



Risk stratification using the 2021 IDF-DAR risk calculator and fasting experience of Bangladeshi subjects with type 2 diabetes in Ramadan: The DAR-BAN study

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ABSTRACT

Aims: To risk-stratify patients with type 2 diabetes mellitus (T2DM) according to the IDF-DAR 2021 guidelines and observe their responsiveness to risk-category-based recommendations and fasting experience.

Methods: This prospective study, conducted in the *peri*-Ramadan period of 2022, evaluated adults with T2DM and categorized them using the IDF-DAR 2021 risk stratification tool. Recommendations for fasting according to the risk categories were made, their intention to fast was recorded, and follow-up data were collected within one month of the end of Ramadan.

Results: Among 1328 participants (age 51.1 ± 11.9 years, female 61.1 %), only 29.6 % had pre-Ramadan HbA1c < 7.5 %. According to the IDF-DAR risk category, the frequencies of participants in the low-risk (should be able to fast), moderate-risk (not to fast), and high-risk (should not fast) groups were 44.2 %, 45.7 %, and 10.1 %, respectively. Most (95.5 %) intended to fast, and 71 % fasted the full 30 days of Ramadan. The overall frequencies of hypoglycemia (3.5 %) and hyperglycemia (2.0 %) were low. Hypoglycemia and hyperglycemia risks were 3.74-fold and 3.86-fold higher in the high-risk group than in the low-risk group.

Conclusion: The new IDF-DAR risk scoring system seems conservative in the risk categorization of T2DM patients in terms of fasting complications.

Introduction

Worldwide, 537 million adults aged 20–79 had diabetes mellitus (DM) in 2021, most of which were type 2 DM (T2DM) [1]. >200 million Muslims worldwide, and the world's widespread Muslim population makes up most people in 49 countries [2]. The Middle East and North

Africa (MENA) and Southeast Asia regions, where there is a high proportion of Muslim inhabitants, have the highest comparative prevalence of diabetes [1]. Fasting during holy Ramadan is one of the five fundamental pillars of Islam and is mandatory for all Muslim adults in good health. Such fasting periods start at dawn and end at dusk, depending on the geographic location and season, which may be ten to twenty hours

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[3]. Due to the metabolic nature of the disease, people with DM are at greater risk from marked changes in fluid and food intake characteristic of Ramadan fasting. Furthermore, altered sleeping patterns and circadian rhythms, and glucose-lowering medications increase the risks of complications such as hypoglycemia, hyperglycemia, dehydration, and hyperglycemic emergencies [3]. Despite these potential health hazards, many people with DM fast during Ramadan, including those exempted from Ramadan fasting [4–7]. In the EPIDIAR study, the frequency of participants fasting for 15 or more days during Ramadan was 42.8 % in type 1 DM (T1DM) and 78.7 % in T2DM [4]. Likewise, in the CREED study, 94.2 % of participants with T2DM fasted for at least 15 days, and 63.6 % fasted on all days of Ramadan [5]. The recent Diabetes and Ramadan-Middle East and North Africa (DAR-MENA) T2DM study revealed that 86 % of participants fasted for 15 or more days in Ramadan [6]. In a study conducted in Bangladesh, most (89.35 %) of the patients with DM fasted in Ramadan, and 58.02 % fasted for the full 30 days of the month [7]. In response to this invincible spiritual desire of these patients, physicians must acknowledge the potential dangers of fasting for people with DM and quantify and stratify the risks for every person individually to provide the best possible care. The current international guidelines have risk-stratified patients with diabetes, considering the presence of diabetic complications, comorbidities, and the various factors that influence fasting into different categories. The decision of fasting or not is made based on this categorization [3,8–10]. Evolving from previous guidelines, the 2021 International Diabetes Federation-Diabetes and Ramadan International Alliance (IDF-DAR) risk stratification system seek to enable more personalized risk assessment by objectively evaluating 14 Ramadan-, disease- and patient-related risk elements [11].

The population of Bangladesh is >165 million, as per the 2022 census report, of which the majority (91.04 %) are Muslim [12]. As 13.1 million adults have DM in the country, ~12 million adults with diabetes are eligible for Ramadan fasting [1]. No studies have described the patient characteristics along with risk assessment using the IDF-DAR risk stratification system 2021 and the real-life application of the recommendations made by the physicians according to the risk categories in the country. We conducted this study to stratify patients with T2DM according to IDF-DAR guidelines and observe the patient's responsiveness to risk-category-based recommendations.

Materials and methods

Study design

We conducted this prospective study at several diabetic clinics throughout the country from February 2022 to May 2022. All the centers participated voluntarily and without financial incentives. All study subjects consented with informed written consent for inclusion. The declaration of the Helsinki accords was followed through the survey. At all times, study subjects' identities were kept confidential. The research imposed no health risk on the study subjects, and their decision to participate did not influence treatment decisions. The study did not offer any financial compensation for participation. Formal ethical approval was taken from the institutional review board of Mymensingh Medical College (Approval No. MMC/IRB/2021/336, Date: 23/09/2021).

Study population

Adults with T2DM attending follow-up clinic visits starting six weeks before Ramadan 2022 who were willing to participate in the study were included. Subjects with diabetes of other types, pregnant women, and those diagnosed with severe psychiatric illnesses or critically ill were excluded.

Study procedure

All consented subjects underwent a survey using an investigator-administered questionnaire focusing on the characteristics of diabetes, diabetes control, the presence of diabetic complications, comorbidities, and the various factors influencing fasting. Relevant sociodemographic data were also collected. The new IDF-DAR elements for risk calculation and suggested risk scores for people with DM who seek to fast during Ramadan were used to risk-stratify the study subjects. These elements for risk calculation include diabetes type and duration, presence of hypoglycemia (<3.9 mmol/L), level of glycemic control (in terms of HbA1c), type of diabetes treatment, self-monitoring of blood glucose (SMBG), acute complications of diabetes (diabetic ketoacidosis, hyperglycemic hyperosmolar state), macrovascular disease (cardiac-cerebral or peripheral) complications/comorbidities, renal complications/comorbidities, pregnancy, frailty and cognitive function, physical labor, previous Ramadan experience, and fasting hours [11]. The risk factors were graded in relation to safety during the fast. The subjects' scores for individual variables were added to obtain the total risk score; the highest obtainable score was 50.5, and the lowest was zero. According to the total score, the subjects were stratified into risk categories: low risk (score 0 to 3), moderate risk (score 3.5 to 6), and high risk (score > 6). The recommendations for Ramadan fasting were made for individual study subjects according to the risk categories: low-risk individuals should be able to fast, moderate-risk individuals not to fast, and high-risk individuals should not fast [11]. Study subjects' intentions to fast, to fast, or not to fast were checked individually after discussing the risk categories and the fasting recommendation based on the risk categories. Ramadan-focused diabetes education was given to all by the investigators, and necessary adjustments to diet, physical exercise, and glucose-lowering medications were made individually. Participants were sensitized to individualized self-monitoring blood glucose (SMBG) schedules as per guidelines and informed of the circumstances of when to break fasting, along with scheduled physician follow-up during Ramadan. All the study subjects were followed up either in person or by telephonic interviews within one month following Ramadan. The post-Ramadan follow-up included the number of days fasted, adherence to prescribed dietary and lifestyle advice and drug treatment, SMBG, physician visit for drug dose adjustment, hypoglycemia (<3.9 mmol/L), and hyperglycemia (>16.6 mmol/L) during Ramadan. Post Ramadan (within the second to fourth weeks after) fasting and 2 h after breakfast plasma glucose were recorded, if available.

Statistical analysis

We analyzed the data using IBM SPSS Statistics for Macintosh, Version 28.0 software (IBM Corp., Armonk, NY). Continuous variables are expressed as the mean \pm standard deviation (SD), and categorical variables are presented as the percentage (number). The variables among the risk-category groups were compared using Chi-square tests. Binary logistic regression analysis determined the risk factors for hypoglycemia and hyperglycemia. A P value of <0.05 was used for statistical significance.

Results

Participants' characteristics

Table 1 describes the study participants' characteristics. Of 1328 subjects with T2DM included in this study, 61.1 % were female. Their mean age was 51.1 (\pm 11.9) years. A higher number of them were from rural areas (40.2 %) than urban (36.3 %) and suburban (23.5 %) areas. Only 29.6 % of them had pre-Ramadan HbA1c < 7.5 %.

Table 1
Baseline characteristics of the study subjects (N = 1328).

Variables	Subgroups	Mean ± SD or frequency (%)
Age (years)		51.1 ± 11.9
Sex	Female	811 (61.1 %)
	Male	517 (38.9 %)
Residence*	Urban	482 (36.3 %)
	Suburban	312 (23.5 %)
	Rural	534 (40.2 %)
Presence of hypoglycemia	Hypoglycemia unawareness	3 (0.2 %)
	Recent severe hypoglycemia	0 (0 %)
	Multiple weekly hypoglycemia	11 (0.8 %)
	Hypoglycemia < 1 per week	98 (7.4 %)
	No hypoglycemia	1216 (91.6 %)
Level of glycemic control	HbA1c > 9 %	166 (12.5 %)
	HbA1c 7.5–9 %	769 (57.9 %)
	HbA1c < 7.5 %	393 (29.6 %)
Type of treatment	Multiple daily mixed insulin injections	524 (39.5 %)
	Basal bolus or Insulin pump	77 (5.8 %)
	Once daily mixed insulin	64 (4.8 %)
	Basal insulin	22 (1.7 %)
	Glibenclamide	26 (2.0 %)
	Gliclazide MR or Glimepiride or Repaglinide	180 (13.6 %)
	Other therapy (not including SU or Insulin)	435 (32.8 %)
SMBG	Indicated but not conducted	191 (14.4 %)
	Indicated but conducted suboptimally	439 (33.1 %)
	Conducted as indicated	698 (52.6 %)
Acute complications	DKA or HONC in the last 3 months	1 (0.1 %)
	DKA or HONC in the last 6 months	4 (0.3 %)
	DKA or HONC in the last 12 months	13 (1.0 %)
	No DKA or HONC	1310 (98.6 %)
MVD Complications/Comorbidities	Unstable MVD	6 (0.5 %)
	Stable MVD	15 (1.1 %)
	No MVD	1307 (98.4 %)
Renal Complications/Comorbidities	eGFR < 30 mL/min	2 (0.2 %)
	eGFR 30–45 mL/min	3 (0.2 %)
	eGFR 45–60 mL/min	32 (2.4 %)
	eGFR > 60 mL/min	1291 (97.2 %)
Frailty and Cognitive function	Impaired cognitive function or Frail	3 (0.2 %)
	>70 years old with no home support	1 (0.1 %)
	No frailty or loss in cognitive function	1324 (99.7 %)
Physical Labor	Highly intense physical labor	0 (0 %)
	Moderate intense physical labor	13 (1.0 %)
	No physical labor	1315 (99.0 %)
Previous Ramadan Experience	Overall negative experience	20 (1.5 %)
	No negative or positive experience	1308 (98.5 %)

*Urban: District towns and city corporation areas, Suburban: Subdistrict towns and municipalities that are not at the district level, Rural: Villages and small towns that are not municipalities.

Gliclazide MR = Gliclazide modified release, SMBG = Self-monitoring of blood glucose, DKA = Diabetic ketoacidosis, HONC = hyperglycemic hyperosmolar nonketotic coma, MVD = Macrovascular disease, eGFR = Estimated glomerular filtration rate.

Risk-categorization for fasting and intention to fast

Most of the subjects were stratified into high-risk (10.1 %) and moderate-risk (45.7 %) categories for whom recommendations were 'should not fast' and 'not to fast,' respectively. Low-risk subjects who 'should be able to fast' constituted only 44.2 % of the study subjects. Overall, 95.5 % intended to fast, and the remaining 4.5 % did not intend to fast during Ramadan. Although the prevalence of subjects not

intending to fast was higher (26.1 %) in the high-risk group than in the moderate-risk (3.8 %) and low-risk (0.3 %) groups, 73.9 % in the high-risk group (for whom the recommendation is 'should not fast') and 96.2 % in the moderate-risk group (for whom the recommendation is 'not to fast') intended to fast during Ramadan (Table 2).

Fasting practice and complications

As a whole, 71 % of the participants fasted all 30 days of Ramadan; the prevalence was 74.1 % (highest) in the low-risk group, 72.8 % in the moderate-risk group, and 49.3 % (lowest) in the high-risk group. In contrast, 11.4 % of them (8.0 % of low-risk, 10.2 % of moderate-risk, and 32.1 % of high-risk subjects) did not fast for a single day. Among them, 92.8 % (91.5 % of low-risk, 95.6 % of moderate-risk, and 86.6 % of high-risk subjects) received drug treatment during Ramadan as prescribed, and 86.1 % (83.6 % of low-risk, 91.3 % of moderate-risk, and 73.9 % of high-risk subjects) followed dietary and lifestyle advice during Ramadan as prescribed. During Ramadan, 60.5 % of the participants performed SMBG as instructed; the prevalence was highest in the moderate-risk group (71.2 %) and lowest in the high-risk group (48.5 %). 46.3 % of the participants visited physicians for dose adjustment of diabetic medications during Ramadan; 37.5 % of low-risk, 59.5 % of moderate-risk, and 25.4 % of high-risk subjects did so. A total of 3.5 % and 2.0 % of the participants experienced hypoglycemia and hyperglycemia, respectively. High-risk subjects had the highest prevalence of both hypoglycemia (7.5 %) and hyperglycemia (4.5 %), followed by medium-risk (4.0 % and 2.3 %) and low-risk subjects (2.2 % and 1.2 %). At post-Ramadan follow-up, only 21.5 % of the participants had their plasma glucose within the target; the prevalence was 29.8 % in the low-risk group, 15.2 % in the medium-risk group, and 13.4 % in the high-risk group (Table 2).

Risk factors of hypoglycemia and hyperglycemia

In bivariate logistic regression analysis, the risks of hypoglycemia and hyperglycemia were 3.74-fold and 3.86-fold higher in high-risk subjects than in low-risk subjects. For subjects in the moderate-risk group, the higher risks of hypo- and hyperglycemia than for low-risk subjects did not reach statistical significance. Subjects not following dietary and lifestyle advice during Ramadan as prescribed had a 3.32-fold higher risk of hypoglycemia and 3.13-fold higher risk of hyperglycemia than those who did so. Subjects not visiting physicians during Ramadan for dose adjustment of diabetic medications had a 0.38-fold lower risk of hypoglycemia than those who visited physicians in the month; receiving drug treatment during Ramadan as prescribed and SMBG during Ramadan as instructed did not influence the occurrence of hypo- and hyperglycemia (Table 3).

Discussion

This study, conducted among 1328 subjects with T2DM attending several diabetic clinics throughout Bangladesh during the *peri*-Ramadan period in 2022, identified that more than half (55.8 %) of the study subjects had moderate- (45.7 %) and high-risk (10.1 %) fasting during Ramadan. Despite such potential risks and physicians' recommendations against fasting, most of the study subjects in the moderate-risk (96.2 %) and high-risk (73.9 %) groups intended to fast; 72.8 % and 49.3 % of the two groups, respectively, fasted for all days of Ramadan month. The overall prevalence of hypoglycemia (3.5 %) and hyperglycemia (2.0 %) was low. The high-risk subjects had higher risks of hypoglycemia (3.74-fold) and hyperglycemia (3.86-fold) than the low-risk subjects.

Several studies risk-stratified the patients with T2DM planning for Ramadan fasting. The CREED study, conducted globally, identified 31.5 % as high-risk and 3.8 % as very high-risk such patients according to ADA 2005 risk stratification [5,13]. Applying the IDF-DAR 2017 risk

Table 2

Risk categories, recommendations for fasting, and study participants' performance of Ramadan fasting (N = 1328).

Variables	Subgroups	All subjects (N = 1328)	Recommendation			P value
			Should be able to fast (n = 587)	Not to fast (n = 607)	Should not fast (n = 134)	
Patient's intention on fasting	To fast	1268 (95.5 %)	585 (99.7 %)	584 (96.2 %)	99 (73.9 %)	<0.001
	Not to fast	60 (4.5 %)	2 (0.3 %)	23 (3.8 %)	35 (26.1 %)	
Number of days fasted in Ramadan	All days of Ramadan	943 (71.0 %)	435 (74.1 %)	442 (72.8 %)	66 (49.3 %)	<0.001
	>15 days, not all days	183 (13.8 %)	78 (13.3 %)	89 (14.7 %)	16 (11.9 %)	
	1–15 days	50 (3.8 %)	27 (4.6 %)	14 (2.3 %)	9 (6.7 %)	
Received drug treatment during Ramadan as prescribed	Yes	1233 (92.8 %)	537 (91.5 %)	580 (95.6 %)	116 (86.6 %)	<0.001
	No	95 (7.2 %)	50 (8.5 %)	27 (4.4 %)	18 (13.4 %)	
Followed dietary and lifestyle advice during Ramadan as prescribed	Yes	1144 (86.1 %)	491 (83.6 %)	554 (91.3 %)	99 (73.9 %)	<0.001
	No	184 (13.9 %)	96 (16.4 %)	53 (8.7 %)	35 (26.1 %)	
SMBG during Ramadan as instructed	Yes	804 (60.5 %)	307 (52.3 %)	432 (71.2 %)	65 (48.5 %)	<0.001
	No	524 (39.5 %)	280 (47.7 %)	175 (28.8 %)	69 (51.5 %)	
Visited physician for dose adjustment of diabetic medications	Yes	615 (46.3 %)	220 (37.5 %)	361 (59.5 %)	34 (25.4 %)	<0.001
	No	713 (53.7 %)	367 (62.5 %)	246 (40.5 %)	100 (74.6 %)	
Hypoglycemia (<3.9 mmol/L) during Ramadan	Yes	47 (3.5 %)	13 (2.2 %)	24 (4.0 %)	10 (7.5 %)	0.009
	No	1281 (96.5 %)	574 (97.8 %)	583 (96.0 %)	124 (92.5 %)	
Hyperglycemia (>16.6 mmol/L) during Ramadan	Yes	27 (2.0 %)	7 (1.2 %)	14 (2.3 %)	6 (4.5 %)	0.042
	No	1301 (98.0 %)	580 (98.8 %)	593 (97.7 %)	128 (95.5 %)	
Post-Ramadan (2 weeks later) glycemic (FPG and PG 2 h-ABF) status	Within target	285 (21.5 %)	175 (29.8 %)	92 (15.2 %)	18 (13.4 %)	<0.001
	Not within target	883 (66.5 %)	328 (55.9 %)	460 (75.8 %)	95 (70.9 %)	
	No data available	160 (12.0 %)	84 (14.3 %)	55 (9.1 %)	21 (15.7 %)	

SMBG = Self-monitoring of blood glucose, FPG = Fasting plasma glucose, PG 2 h-ABF = Plasma glucose 2 h after breakfast.

Table 3

Risk factors for hypoglycemia and hyperglycemia in Ramadan.

Variables	Subgroups	Hypoglycemia		Hyperglycemia	
		Odds Ratio (95 % CI)	P value	Odds Ratio (95 % CI)	P value
Risk categories	Low risk	Referent		Referent	
	Moderate risk	1.64 (0.81–3.31)	0.166	1.91 (0.75–4.87)	0.177
	High risk	3.74 (1.57–8.88)	0.003	3.86 (1.26–11.88)	0.018
Received drug treatment during Ramadan as prescribed	Yes	Referent		Referent	
	No	0.14 (0.02–1.18)	0.071	0.22 (0.03–1.95)	0.176
Followed dietary and lifestyle advice during Ramadan as prescribed	Yes	Referent		Referent	
	No	3.32 (1.34–8.22)	0.010	3.13 (1.02–9.66)	0.047
SMBG during Ramadan as instructed	Yes	Referent		Referent	
	No	1.22 (0.53–2.80)	0.633	1.51 (0.52–4.34)	0.447
Visited physician for dose adjustment of diabetic medications	Yes	Referent		Referent	
	No	0.38 (0.17–0.84)	0.017	0.44 (0.16–1.25)	0.124

SMBG = Self-monitoring of blood glucose.

calculator, two other studies comprising most of the patients with T2DM in Pakistan and Saudi Arabia reported that most study subjects fall into moderate- and high-risk groups. [14,15] Chiew et al., in their study comprising most of the subjects (93.8 %) with T2DM in Malaysia, identified almost three-fourths (73.8 %) of them in the moderate- (33.3 %) and high-risk (40.5 %) categories according to the new IDF-DAR 2021 risk stratification [16]. The significant discrepancies in the study results may be explained by the diverse nature of the included study subjects and geographical locations that influence Ramadan fasting and

also different methods for risk stratification.

Most patients intend to fast during Ramadan irrespective of their risk category for fasting and even against their individual fasting recommendations [17]. The intention to fast in most of the present study subjects in the moderate-risk (96.2 %) and the high-risk (73.9 %) against the medical advice is similar to other studies [15,16]. Fasting is nonetheless a spiritual issue for which people decide themselves after receiving appropriate advice from religious teachings and health care providers. The subject's decision to fast is the most crucial driving element in deciding whether to fast or not. In the DAR-MENA T2DM study, the majority (80.4 %) of the population who fasted listed personal decisions as their motivating factor [6]. Almost three-fourths (71 %) of the present study subjects fasted for all 30 days of Ramadan; the frequency is higher than in previous studies conducted nationally and globally [5–7,17,18]. Another striking finding of this study is that half (49.3 %) of the high-risk subjects fasted all days of the month, reminding us that most fasters do not care about their fasting-related risk. In the CREED study, the average number of days fasted for the T2DM cohort was 26.9 in moderate risk, 27.5 in high risk, and 25.3 in very high risk [6]. Although the tendency to follow the physical-prescribed dietary and lifestyle advice and drug treatment specified for Ramadan fasting is good by the present study participants, most of them did not visit physicians during Ramadan for dose adjustment of diabetic medications. Previous studies in the country reported similar, even poorer practices of physician visits during fasting days [7,18].

The poor pre-Ramadan HbA1c in most (70.4 %) study subjects reflects poor glycemic control in T2DM patients in Bangladesh [19]. Similar uncontrolled pre-Ramadan HbA1c was observed in the DAR 2020 Global survey (63.9 %) and among Malaysian fasters with T2DM (57.6 %) [16,17]. The uncontrolled glycemia persisted beyond Ramadan in the current study subjects, as reflected by their post-Ramadan blood glucose status. The SMBG performance of study subjects is similar to such practice in the country observed previously [7].

Hypoglycemia (3.5 %) and hyperglycemia (2 %) were surprisingly very low in this study; the frequencies are even lower than in previous studies conducted in Bangladesh and other countries [6,7,13,14,17,18]. Increasing awareness and implementation of global and national guidelines for managing diabetes with pre-Ramadan assessment for risk categorization and therapeutic dose modification with SMBG have

markedly reduced fasting-related risks [20]. All the participants of the present study were under special care and received structured education for Ramadan fasting and advice to adjust their lifestyle and glucose-lowering drugs during the fasting period; this may contribute to the lower occurrence of hypo and hyperglycemia in them. However, high-risk subjects in this study had higher (7.5 %) hypoglycemic events than moderate- (4.0 %) and low-risk (2.2 %) subjects; a similar was observed for hyperglycemia too (4.5 % in high-risk, 2.3 % in moderate-risk, and 1.2 % in low-risk group). The high-risk subjects in this study had 3.74-fold higher risks of hypoglycemia and 3.86-fold higher risks of hyperglycemia than the low-risk subjects. Individuals in the high-risk category are at a very high risk of developing complications when fasting during Ramadan, which is lower in individuals at the low-risk level [11]. In the CREED study, the overall incidence of hypoglycemia was 4.2 % in the low-risk group, 7.5 % in the moderate-risk group, 9.2 % in the high-risk group, and 13.8 % in the very high-risk group [5].

Predictably, participants who did not follow recommended dietary and lifestyle advice during Ramadan had higher risks of both hypo- and hyperglycemia. Changes in meal timing, fasting and feasting dietary patterns, and physical activities during Ramadan increase the risks of both hypoglycemia and hyperglycemia among fasters with DM; such risks can be minimized by providing individualized dietary advice and meal planning, which can also help these people follow a healthy balanced diet during Ramadan. A similar favorable effect on fasting complications has been observed for appropriate adjustment of lifestyle and physical activity during Ramadan [4,5,11]. The higher risk of hypoglycemia in the participants who visited physicians for dose adjustment of diabetic medications may be explained by their hypoglycemic event-driven necessity for physician consultations. Adherence to recommended drug prescriptions and SMBG did not influence hypo- and hyperglycemia in this study, which is discordant with previous reports [4,5,11].

This study has several limitations; it was conducted at several diabetic clinics run by specialists throughout Bangladesh. All investigators were located in urban areas; the results may not be country-representative. Caution should also be exercised when interpreting these study results about other geographic regions. The validity of patient-reported hypoglycemia and hyperglycemia may be subject to recall bias. Moreover, data regarding severe hypoglycemia, hyperglycemia, diabetic complication-related hospitalization, and other complications related to fasting were not quantified. We did not have post-Ramadan HbA1c, which would better describe the participants' glycaemic control and change. Nevertheless, to our knowledge, this one is the first prospective, large-scale, prospective study in people with T2DM before and during Ramadan that categorized these patients using the new IDF-DAR risk calculator and reported follow-up data on fasting behavior, diabetes control, and events of hypoglycemia and hyperglycemia.

In conclusion, although most subjects with T2DM, assuming their risk of developing complications from fasting, are advised against fasting during Ramadan, most ignore such risks and fast against physicians' recommendations, as observed in this study. Fasting complications were higher in the IDF-DAR high-risk subjects, but the overall risk was surprisingly low among the participants. Further large-scale multinational studies are needed to justify the new IDF-DAR risk scoring system's real-world usefulness and practical modifications if required.

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Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] International Diabetes Federation. IDF Diabetes Atlas. 10th edn. Brussels, Belgium: International Diabetes Federation; 2021. Available at: <https://www.diabetesatlas.org>.
- [2] The Future of World Religions: Population Growth Projections; 2010–2050. Pew Research Center [cited 2022 Sep 09]. Available at: <http://www.pewforum.org/2015/04/02/religiousprojections-2010-2050>.
- [3] Jabbar A, Malek R, Hussein Z. Chapter 2 - Epidemiology of diabetes and fasting during Ramadan. In Hassanein MM (Editor). Diabetes and Ramadan: Practical Guidelines 2021. Publisher: International Diabetes Federation and the DAR International Alliance January 2021.
- [4] Salti I, Bénard E, Detournay B, Bianchi-Biscay M, Le Brigand C, Voinet C, et al. EPIDIAR study group. A population-based study of diabetes and its characteristics during the fasting month of Ramadan in 13 countries: results of the epidemiology of diabetes and Ramadan 1422/2001 (EPIDIAR) study. *Diabetes Care* 2004;27(10):2306–11. <https://doi.org/10.2337/diacare.27.10.2306>.
- [5] Babineaux SM, Toaima D, Boye KS, Zagar A, Tahbaz A, Jabbar A, et al. Multi-country retrospective observational study of the management and outcomes of patients with Type 2 diabetes during Ramadan in 2010 (CREED). *Diabet Med* 2015; 32(6):819–28. <https://doi.org/10.1111/dme.12685>.
- [6] Hassanein M, Al Awadi FF, El Hadidy KES, Ali SS, Eghtay A, Djaballah K, et al. The characteristics and pattern of care for the type 2 diabetes mellitus population in the MENA region during Ramadan: An international prospective study (DAR-MENA T2DM). *Diabetes Res Clin Pract* 2019;151:275–84. <https://doi.org/10.1016/j.diabres.2019.02.020>.
- [7] Siddiqui NI, Kamrul-Hasan M, Hossain MA, Chanda PK, Bakar MA, Rahman M, et al. Ramadan perspective epidemiology and education in diabetes (RAPEED) study. *Mymensingh Med J* 2017;26(2):256–65. <https://pubmed.ncbi.nlm.nih.gov/28588159>.
- [8] Al-Arouj M, Bouguerra R, Buse J, Hafez S, Hassanein M, Ibrahim MA, et al. Recommendations for management of diabetes during Ramadan. *Diabetes Care* 2005;28(9):2305–11. <https://doi.org/10.2337/diacare.28.9.2305>.
- [9] Al-Arouj M, Assaad-Khalil S, Buse J, Fahdil I, Fahmy M, Hafez S, et al. Recommendations for management of diabetes during Ramadan: update 2010. *Diabetes Care* 2010;33(8):1895–902. <https://doi.org/10.2337/dc10-0896>.
- [10] Hassanein M, Al-Arouj M, Hamdy O, Bebakar WMW, Jabbar A, Al-Madani A, et al. International Diabetes Federation (IDF), in collaboration with the Diabetes and Ramadan (DAR) International Alliance. Diabetes and Ramadan: practical guidelines. *Diabetes Res Clin Pract* 2017;126:303–16. <https://doi.org/10.1016/j.diabres.2017.03.003>.
- [11] Hassanein M, Afandi B, Yakoob Ahmedani M, Mohammad Alamoudi R, Alawadi F, Bajaj HS, et al. Diabetes and Ramadan: practical guidelines 2021. *Diabetes Res Clin Pract* 2022;185:109185. <https://doi.org/10.1016/j.diabres.2021.109185>.
- [12] 2 Census of Bangladesh. Wikipedia [cited 2 Sep 09]. Available at: https://en.wikipedia.org/wiki/2_Census_of_Bangladesh.
- [13] Jabbar A, Hassanein M, Beshyah SA, Boye KS, Yu M, Babineaux SM. CREED study: Hypoglycaemia during Ramadan in individuals with Type 2 diabetes mellitus from three continents. *Diabetes Res Clin Pract* 2017;132:19–26. <https://doi.org/10.1016/j.diabres.2017.07.014>.
- [14] Syed F, Arif MA, Ramzan A, Niazi R, Murtaza MI, Javed A. DAR-GRACE: Diabetes and Ramadan: glycaemic control, physician counselling and patient practices -experience from a tertiary care hospital in Pakistan. *J Pak Med Assoc* 2020;70(11):1990–5. <https://doi.org/10.5455/JPMA.42922>.
- [15] Hassan A, Aldahasai WA, Alsalmi SA. A snapshot of risk stratification of diabetic patients fasting during the month of Ramadan. *Pakistan J Med Health Sci* 2021;15(12):3427–9. <https://doi.org/10.53350/pjmhs2115123427>.
- [16] Chiew KS, Zanariah H, Mahtar MM, Zainuddin M. A tertiary center experience in using the 2021 IDF-DAR risk calculator for people with diabetes before Ramadan. *J ASEAN Federation Endocrine Societies* 2021;36:30. <https://doi.org/10.15605/jafes.036.S33>.
- [17] Hassanein M, Hussein Z, Shaltout I, Wan Seman WJ, Tong CV, Mohd Noor N, et al. The DAR 2020 Global survey: Ramadan fasting during COVID 19 pandemic and the impact of older age on fasting among adults with Type 2 diabetes. *Diabetes Res Clin Pract* 2021;173:108674. <https://doi.org/10.1016/j.diabres.2021.108674>.
- [18] Amin MF, Afsana F, Nazneen NE, Pathan F, Jamil SNAA, Sultana SR, et al. Life style practice and awareness during Ramadan fasting in Bangladeshi diabetic population. *BIRDEM Med J* 2016;6(1):26–31. <https://doi.org/10.3329/birdem.v6i1.28407>.
- [19] Afroz A, Ali L, Karim MN, Alramadan MJ, Alam K, Magliano DJ, et al. Glycaemic control for people with type 2 diabetes mellitus in Bangladesh - An urgent need for optimization of management plan. *Sci Rep* 2019;9(1):10248. <https://doi.org/10.1038/s41598-019-46766-9>.
- [20] Rashid F, Abdelgadir E, Bashier A. A systematic review on the safety of Ramadan fasting in high-risk patients with diabetes. *Diabetes Res Clin Pract* 2020;164:108161. <https://doi.org/10.1016/j.diabres.2020.108161>.