Original Article

Hyperglycaemic and hypoglycaemic emergencies among patients with diabetes mellitus who participated in pilgrims of the 2019/1440H Hajj season

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Abstract

Background: Diabetic emergencies are serious acute life-threatening complications of diabetes mellitus (DM). The Hajj season requires the health system in Saudi Arabia to prepare efficiently for the healthcare of millions of pilgrims, particularly for diabetic emergencies. Thus, diabetic emergencies need rapid recognition, diagnosis and treatment. This study aimed to explore the frequency and associated factors of diabetic emergencies among the pilgrim's patients with DM during Hajj, Mecca 2019. **Methods:** This is a prospective study which was conducted on 153 patients with DM. They were selected from three major healthcare-providing facilities during Hajj, which are Arafat, Muzdelefah and Muna healthcare centres. The study was conducted from Aug 5 to 12, 2019. All the patients who presented with any of the hypoglycaemic or hyperglycaemic emergencies had their demographic and clinical characteristics recorded to estimate the prevalence of each emergency and identify its significant associated factors. **Result:** More than 90% of the study participants were patients with type 2 diabetes mellitus (T2DM), while around 7% had type 1 diabetes mellitus (T1DM). Diabetic ketoacidosis (DKA) and hyperosmolar hyperglycaemic state (HHS) and hypoglycaemia were presented in (n = 11, 7.2%), (n = 19, 12.4%) and (n = 28, 18%), respectively, of the participants. Moreover, the study found that "younger age" (odds = 30.4, P = 0.0115) and "type of medication" are significantly associated with DKA. Furthermore, "older age", "type of medication", "having Cardiovascular Disease (CVD)" and "diabetes duration" were found to have a significant association with HHS. Moreover, hypoglycaemia was associated with neuropathy complication (odds = 3.54948, P = 0.0187). **Conclusions:** Among the pilgrims with diabetes participating in Hajj, a considerable proportion with a range of diabetic emergencies present to the onsite medical facilities. Preparation is required in terms of logistics and health education about diabetic emergencies to meet the needs of pilgrims with DM, especially those who use insulin and have longstanding diabetes. Further research on DM and the creation of guidelines for health providers and patients with DM during Hajj are important focuses for the future.

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Introduction

Diabetes mellitus (DM) is considered a leading cause of disability worldwide and it is associated with more than 25 million deaths globally every year. In Saudi Arabia, over 4 million people live with diabetes, with an estimated prevalence of 18.3% in Saudi adults.[1] The health system in Saudi Arabia needs to be prepared for DM prevention and treatment, as well as prevention and monitoring of its complications and related emergencies. The main diabetes-related emergencies dealt with in Saudi Arabia are hypoglycaemia, diabetic ketoacidosis (DKA) and hyperosmolar hyperglycaemic state (HHS). The responsibilities of the health sectors in Saudi Arabia extend beyond the patients with DM who are residents in the Kingdom and include caring for the pilgrims and visitors who come to Mecca for Hajj and/or Umrah. Hajj is the fifth pillar of Islam; every Muslim must participate in Hajj at least once in their life. The Hajj rituals last for about a week in the last month of the Islamic calendar. According to the Saudi General Authority for Statistics, approximately 2.5 million pilgrims participated in Hajj during the 1440 H season alone, of whom 1,855,027 came from outside Saudi Arabia.[2] Participating in Hajj involves a remarkable change in physical activity, mental effort and diet. Therefore, pilgrims with DM are at an increased risk of diabetic emergencies, which include DKA, HHS and hypoglycaemia.[3]

In recent decades, an increasing number of hospital admissions of patients with DM during the Hajj season have been reported. For instance, a study conducted at seven hospitals during the Hajj season reported that the hospital admissions for DM constituted 8.5% of the total admissions. The main reason for admission was DKA, followed by hypoglycaemia and uncontrolled DM. Moreover, DM was evident in 26% of all the admissions as a comorbid disease.[4]

Several studies have examined the associated risk factors of DKA, HHS and hypoglycaemia. For example, a study conducted by Hekkala *et al.* showed that DKA was more common in the paediatric age group with type 1 DM (T1DM)[5] but can occur in patients with type 2 DM (T2DM).[6,7] Hypoglycaemia is more common in insulin-treated patients, particularly those with a longer duration of diabetes and lower glycosylated haemoglobin (HbA1c) readings.[8] A meta-analysis indicated that DKA is more common with tight glycaemic control and that hypoglycaemia is more common with the use of insulin therapy.[9] Furthermore, inadequate insulin use is one of the most important factors that contribute to the development of diabetic emergencies.[10] Moreover, a study which included 18 pilgrims admitted to the hospital with DKA revealed that poor treatment adherence was reported in 94.5% of the patients and the mortality rate was around 6%.[11] In HHS, osmotic diuresis induces combined states of hyperglycaemia and dehydration, which causes hyperviscosity and a hypercoagulable state.[12] Therefore, HHS carries a huge risk of ischaemic stroke.[13] Overall, diabetic emergencies have serious impacts on a patient's life.

Given that there is an increased risk of diabetic emergencies during the Hajj season and a lack of data about the diabetic emergencies during this period, this study aimed to assess the diabetic emergencies and their associated factors among patients with DM who participated in Hajj 2019.

Methods

Study design and target population

This is a prospective study which was carried out in Mecca City. It is situated in the centre of the western area of Saudi Arabia. The study target population was patients with DM in Mecca City, who participated in Hajj 2019. The samples were selected from three emergency units at the healthcare-providing facilities of Arafat, Muzdalifah and Muna healthcare centres and they were asked to participate in the study. Ethical approval was granted on 11-9-2017 Registration number H-02-T-078.

Sample size

A total of 153 participants were included in the current study. The sample was selected from three emergency units at the healthcare-providing facilities of Arafat, Muzdelefah and Muna.

Recruitment of the participants

The participants were invited by the research team representative to take part in the study. They were informed that the data would be anonymous to ensure the privacy of the collected data. The participation was entirely voluntary, and all the individuals could withdraw from the study at any time without any consequences. Written informed consent was taken from the participants who agreed to be included in the survey.

Inclusion criteria

- Performance of pilgrimage during the 1440 H season.
- Consent of participation in the study.

Exclusion criteria

- Refused to sign consent.

Ethical considerations

Permission was obtained from the Ethical Committee in the Alhada Armed Forces Hospitals, Saudi Arabia.

Data collection and measurement tools

The study data were collected using a validated questionnaire filled by the research investigators which includes two parts. The first part includes sociodemographic variable, and the second part includes the clinical characteristics of the participants.

Statistical analyses

The analysis was performed by descriptive and inferential statistics. Any missing information was managed with multiple interpolations using chain equations. The normally distributed continuous variables were described using mean and standard

deviation. The continuous variables deviating from normality assumption are reported using the median and interquartile range. The data distribution was checked by the Kolmogorov–Smirnov method. The categorical variables were summarised by percentages and counts. Adjustment for the clinical and demographic covariates was conducted. The unadjusted association between the continuous variables was assessed by *t*-test or Mann–Whitney depending on the normality of the data. The categorical variables were assessed by a Chi-square test or Fisher's exact test. Multiple logistic regression was used to adjust for the potential confounders. A *P* value of less than 0.05 is assumed as the statistical significance level.

Results

The total number of patients with DM included in the current investigation was 153. Of these, 11 patients (7.2%) (95% confidence interval [CI]: 5.1–9.3) developed DKA, 19 patients (12.4%) (95% CI: 9.5–15.1) presented with HHS, and 28 patients (18.3%) (95% CI: 15.2–21.4) presented with hypoglycaemia during the Hajj season.

In terms of the background demographic factors, 140 participants (91.4%) were aged over 30 years and only 13 participants (8.5%) were aged under 30 years. Furthermore, 139 participants (90.8%) suffered from T2DM, whereas 11 participants (7.2%) had T1DM. In addition, 82 participants (53.6%) had suffered from diabetes for over 10 years and 71 participants (46.4%) had lived with diabetes for under 10 years. Table 1 shows the full account of the sociodemographic characteristics of the study participants.

Regarding the patients' random blood sugar (RBS) measurements, 89 (58.2%) were greater than 200 mg/dL (58.2%), 54 (35.3%) were between 100 and 200 mg/dL, and only 10 (6.5%) were less than 100 mg/dL. Furthermore, 74 participants were on oral hypoglycaemics (48.4%), 25 participants (16.3%) were on insulin, 43 participants (28.1%) were on a combination of oral hypoglycaemics and insulin and 8 participants (5.2%) were on no treatment.

More than 90% of the participants were patients with T2DM while around 7% had T1DM. In addition, 71 participants (46.4%) presented with hypoglycaemia.

Regarding microvascular complications among the participants, diabetic retinopathy, diabetic neuropathy and diabetic nephropathy were evident, with 23.5, 26.1 and 5.9%, respectively. CVD was reported in 18.3% of the participants. More than 48% of the participants had hypertension.

In the adjusted multiple regression analysis, DKA was exceedingly common in the younger individuals (odds ratio [OR] = 30.4, $P = 0.0115$), as shown in Figures 1 and 2. Other clinical and demographic factors were not statistically significant. None of the background factors exerted a significant effect on the HHS likelihood. The patients with neuropathy were far more likely to present with a hypoglycaemic emergency (OR = 3.54948,

Table 1: Sociodemographic and clinical characteristics of the study participants

	Frequency	Percent
Overall	153	100%
Age, years		
15-30	13	8.5%
>30	140	91.5%
RBS, mg/dL		
<100	10	6.5%
100-200	54	35.3%
>200	89	58.2%
Type of DM		
T1DM	11	7.2%
T2DM	139	90.8%
GDM	1	0.7%
Others	2	1.3%
HbA1c		
No result	121	79.1%
Good control	9	5.9%
Poor control	23	15.0%
Diabetes duration		
≤10	71	46.4%
>10	82	53.6%
Diabetes complications		
DR		
Absent	117	76.5%
Present	36	23.5%
DN		
Absent	113	73.9%
Present	40	26.1%
DNP		
Absent	144	94.1%
Present	9	5.9%
CVD		
Absent	125	81.7%
Present	28	18.3%
HTN		
Absent	79	51.6%
Present	74	48.4%
Diabetes medication		
Missing data	3	2.0%
No medication	8	5.2%
Oral	74	48.4%
Insulin	25	16.3%
Both	43	28.1%
Diabetic emergency		
DKA		
Absent	142	92.8%
Present	11	7.2%
HHS		
Absent	134	87.6%
Present	19	12.4%
Hypoglycaemia		
Absent	125	81.7%
Present	28	18.3%

RBS: Random blood sugar, DM: Diabetes mellites, HbA1c: glycosylated haemoglobin, DR: diabetic retinopathy, DNP: diabetic nephropathy, DN: diabetic neuropathy, HTN: hypertension, SD: standard deviation, *n*: sample size

P = 0.0187). See Tables 2, 3, and 4 for correlates of DKA, HHS, and hypoglycemia among the participating pilgrims.

Discussion

The current study showed that a considerable number of patients with DM had diabetic emergencies during the Hajj season. It showed that 7.2% of the participants had a DKA episode. This is considered high, as the reported rate of DKA is 1.3–5.4% in young patients with DM and 0.2–0.3% in patients who are aged over 30.[14] However, a study conducted with a sample of 80 Moroccan pilgrims with DM found that 5% of them had had a DKA episode during the Hajj season.[15] In the current study, age was the most significant factor, with younger adults (<30 years) 30 times more likely to have DKA than the older adults. Moreover, another explanation could be the improper use of insulin,[16] as the current study found that insulin use is significantly associated with DKA. In line with the previous research,[16] the current study found that DKA is more common in patients with T1DM (73%) than those with T2DM (27%). A small-scale study surveyed 18 patients with DKA who visited Al-Madinah during the 1998 Hajj season and found that poor compliance with diabetes medications was the most important factor in precipitating DKA.[11,17] The paper by Sharif *et al* (2010)[17] reported that diabetic pilgrims face a range of practical difficulties during the Hajj season, including acquisition and transport of oral hypoglycaemic medications and storage of insulin.

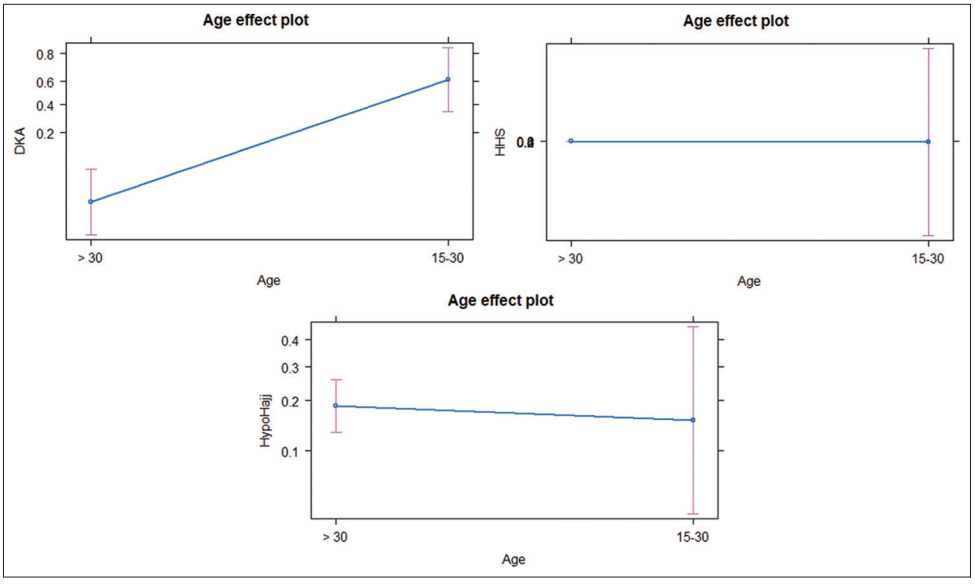

Figure 1: Age effect on DKA, HHS and hypoglycaemia among the pilgrims

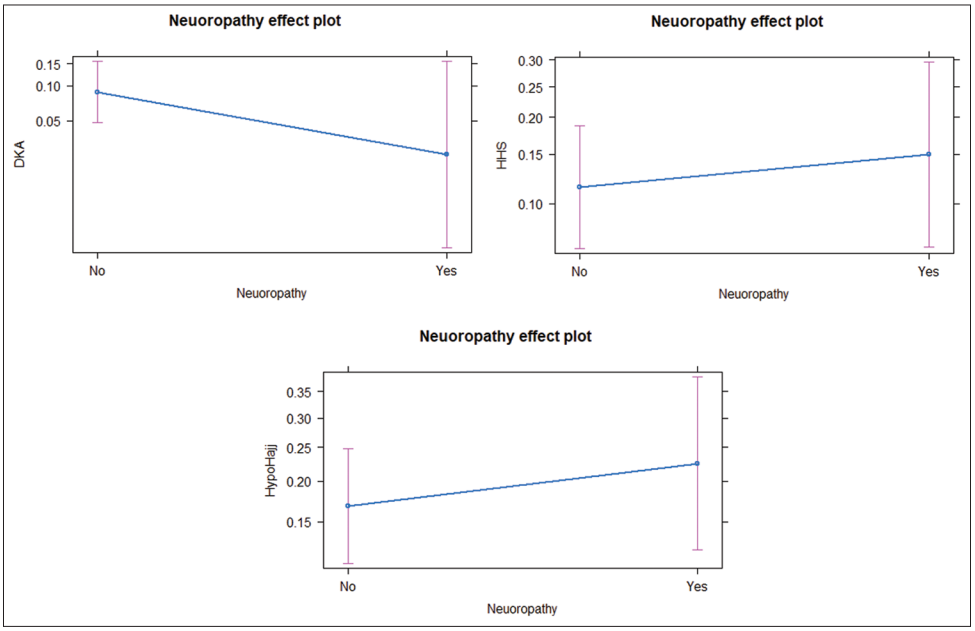

Figure 2: Neuropathy effect on DKA, HHS and hypoglycaemia among the pilgrims

Table 2: DKA and its association with clinical variables

Factor	Unadjusted Analysis				Adjusted Analysis			
	Number with DKA	Number without DKA	Chi-squared	*P*	Estimate	Odds	Standard error	*P*
Age								
15-30	8 (61.5%)	5 (38.5%)	54.305	< 0.0001	3.4159	30.44434	1.6873	0.0115
More than 30	3 (2.1%)	137 (97.9%)						
Diabetes Type			64.676	< 0.0001		0.082356		
Type 1	8 (72.7%)	3 (27.3%)			-2.4967		2.0100	0.0832
Type 2	3 (2.2%)	136 (97.8%)						
Diabetes duration						0.133467		
<10 years	7 (9.9%)	64 (90.1%)	0.767	0.3812	-2.0139		1.7552	0.2637
Over 10 years	4 (4.9%)	78 (95.1%)						
HbA1c	Mean=10.3%(89.1)	Mean=8.5%(69.4)	*t*=3.5294	0.08843	0.0455	1.046551	0.3945	0.9119
RBS						0.285732		
100-200 mg/dL	2 (3.7%)	52 (96.3%)	1.5335	0.4645	-1.2527		3.615	0.7230
<100 mg/dL	1 (10%)	9 (90%)			-0.2267		1.8490	0.9221
>200 mg/dL	8 (9%)	81 (91%)						
Retinopathy						0.79716		
Yes	8 (6.8%)	109 (93.2%)	0	1	-0.0262		1.6364	0.9899
No	3 (8.3%)	33 (91.7%)						
Neuropathy						0.97414		
Yes	10 (8.8%)	103 (91.2%)	0.96023	0.3271	0.3900		1.7256	0.8471
No	1 (2.5%)	39 (97.5%)						
Nephropathy						1.476981		
Yes	11 (7.7%)	131 (92.3%)	0.12418	0.7245	1.9742		2.3702	0.4758
No	0 (0%)	11 (100%)						

RBS: Random blood sugar, DM: Diabetes mellites, HbA1c: glycosylated haemoglobin, DR: diabetic retinopathy, DNP: diabetic nephropathy, DN: diabetic neuropathy, HTN: hypertension, SD: standard deviation, *n*: sample size, *P*: *P*<0.05 is the significance level, as tested by *t*-test, Chi-square and Fisher's exact, where appropriate

Table 3: HHS and its association with clinical variables

Factor	Unadjusted Analysis				Adjusted Analysis			
	Number with HHS	Number without HHS	Chi-squared	*P*	Estimate	Odds	Standard error	*P*
Age								
15-30	13 (100%)	0 (0%)	0.95987	0.3272	-17.07101	3.86	3228.25750	0.9958
More than 30	121 (86.4%)	19 (13.6%)				$\times 10^{-8}$		
Diabetes Type					17.9408	6.19	3761.7391	0.996
Type 1	11 (100%)	0 (0%)	0.70773	0.4002		$\times 10^{-7}$		
Type 2	120 (86.3%)	19 (13.7%)						
Diabetes duration					0.81221	2.253	1.60714	0.6133
<10 years	67 (94.4%)	4 (5.6%)	4.503	0.03383				
Over 10 years	67 (81.7%)	15 (18.3%)						
HbA1c	Mean=8.5 (69.4)	Mean=8.7 6 (72.2)	*t*=0.31181	0.7612	-0.02112	0.9791	0.40184	0.9581
RBS					23.33358	1.36	6522.63925	0.9971
100-200 mg/dL	8 (80%)	2 (20%)	3.7645	0.1522		$\times 10^{-10}$		
<100 mg/dL	51 (94.4%)	3 (5.6%)						
>200 mg/dL	75 (84.3%)	14 (15.7%)						
Retinopathy					3.97464	53.23	2.09414	0.0577.
No	105 (89.7%)	12 (10.3%)	1.3755	0.2409				
Yes	29 (80.6%)	7 (19.4%)						
Neuropathy					0.33610	1.399	1.34626	0.8029
No	100 (88.5%)	13 (11.5%)	0.08831	0.7663				
Yes	34 (85%)	6 (15%)						
Nephropathy					2.54080	12.69	1.56398	0.1043
No	126 (87.5%)	18 (12.5%)	1.1581	0.2819				
Yes	8 (88.9%)	1 (11.1%)						

RBS: Random blood sugar, DM: Diabetes mellites, HbA1c: glycosylated haemoglobin, DR: diabetic retinopathy, DNP: diabetic nephropathy, DN: diabetic neuropathy, HTN: hypertension, SD: standard deviation, *n*: sample size, *P*: *P*<0.05 is the significance level, as tested by *t*-test, Chi-square and Fisher's exact, where appropriate

Regarding HHS, 12.4% of the participants had an HHS episode. In our sample, the HHS could be related to different factors. The first factor is T2DM, as most of the study participants had T2DM and all the cases of HHS were presented in patients with T2DM. Second, old age could be a factor, as most of the HHS episodes (68.4%) in our study occurred in the elderly patients. This result is consistent with that of the previous research which reported that HHS is mainly presented in the elderly.[18] The third factor is CVD, as our

Table 4: Hypoglycaemia and its association with clinical variables

Factor	Unadjusted Analysis				Adjusted Analysis			
	Number with Hypoglycaemia	Number without Hypoglycaemia	Chi-squared	*P*	Estimate	Odds	Standard Error	*P*
Age								
15-30	2 (15.4%)	11 (84.6%)	1.48×10^{-30}	1	-17.0011	4.135 $\times 10^{-8}$	2681.1330	0.9949
More than 30	26 (18.6%)	114 (81.4%)						
Diabetes Type						1.387		
Type 1	1 (9.1%)	10 (90.9%)	0.19784	0.6565	16.44534	$\times 10^{-7}$	3251.90734	
Type 2	27 (19.4%)	112 (80.6%)						
Diabetes duration						0.90999		
<10 years	16 (22.5%)	55 (77.5%)	1.1043	0.2933	-0.09432		1.0881	0.931
Over 10 years	12 (14.6%)	70 (85.4%)						
HbA1c	Mean=7.875 (62.6)	Mean=8.821 (72.9)	*t*=1.4404	0.1897	-0.16012	0.85204	0.35353	0.651
RBS								
100-200mg/dL	8 (14.8%)	46 (85.2%)	48.053	3.667	37.8315	0.66965	3468.5703	0.9913
<100 mg/dL	10 (100%)	0 (0%)		$\times 10^{-11}$	-0.4010		0.5359	0.4543
>200 mg/dL	10 (11.2%)	79 (88.8%)						
Retinopathy						1.6743	0.5821	0.3759
No	22 (18.8%)	95 (81.2%)	0.0018915	0.9653	0.5154			
Yes	6 (16.7%)	30 (83.3%)						
Neuropathy						3.54948		
No	19 (16.8%)	94 (83.2%)	0.31509	0.5746	1.2668		0.5385	0.0187
Yes	9 (22.5%)	31 (77.5%)						
Nephropathy								
No	27 (19%)	115 (81%)	0.17246	0.6779	-18.4291	9.916 $\times 10^{-9}$	2381.6167	0.9938
Yes	1 (9.1%)	10 (90.9%)						

RBS: Random blood sugar, DM: Diabetes mellites, HbA1c: glycosylated haemoglobin, DR: diabetic retinopathy, DNP: diabetic nephropathy, DN: diabetic neuropathy, HTN: hypertension, SD: standard deviation, *n*: sample size, *P*: $P<0.05$ is the significance level, as tested by *t*-test, Chi-square and Fisher's exact, where appropriate

study showed that CVD was significantly associated with HHS. This result is in line with that of the previous research which reported that CVD was associated with HHS.[16] Moreover, 'use both oral medication and insulin' and 'diabetes duration for >10 years' were significantly associated with the development of HHS.

The Hajj season is often quite warm, and thirst develops quickly among the diabetic pilgrims, thereby increasing the risk of HHS. Hydration advice should be given to all the diabetic patients participating in Hajj and the risk of HHS should be explained to them. These results are relevant for all the family physicians practising during the Hajj season and caring for pilgrims with diabetes.

The current study found that 18.3% of the pilgrims with DM presented with hypoglycaemia. This is close to the 13% figure reported by Khogeer *et al*.[19] during the period of staying in Mina in the 1439 Hajj season. Probable reasons for this high rate are the increased physical effort and diet change during Hajj.[20]

Recommendations and Conclusion

This study aims to shed light on hyperglycaemia emergencies, hypoglycaemia, and its associated factors among patients with DM who participated in a pilgrimage at Mecca in 2019. Our sample of patients with DM comprised 7.2% with DKA, 12.4% with HHS and 18% with hypoglycaemia attacks. Further efforts are needed to promote awareness by holding health education sessions for patients with DM who wish to participate in Hajj, especially those who use insulin treatment and have longstanding diabetes. Furthermore, guidelines for health providers and patients with diabetes participating in Hajj are needed to prevent and manage the expected diabetes complications. Future research should be large-scale, involving collaboration with all medical missionaries, and be planned well before the arrival of the pilgrims.

Data Availability

Data can be provided by the corresponding author upon formal written request.

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Conflicts of interest

There are no conflicts of interest.

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