and its impact on driving. This finding is consistent with that of a previous study in Saudi Arabia that found only a minority of HCPs provided correct answers for all questions about the driving safety. Among the participants, the fewest correct answers were observed among

general practitioners and diabetes educators. Only 12.6% of the HCPs claimed to always advise patients about driving safety precautions [27]. Therefore structured refresher courses and updates in clinical guidelines could help bridge this gap. Ensuring that physicians are well-versed in the latest clinical guidelines related to diabetes management and safe driving is critical.

In contrast, Batais et al. (2018) carried out a cross-sectional study among 285 HCPs at four tertiary hospitals in Riyadh, Saudi Arabia to assess their awareness and knowledge about diabetes and driving recommendations. The majority of participants were aware of the recommendations for patients with ITDM to drive safely. Nonetheless, roughly one-third of the participants believed it was unnecessary to check the levels of blood glucose before driving. Less than one-third of the participants correctly recognized the ideal time to check blood sugar levels before driving, and only a quarter correctly identified the ideal blood glucose level that is safe for a patient when driving [20]. While education on hypoglycemia symptoms is universally provided, there is a need to increase the focus on driving safety. Given that 13% of healthcare professionals in our study are not discussing the impact of hypoglycemia on driving, healthcare providers should be encouraged to routinely address this issue as part of diabetes education.

With 47.8% of healthcare professionals encountering diabetic patients who had experienced driving mishaps, there is clear evidence that more education is needed to prevent these incidents. Providers should emphasize the real-life dangers of hypoglycemia while driving, using these experiences as case studies to improve patient awareness. Previous studies have demonstrated a clear association between diabetes and an elevated risk of MVCs. For instance, a meta-analysis indicated that drivers with diabetes have a 12% higher likelihood of experiencing MVCs compared to drivers without diabetes [28]. However, evidence regarding the relationship between the type of diabetes and the increased risk of MVCs remains inconsistent.

The decline in knowledge with increasing age among the patients in our study highlights the need for tailored education programs targeting older patients. Age-appropriate strategies, such as simplified messaging and regular reinforcement, may be beneficial in addressing this gap. Additionally, since patients with Type I diabetes demonstrated better knowledge, it is crucial to enhance education for Type II diabetic patients, who may be less aware of hypoglycemia risks.

The study has limitations that may affect its generalizability and the depth of its findings. The use of convenience sampling could introduce selection bias, as participants may not be fully representative of the larger diabetic population. Additionally, the reliance on self-reported data from both patients and healthcare providers also introduces the possibility of recall bias or social desirability bias, where respondents may not fully disclose behaviors or attitudes. Moreover, by excluding diabetic patients not using insulin or insulin secretagogues, the study omitted a significant segment of the diabetic population, thereby limiting the scope of its findings on hypoglycemia and driving risks.

CONCLUSIONS

The inconsistent responses regarding unsafe blood glucose levels suggest a need for clearer education on this topic. Providers should emphasize the importance of maintaining safe glucose levels while driving, potentially standardizing recommendations to avoid confusion. The fact that 44% of patients have poor knowledge about hypoglycemia and its effects on driving underscores the need for targeted educational interventions. These programs should focus on the specific risks of hypoglycemia while driving, emphasizing symptom recognition and preventive measures.

REFERENCES:

1. Lee JD. Fifty years of driving safety research. Human factors. 2008 Jun;50(3):521-8.
2. Salari M, Kazemnejad A, Zayeri F. Using growth mixture modeling for clustering Asian and north African countries on the road injury death trend (1990–2010). Oman Medical Journal. 2017 Sep;32(5):417.
3. Algadhi SA, Mufti RK, Malick DF. Estimating the total number of vehicles active on the road in Saudi Arabia. Engineering Sciences. 2002;14(1).
4. Ansari S, Akhdar F, Mandoorah M, Moutaery K. Causes and effects of road traffic accidents in Saudi Arabia. Public health. 2000 Jan 1;114(1):37-9.
5. Gazette S. Traffic accidents: their heavy costs. Editorial.[Updated 2013 Sept 2]. Riyadh (KSA): Saudi Gazette; 2013.
6. Elshinnawey MA, Fiala LE, Abbas MA, Othman N. Road traffic injuries in Saudi Arabia, and its impact on the working population. J Egypt Public Health Assoc. 2008 Jan 1;83(1-2):1-4.
7. Al Turki YA. How can Saudi Arabia use the Decade of Action for Road Safety to catalyse road traffic injury prevention policy and interventions?. International journal of injury control and safety promotion. 2014 Oct 2;21(4):397-402.
8. Saudi Arabia Monetary Agency. The 32nd Annual Report 1417H. Riyadh (KSA): The Economical and Statistical Research Office; 1997.
9. Graveling AJ, Frier BM. Driving and diabetes: problems, licensing restrictions and recommendations for safe driving. Clinical diabetes and endocrinology. 2015 Dec;1:1-8.

10. American Diabetes Association. Diabetes and driving. Diabetes Care. 2014 Jan 1;37(Supplement_1):S97-103.
11. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes research and clinical practice. 2010 Jan 1;87(1):4-14.
12. Majeed A, El-Sayed AA, Khoja T, Alshamsan R, Millett C, Rawaf S. Diabetes in the Middle-East and North Africa: an update. Diabetes research and clinical practice. 2014 Feb 1;103(2):218-22.
13. Al Dawish MA, Robert AA, Braham R, Al Hayek AA, Al Saeed AA, Ahmed RA, Al Sabaan FS. Diabetes mellitus in Saudi Arabia: a review of the recent literature. Current diabetes reviews. 2016 Dec 1;12(4):359-68.
14. Muggeo M. Accelerated complications in type 2 diabetes mellitus: the need for greater awareness and earlier detection. Diabetic medicine. 1998 Dec;15(S4 4):S60-2.
15. Cox DJ, Singh H, Lorber D, Hermayer K. Diabetes and driving safety: science, ethics, legality and practice. The American journal of the medical sciences. 2013 Apr 1;345(4):263-5.
16. UK Hypoglycaemia Study Group S. heller@ sheffield. ac. uk. Risk of hypoglycaemia in types 1 and 2 diabetes: effects of treatment modalities and their duration. Diabetologia. 2007 Jun;50:1140-7.
17. Hemmingsen B, Sonne DP, Metzendorf MI, Richter B. Insulin secretagogues for prevention or delay of type 2 diabetes mellitus and its associated complications in persons at increased risk for the development of type 2 diabetes mellitus. Cochrane Database of Systematic Reviews. 2016(10).
18. Leese GP, Wang J, Broomhall J, Kelly P, Marsden A, Morrison W, Frier BM, Morris AD, DARTS/MEMO Collaboration. Frequency of severe hypoglycemia requiring emergency treatment in type 1 and type 2 diabetes: a population-based study of health service resource use. Diabetes care. 2003 Apr 1;26(4):1176-80.
19. Graveling AJ, Warren RE, Frier BM. Hypoglycaemia and driving in people with insulin-treated diabetes: adherence to recommendations for avoidance. Diabetic medicine. 2004 Sep;21(9):1014-9.
20. Batais MA, Alamri AK, Alghammass MA, Alzamil OA, Almutairi BA, Al-Maflehi N, Almigbal TH. Diabetes and driving recommendations among healthcare providers in Saudi Arabia: A significant gap that requires action. Saudi Medical Journal. 2018 Apr;39(4):386.
21. Ma T, Chee JN, Hanna J, Al Jenabi N, Ilari F, Redelmeier DA, Elzohairy Y. Impact of medical fitness to drive policies in preventing property damage, injury, and death from motor vehicle collisions in Ontario, Canada. Journal of safety research. 2020 Dec 1;75:251-61.
22. Nakhleh A, Shehadeh N. Hypoglycemia in diabetes: An update on pathophysiology, treatment, and prevention. World J Diabetes. 2021 Dec 15;12(12):2036-2049.
23. Ahmed AA. Hypoglycemia and safe driving. Ann Saudi Med. 2010 Nov-Dec;30(6):464-7.
24. Almigbal TH, Alfaifi AA, Aleid MA, Billah B, Alramadan MJ, Sheshah E, AlMogbel TA, Aldekhayel GA, Batais MA. Safe driving practices and factors associated with motor-vehicle collisions among people with insulin-treated diabetes mellitus: Results from the Diabetes and Driving (DAD) study. Journal of safety research. 2018 Jun 1;65:83-8.
25. Inkster B, Frier BM. The effects of acute hypoglycaemia on cognitive function in type 1 diabetes. Br J Diabetes Vasc Dis. 2012;12:221–226.
26. Alkharboush GA, Al Rashed FA, Saleem AH, Alnajashi IS, Almeneessier AS, Olaish AH, et al. Assessment of patients' medical fitness to drive by primary care physicians: A cross-sectional study. Traffic Injury Prevention. 2017;18:488–492.
27. Samargandy S, ALJadani A. Diabetes and driving safety: A survey among health care professionals in Saudi Arabia. Primary care diabetes. 2021 Oct 1;15(5):837-41.
28. ECRI Institute (2011). ECRI 2010 update: Diabetes and commercial motor vehicle safety (federal motor carrier safety administration). Plymouth, PA: Author.

Appendix:

Physician/Educator-Specified Questionnaire (English Form)

☐ I would like to participate in the study by filling the questionnaire.
☐ I would not like to participate in the study.

Physician/Educator Demographics

1. Age (years)
..... years

2. Gender
☐ Male ☐ Female

3. Nationality
☐ Saudi ☐ Non-Saudi

4. Specialty
☐ Family physicians ☐ Endocrinologist/diabetologist
☐ Internist ☐ Diabetes Educator

5. Job title
☐ Consultant ☐ Resident
☐ Registrar ☐ Diabetes Educator

6. How many years have you been in practice since completing your medical college?

..... years

7. Approximately, how many diabetic patients in outpatient setting do you see in a week?
..... patients.

8. Approximately, what is the proportion of patients with diabetes among all patients seen?
- ☐ < 10%
- ☐ 10–30%
- ☐ > 30–50%
- ☐ > 50%

9. Are you aware to the recommendations for insulin-treated patients with diabetes and safe driving?
- ☐ Yes
- ☐ No

10. Have you ever had a patient who experiences driving mishaps due to his diabetes?
- ☐ Yes
- ☐ No

11. Did you provide education of diabetic patients about symptoms of hypoglycemia?
- ☐ Yes
- ☐ No

12. Did you provide education of diabetic patients about the impact of hypoglycemia on driving?
- ☐ Yes
- ☐ No

13. Did you provide education of diabetic patients about the recommendations of safe driving?
- ☐ Yes
- ☐ No

Knowledge about the Recommendations of Diabetes and Safe Driving

The following questions and statements are specific to diabetes and safe driving. Please respond to the best of your knowledge, and if you are unsure on any question, select "don't know".

1. Insulin-treated patients with diabetes require evaluation for their ability to drive?
- ☐ Yes
- ☐ No
- ☐ Don't know

2. Insulin-treated patients with diabetes need to check their blood glucose before driving.
- ☐ Yes
- ☐ No
- ☐ Don't know

3. The level of blood glucose which is safe for the patient to drive is:
- ☐ > 4 mmol/L (> 72 mg/dL¶)
- ☐ > 5 mmol/L (> 90 mg/dL¶)*
- ☐ > 6 mmol/L (> 108 mg/dL¶)
- ☐ > 7 mmol/L (> 126 mg/dL¶)
- ☐ Don't know

4. The recommended time for checking blood glucose before driving is:
- ☐ Just before driving*
- ☐ 30 minutes before
- ☐ 60 minutes before
- ☐ 90 minutes before
- ☐ Don't know

5. Persons with diabetes should not drive after effective treatment of mild to moderate hypoglycemia until at least..... minutes.
- ☐ 5 to 10 min
- ☐ 15 to 20 min
- ☐ 30 to 45 min*
- ☐ Don't know

6. During long-time trip, the recommended time for rechecking blood glucose is:
- ☐ Every hour
- ☐ Every 2 hours*
- ☐ Every 3 hours
- ☐ Every 4 hours
- ☐ Don't know

7. Which type of diabetes associated with higher incidence of driving mishaps?
- ☐ Type 1
- ☐ Type 2
- ☐ Don't know

8. Drivers should stop and treat themselves as soon as hypoglycemia and/or impaired driving is suspected?
- ☐ Yes
- ☐ No
- ☐ Don't know

9. Do you think that insulin-treated patients with diabetes shouldn't drive?
- ☐ Yes
- ☐ No
- ☐ Don't know

10. Insulin-treated patients who have diabetes need to carry fast acting carbs during driving?
- ☐ Yes
- ☐ No
- ☐ Don't know

11. Insulin-treated patients who have diabetes need to carry their glucose meters during driving?
- ☐ Yes
- ☐ No
- ☐ Don't know

12. Insulin-treated patients who have diabetes need to carry ID that says they have diabetes?
- ☐ Yes
- ☐ No
- ☐ Don't know

Asterisks (*) indicate the correct answers; according to the American Diabetes Association (ADA) [44,45], the Australian Diabetes Association [46], and the National Diabetes Service Scheme (NDSS; an Australian Governmental Initiative). [47]

¶ Conversion from mmol/L to mg/dL was performed by the authors using the following formula: mg/dL = 18 × mmol/L.