

Perceptions of, and Practices for Coping with, Heat Exposure among Male Arab Pilgrims to the Hajj, 1436

Zayid K. Al Mayahi, MD, DFE,¹  Ibrahim Ali Kabbash²

1. Resident Field Epidemiology Training Program, Riyadh, Kingdom of Saudi Arabia
2. Professor of Public Health & Community Medicine, Faculty of Medicine, Tanta University, Tanta, Egypt

Correspondence:

Zayid K. Al Mayahi, MD, DFE
 Medical Epidemiologist
 Disease Surveillance and Control
 South Batinah Ministry of Health
 Sultanate of Oman
 P.O. Box 543, P.C 329, Rustaq
 E-mail: almayahi96@hotmail.com

Conflicts of interest: none

Keywords: climate change; cross-sectional study; excessive heat; Hajj; heat exposure

Received: July 12, 2018

Revised: September 14, 2018

Accepted: September 29, 2018

doi:[10.1017/S1049023X19000025](https://doi.org/10.1017/S1049023X19000025)

Abstract

Background: The problems associated with exposure to excessive heat are a key health concern throughout the world, and are likely to become increasingly important as Earth's climate warms. Heat exposure is particularly problematic when large groups of people gather, but there is relatively little literature on the subject. Islam requires all adherents who are able to undertake a pilgrimage to Mecca (Saudi Arabia), known as the Hajj. This can result in huge numbers of pilgrims travelling to Mecca in the summer months, during which the temperatures can be very high, and to undertake physically demanding activities.

Objective: The aim of this study was to identify the perception level of heat-related health issues and the coping behaviors adopted by pilgrims in the face of excessive heat exposure.

Methods: A cross-sectional study was conducted in Mecca, Saudi Arabia among male Arab pilgrims performing Hajj of the Islamic calendar year 1436 (Summer 2015). Sample was divided into two strata: domestic pilgrims and international Arabs. A total of 14 camps were selected randomly, seven from each stratum. A total of 412 participants completed the questionnaire.

Results: Mean age was 43.48 (SD = 13.42) years. Majority of pilgrims had never performed Hajj before (68.2%). Almost 89.5% among pilgrims more than 40 years of age had more water intake compared to only 76.5% for people under 40 years. Only 7.3% of educated people used to go out at noon time, and almost two-fold of pilgrims with lower educational level did so (15.4%). Approximately 51.8% among those who were aware of Mecca's weather used cotton clothes, compared to 36.0% among pilgrims unaware of Mecca's weather.

Conclusion: This study reveals the extent of pilgrims' understanding of, and abilities to cope with, excessive heat and also suggests coping strategies and options for improved understanding of heat-related health issues world-wide.

Al Mayahi ZK, Ali Kabbash I. Perceptions of, and practices for coping with, heat exposure among male Arab pilgrims to the Hajj, 1436. *Prehosp Disaster Med.* 2019;34(2):161–174

Introduction

Heat exposure is a matter of significant global concern, so it is perhaps surprising that relatively few scholars have studied it specifically. Many countries report increasing volumes of morbidity and mortality secondary to heat exposure; for example, from 1999 through 2009 in the US, more than 7,800 deaths were caused or influenced by heat exposure.^{1–6} Exposure to excessive heat can affect brain, liver, kidney, and heart function, generating effects such as heat rash, heat cramp, heat syncope, heat exhaustion, and heat stroke.^{7–9}

The scientific community knows that Earth is getting warmer, due to human actions and atmospheric changes, and the average temperature globally has increased since the beginning of the last century.¹⁰ In the US, the National Centers for Environmental Information (NCEI; Asheville, North Carolina USA) has declared the years 2014 and 2015 to be the warmest recorded across global land and ocean surfaces since records began in 1880.¹¹

Studies have shown that people aged 65 years and older, those living in poverty, and the homeless have an elevated risk of heat-related health problems.^{12–15} The risk is also increased for patients with comorbidities; physiologically, the ability to cope with heat stress is primarily determined by the status of an individual's cardiovascular system, so the risk is significantly increased among patients with heart disease.¹⁶

Wherever large numbers of people gather, heat-related illnesses are often primary public health concerns, along with the risks of infectious disease, injuries, traffic accidents,

non-communicable disease, and terrorism.¹⁷ Clearly, heat-related health illnesses are a particular concern at mass gatherings in places with a hot climate. However, the literature contains relatively few studies of the effects of heat at such gatherings.¹⁷

Background and Study Objectives

The Arabian Peninsula, which falls mainly within the Kingdom of Saudi Arabia, is the largest peninsula in the world, with an extremely hot and arid climate. The annual Hajj season sees more than two million pilgrims, from all corners of the world, gather in a small area within Mecca (Saudi Arabia) for six days. Temperatures in Mecca can reach 50°C (122°F), and thus climate constitutes most of the overall heat load, although there is also heat dissipated from Hajj activities, including crowds, vehicular, and human activities.¹⁸

Mecca's Hajj experience has never been thoroughly evaluated, and there is a similar lack of research focusing on the effects of heat exposure and the perception of pilgrims. Just a few studies have explored the behavioral risk factors for important medical issues, including heat exhaustion and heat stroke, among pilgrims in Mecca over the past three decades. However, with the annual pilgrimage now set to coincide with the summer months of June, July, August, and September for many years to come, such knowledge is likely to be of increasing value, particularly to organizations concerned with public health. Therefore, any increase in understanding should help to minimize problems related to heat and health.

The annual pilgrimage (Hajj) in Mecca, Saudi Arabia is one of the essential pillars of the Islam religion. All Muslims in the world who are capable of doing so are required to visit Mecca for Hajj at least once in their lifetime. Thus, more than two million Muslims gather in this small city during the Arabic lunar calendar month of Dho Alhijja every year.

Pilgrims start to arrive in Mecca before the eighth day of Dho Alhijja, which marks the beginning of the formal six-day Hajj. During their pilgrimage, travelers must visit four specific sites in Mecca, and must do so during specified days and at particular times. The sites are Masjid Al Haram, Mina, Mozdalifa, and Arafat. The last three holy places are located to the east of Masjid Haram, and all sites are within 20 kilometers of each other.

Pilgrims spend their first night, that of the eighth of Dho Alhijja, in Mina, which is also known as "tent city" due to the sheer volume of pilgrims camping there. On the following day, pilgrims must go to Arafat, and they leave for Mozdalifa that evening. On the tenth of Dho Alhijja, pilgrims go back to Mina, where they spend the next three days performing the ritual "stoning of the devil" (also known as "stoning Jamarat").

In light of the above, the authors decided to carry out a cross-sectional study of male Hajj pilgrims in order to identify their perceptions of heat and related health issues, and their behavioral strategies for coping with the challenges of Mecca's climate. The setting of the study was the annual pilgrimage to Mecca in the Islamic calendar year 1436, which coincided with the western year 2015.

Methodology

A cross-sectional study was conducted in Mecca, Saudi Arabia. Data collection for the study reported here was carried out on the tenth, eleventh, and twelfth days of Dho Alhijja 1436 (September 23–25, 2015). These days were chosen because all pilgrims stay in Mina during these days, and so it was easier to find a good number of participants in the camps.

As the Hajj pilgrims come from all over the world and speak many different languages, it was impossible to cover all of the nations and languages represented at the Hajj through this study alone. Study participants were exclusively male Arab pilgrims; females were not included, due to cultural constraints.

The sample was selected by a one-stage, random stratifying method. Arab pilgrims were divided into two categories: domestic Arabs and international Arabs. Pilgrims from Saudi Arabia were considered domestic, whereas those from other Arabic countries were regarded as international. Arabic refers to the language; Arabic speaking country. At the Hajj, each camp site at Mina contains pilgrims from one country and has a unique number. A group of countries from the same region of the world may be hosted in the same area, and similarly applies to the domestic camps. For this study, a map of Mina, which was provided by the Ministry of Hajj Affairs (Kingdom of Saudi Arabia), was used to identify the locations of camps for Arab hajjis. It contained detailed information about the exact locations of all camps, along with their unique identifying numbers, pathways, and other important landmarks. When the authors had identified all Arabic and domestic camps, 14 camps were selected by a simple randomization method: seven from each category. Epi Info (version 7; Centers for Disease Control and Prevention [CDC]; Atlanta, Georgia USA) software was used to randomly select these camps.

The sample size was calculated as $N > 384$ subjects. This was calculated by Epi Info based on 95% confidence limits and the assumption that 50% of the participants were aware of the problems associated with excessive heat exposure and adopted healthy practices to cope with the heat. The sample size was increased, however, to 400 to compensate for missing data and non-responses.

A pre-designed, structured questionnaire was used for data collection. The first nine questions asked for socio-demographic information. The next seven questions explored the extent to which subjects understood heat exposure and associated health problems. The remaining 13 questions were designed to identify the coping practices adopted by the Arab pilgrims. The questionnaire contained closed questions, except for two which also contained a space for participants to fill with their own narrative.

The self-administered questionnaire was distributed over three days, during which pilgrims were staying in their camps in Mina. A total of 42 paper questionnaires were distributed in each camp. The extra papers were to compensate for losses, non-responses, and forms with significant missing data. The participants included in the Arabic international category were mainly from Egypt, Morocco, Lebanon, Sudan, and Somalia, whereas the hajjis in the domestic strategy were mainly Saudis and others belonging to different Arabic nationalities living in Saudi Arabia.

The questionnaire was distributed during daylight hours, and also in the evening; in short, whenever pilgrims were available at their tents. During these three days, pilgrims were constantly leaving the camp to undertake Jamarat stoning; therefore, they were not available all of the time, even when inside their camps. Many of them were out for Jamarat, and many of those who returned were exhausted and could not participate in the study. In some camps, pilgrims were angry due to (entirely unrelated) problems with logistics, and so refused to participate. In a very few cases, the camp managers were not co-operative. In such cases, the researcher had to wait for some time or come back later. In other cases, where the camps were completely inaccessible, adjacent camps were selected instead.

Before data were gathered from each camp, permission was secured from that camp’s manager. The choice of tents from those inside each camp was made by the manager himself, depending on the availability of pilgrims and their readiness to contribute by filling in the study questionnaire. For some camps, one tent contained a sufficient number of participants, whereas more than one tent was selected from other camps in order to achieve the desired sample.

Before a questionnaire was handed to them, the nature and objectives of this study were explained to each participant. After that, each participant was given one form and a pen. Further clarification was provided for those who asked for explanation of some questions. Participants unable to read and write were helped to complete the questionnaire, either by the researcher or by a fellow hajji. In total, 412 forms were completed by the participants.

The data thus collected were organized, tabulated, and statistically analyzed using IBM SPSS 21.0 (IBM Corp.; Armonk, New York USA). The numerical data were presented in terms of mean and standard deviation and the categorical data were presented as number and percentage. The chi-square was used to test for differences in sub-categories. The P value adopted was $P < .05$.

Witnessed verbal consent was secured from each participant. No pressure of any kind was exerted to encourage participation in this study. Data were collected anonymously and used only for the purposes of the study, and confidentiality of data was ensured throughout the study period.

This research was revised by the Field Epidemiology Training Program (FETP; Centers for Disease Control and Prevention [CDC]; Atlanta, Georgia USA) scientific board, as was accepted technically and ethically, and was also revised by the Institutional Review Board of the King Fahad Medical City, Ministry of Health (Kingdom of Saudi Arabia), as was approved ethically. The research was addressing behaviors of pilgrims in the public places and did not address any private behaviors.

Results

Table 1 describes the demographic characteristics of the study participants. Participants’ ages ranged from 14 to 77 years, with a mean age of 43.48 (SD = 13.42) years. Men in the age range of 30–60 years accounted for 67.2% of the total study participants, while the age groups least represented were below 20 and above 70 years, both groups contributing less than 4.0% of the total. Participants were mainly Saudis (40.5%), while Egyptians represented the second largest group at 20.9%. Participants from Morocco, Algeria, and Palestine were 9.7%, 8.7%, and 7.3%, respectively. The other Arab nationalities represented 12.0%, while for almost 0.9%, a nationality was not identified. Most participating hajjis were educated; approximately 56.3% had a university degree and 24.3% had finished secondary school. Almost one-third had professional occupations (31.3%), and 29.3% of participants worked in offices. Manual workers comprised just 3.9% of the total. When asked, 30.5% said that they were exposed to heat in the course of their work.

Table 2 shows the distribution of study participants in medical/clinical terms. Hypertension and diabetes mellitus were the most common chronic diseases among participants, with incidences of 17.7% and 12.1%, respectively. Almost 27.7% of participants reported that they regularly took medicines to treat chronic diseases. Predictably, many hajjis experienced excessive sweating (42.5%) and fatigability (36.4%) during their pilgrimage. Skin problems were also common; almost 30.1% had experienced skin inflammation and flushing. Approximately two-thirds reported at

Variables	Number (n = 412)	%
Age in Years:		
<20	8	1.9
20–	56	13.6
30–	101	24.5
40–	89	21.6
50–	87	21.1
60–	49	12.0
70±	8	1.9
Not Identified	14	3.4
Range	14–77	
Mean (SD)	43.48 (SD = 13.42)	
Nationality:		
Algerian	36	8.7
Egyptian	86	20.9
Moroccan	40	9.7
Palestinian	30	7.3
Saudi	167	40.5
Other Arab	49	12.0
Not Identified	4	0.9
Educational Level:		
Illiterate	3	0.7
Primary (Read & Write)	14	3.4
Intermediate	45	11.0
Secondary	100	24.3
University Level and Above	232	56.3
Not Identified	18	4.3
Job:		
Unemployed	16	3.9
Student	24	5.8
Manual Work	16	3.9
Office Work	121	29.3
Professional Work	129	31.3
Private Works	74	18.0
Retired	11	2.7
Not Identified	21	5.1
Exposure to High Heat during Work:		
Did Not Apply	32	7.8
No	254	61.7
Yes	126	30.5

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 1. Distribution of Studied Pilgrims According to Their Characteristics

least one of the following symptoms of headache, high body temperature, and dizziness. Only 17.5% of hajjis participating in the study had not experienced any symptoms.

Table 3 shows data related to previous and current Hajj visits. Most of the hajjis who completed the questionnaire (68.2%) had never performed Hajj before. Of those who had previously performed Hajj or Umra, a minor pilgrimage to Mecca performed at any time of the year, 53.9% had visited Mecca during the summer season. For their current Hajj visit, almost 49.0% of

Manifestations	Number (n = 412)	%
Having Chronic Illness:		
Diabetes	50	12.1
Hypertension	73	17.7
Cardiac Disease	25	6.1
Renal Disease	7	1.7
Lung Disease	14	3.4
Liver Disease	5	1.2
Rheumatology	38	9.2
Allergic Disease	10	2.4
Regular Use of Medication for a Chronic Illness		
Yes	114	27.7
No	273	66.3
Unidentified	25	6.1
Manifestations of High Temperature during Current Hajj:		
Fainting	13	3.2
Nausea and Vomiting	14	3.4
Skin Flushing	45	10.9
Dizziness	70	17.0
None	72	17.5
Muscle Pain	72	17.5
Skin Inflammation	79	19.2
Elevated Body Temperature	88	21.4
Headache	109	26.5
Fatigability	150	36.4
Excessive Sweating	175	42.5

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 2. Distribution of Participants in Relation to Experience of Chronic Illness and Manifestations of High Heat Exposure during Current Hajj

pilgrims had planned to stay in the area for at least two weeks. Pilgrims who had sought medical advice for problems secondary to heat exposure were almost 13.8% of the whole group.

Table 4 shows that 52.7% of participants came from areas generally colder than Mecca, and perhaps unsurprisingly, 80.6% were aware of Mecca's climate before their arrival. Over 50.0% considered elevated body temperature, excessive sweating, dizziness, fatigability, and headache to be the main manifestations of problematic heat exposure.

Participants were divided into two categories by age: less than 40 and more than 40 years of age. Respondents aged above 40 tended to cover their heads all of the time to a greater extent than those under 40 (26.0% versus 18.4%, respectively), and this difference was statistically significant ($P = .032$). In a similar way, older people drank water more frequently during Hajj compared to the younger age group ($P < .001$). Almost 89.5% of pilgrims aged over 40 said that their water intake had increased during Hajj, compared to 76.5% of people under 40 years old. However, participants older than 40 were more likely to venture outside at noon; approximately 16.4% of this group "always" went out at noon, whereas only 5.6% of younger pilgrims did so. This was statistically significant

Variables	Number (n = 412)	%
Previous Hajj or Umra Visits:		
Once	281	68.2
Two to Three Times	81	19.7
More than Three times	42	10.2
Not Identified	8	1.9
Timing of Previous Hajj or Umra:		
Summer	222	53.9
Autumn	52	12.6
Winter	28	6.8
Spring	14	3.4
Non-Response	96	23.3
Duration of Stay at Hajj This Year:		
Less than One Week	111	27.0
One Week	87	21.1
2 Weeks	20	4.9
3 Weeks	92	22.3
4 Weeks or More	90	21.8
Not Identified	12	2.9
Visiting Health Care Facility during Current Hajj	57	13.8

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 3. Distribution of Studied Pilgrims in Relation to Previous and Current Hajj Visits

($P = .005$). Similarly, people older than 40 tended to visit the Haram Mosque more frequently than younger participants did. Only 11.4% among the older group said they never walked, while 52.1% of them had made frequent visits to the Haram Mosque. In contrast, just 21.8% of the other younger age group visited the mosque frequently on foot, and almost 22.3% had never walked to Haram. This was, again, statistically significant ($P < .001$).

In spite of the difficulties they faced during Hajj, some pilgrims also carried heavy objects for different purposes: food, sleeping, transport, and personal properties. Almost 6.8% of pilgrims over 40 years of age always carried heavy objects, compared with 3.4% of younger pilgrims. Thus, this practice was twice as common among pilgrims over 40 years of age, with a significant P value of .015. Differences between the groups in terms of clothing, the use of umbrellas, and the frequency of taking showers were all insignificant, as Table 5 illustrates.

Nationalities were further classified into three groups: Saudis, African Arabs, and Asian Arabs. Arabs from African countries showed more positive, helpful practices regarding the types of clothing worn and use of head coverings compared to the other two groups. Almost 62.2% of African Arabs only used clothes made of cotton. Cotton clothes were less-widely used by Asian Arabs and Saudis, at 48.2% and 38.3%, respectively, and this was statistically significant ($P < .001$). Head cover use was also more common among African Arabs ($P = .004$). Approximately 27.0% of this group stated that they always covered their heads, whereas only 19.8% and 10.7% of the Saudi and Asian groups, respectively, did so.

Variables	Number (n = 412)	%
Exposure to Hot Weather at Home:		
Less than Mecca	217	52.7
Similar to Mecca	156	38.0
More than Mecca	28	6.8
No Response	11	2.5
Aware of High Heat Exposure at Mecca	332	80.6
Reported Manifestations of Heat Exposure:		
None	49	11.9
Elevated Body Temperature	228	55.3
Skin Inflammation	110	26.7
Diarrhea	47	11.4
Excessive Sweating	265	64.3
Dizziness	217	52.7
Fatigability	233	56.6
Headache	222	53.9
Loss of Hair	13	3.2
Muscle Pain	52	12.6
Nausea and Vomiting	98	23.8
Coma	177	43.0
Skin Flushing	177	43.0
Abdominal Pains	35	8.5

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 4. Participants' Home Climates, Plus Awareness of Mecca's Climate and Heat Exposure Symptoms

Going out of one's residence at noon was seen more frequently among African Arabs (18.9%) than Saudis (3.6%) and Asian Arabs (8.9%). This was statistically significant ($P < .001$). Similarly, a significant P value of $< .001$ was present with the frequency of walking to the Haram Mosque. This was highest among African Arabs, of whom almost 60.5% "frequently" walked to Haram Mosque, compared to 41.1% and 13.8% of Asian Arabs and Saudis, respectively.

Most of the pilgrims, from all three groups, didn't carry heavy objects. However, approximately 8.9% of Asian Arabs and 7.6% of African Arabs "always" carried heavy objects, compared to just 1.8% of Saudis who did so. This was again statistically significant ($P = .017$). The remaining variables didn't show any significant differences between nationalities, as [Table 6](#) shows.

In terms of education, the Arab pilgrims were categorized into two groups. The first group included all Arab pilgrims without a university degree; the second included those educated to university level and above. Significantly, the second (more extensively educated) group showed better water intake; almost 86.6% increased their water intake during Hajj days, while 79.0% of those less educated increased their water intake ($P = .014$). Similarly, participants with a university degree appeared more inclined to stay within their residences at noon time, when the heat reaches its maximum level. Only 7.3% of the more highly educated participants "always" went out at noon, yet almost twice as many (15.4%) of the pilgrims with less education did so. This result was again significant ($P = .048$). Pilgrims with less education carried heavy objects significantly more frequently than pilgrims with higher

education: 33.3% and 20.7%, respectively ($P = .009$). Insignificant differences were found with regard to the clothing, head cover and umbrella use, frequency of taking showers, and walking to the Haram Mosque; [Table 7](#) illustrates.

The link between workplace exposure to heat and heat-related behavior at the Hajj seemed very limited. Of 254 pilgrims who didn't experience heat exposure at work, 7.1% always carried heavy objects when they moved around Mecca's holy places. However, only 2.4% of 126 pilgrims who experienced heat exposure at work always carried heavy objects. This was statistically significant (P value = .013); [Table 8](#) illustrates this point.

The presence of comorbidities was, in this study, signaled by the participants' regular use of medications. Thus, Arab pilgrims were categorized into two groups according to their use (or otherwise) of medications. Notably, the wearing of clothes made of cotton was more common among pilgrims with comorbidities (61.4%). Only 46.2% of the other group, those deemed to be without comorbidities, used this type of clothing. This was statistically significant ($P = .030$). Though the use of umbrellas was quite similar in both groups, pilgrims who didn't have comorbidities appeared to use umbrellas more, with almost 48.7% of them stating that they "sometimes" used one, compared to 39.5% among pilgrims with comorbidities ($P = .017$). Frequency of walking to the Haram Mosque was higher for pilgrims with comorbidities than it was for those without. Almost 11.4% of the pilgrims who had comorbidities didn't walk to the Masjid Haram, while 46.5% walked "frequently" ($P = .019$). Carrying heavy objects was significantly more common among the group with comorbidities (32.5%) than for the group without (22.3%; $P < .001$). [Table 9](#) illustrates this in more detail.

Carrying heavy objects while moving between holy places during Hajj days was significantly associated with the experience of previous visits. Almost 81.3% of pilgrims who had made two previous visits or more never carried heavy objects during the Hajj, and only 1.6% stated that they always did. This behavior was significantly different to that of those participants for whom this was their first Hajj. Of first-time pilgrims, 68.3% never carried heavy objects, while 7.1% always did ($P = .025$). [Table 10](#) provides further detail.

There seemed to be a strong link between the extent to which pilgrims were aware of Mecca's weather and the types of clothing worn. Approximately 51.8% of those who were aware of Mecca's weather wore cotton clothes. However, cotton clothing was used only by 36.0% of those pilgrims who declared themselves unaware of Mecca's climate. Statistically, this difference was significant (P value = .023). [Table 11](#) provides further detail.

Discussion

Heat exposure is one of the most serious health issues encountered at mass gatherings of people. Physiologically, when the body temperature goes beyond 40°C (104°F), rapid cellular damage takes place that leads ultimately to a series of multi-system failures and possibly death.¹⁹ Unfortunately, the literature does not contain much research on the effects of exposure to extremely high heat loads.

The authors have identified five previous studies, conducted in 1995, 1998, 2002, and 2008, that identify behavioral risk factors for disease in Mecca, including heat exhaustion. Those studies focused on various factors, such as subjects' means of transport to Mecca, frequency of walking between the holy places, umbrella use, time spent inside the tent or building, and the effects of comorbidities.^{20–24} In contrast, this study deals specifically with

Variables	Age ≤40 (n = 179)		Age >40 (n = 219)		X ²	P
	n	%	n	%		
Type of Clothes:					7.043	.071
Cotton Only	77	43.0	123	56.2		
Synthetic Fabrics	8	4.5	9	4.1		
Cotton with Synthetic Fabrics	56	31.3	50	22.8		
No Response	38	21.2	37	16.9		
Wearing Head Cover:					10.587	.032*
Never	57	31.8	53	24.2		
Rarely	23	12.8	15	6.8		
Sometimes	63	35.2	85	38.8		
Always	33	18.4	57	26.0		
No Response	3	1.7	9	4.1		
Use of Umbrella:					6.990	.136
Never	47	26.3	68	31.1		
Rarely	28	15.6	26	11.9		
Sometimes	84	46.9	96	43.8		
Always	18	10.1	18	8.2		
No Response	2	1.1	11	5.0		
Frequency of Taking Showers:					5.034	.169
Daily	121	67.6	137	62.6		
2-3 Times/Week	51	28.5	65	29.7		
<Once/Week	5	2.8	6	2.7		
No Response	2	1.1	11	5.0		
Drinking Water During hajj:					21.618	<.001*
Less than Usually	13	7.3	2	0.9		
Same as Usually	27	15.1	14	6.4		
More than Usually	137	76.5	196	89.5		
No Response	2	1.1	7	3.2		
Out of Residence at Noon:					15.008	.005*
Never	33	18.4	43	19.6		
Rarely	56	31.3	45	20.5		
Sometimes	76	42.5	92	42.0		
Always	10	5.6	36	16.4		
No Response	4	2.2	3	1.4		
Frequency of Walking to Mosque:					49.211	<.001*
Never	40	22.3	25	11.4		
Rarely	34	19.0	12	5.5		
Sometimes	22	12.3	25	11.4		
Often	28	15.6	33	15.1		
Frequently	39	21.8	114	52.1		
No Response	16	8.9	10	4.6		
Carrying Heavy Objects:					10.426	.015
No	144	80.4	146	66.7		
Sometimes	27	15.1	50	22.8		
Always	6	3.4	15	6.8		
No Response	2	1.1	8	3.7		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 5. Distribution of Studied Pilgrims by Age and Practices Related to Excessive Heat Exposure

Variables	Saudi (n = 167)		African Arabs (n = 185)		Asian Arabs (n = 56)		X ²	P
	n	%	n	%	n	%		
Type of Clothes:								
Cotton Only	64	38.3	115	62.2	27	48.2	28.407	<.001*
Synthetic Fabrics	10	6.0	8	4.3	0	0.0		
Cotton with Synthetic Fabrics	60	35.9	33	17.8	13	23.2		
No Response	33	19.8	29	15.7	16	28.6		
Wearing Head Cover:								
Never	49	29.3	45	24.3	19	33.9	22.614	.004*
Rarely	27	16.2	10	5.4	3	5.4		
Sometimes	54	32.3	72	38.9	25	44.6		
Always	33	19.8	50	27.0	6	10.7		
No Response	4	2.4	8	4.3	3	5.4		
Use of Umbrella:								
Never	56	33.5	44	23.8	16	28.6	11.337	.183
Rarely	23	13.8	25	13.5	8	14.3		
Sometimes	68	40.7	90	48.6	27	48.2		
Always	17	10.2	15	8.1	5	8.9		
No Response	3	1.8	11	5.9	0	0.0		
Frequency of Taking Showers:								
Daily	106	63.5	122	65.9	39	69.6	3.802	.704
2-3 Times/Week	51	30.5	49	26.5	15	26.8		
<Once/Week	4	2.4	5	2.7	2	3.6		
No Response	6	3.6	9	4.9	0	0.0		
Drinking Water during Hajj:								
Less than Usually	9	5.4	5	2.7	1	1.8	12.300	.056
Same as Usually	25	15.0	12	6.5	4	7.1		
More than Usually	130	77.8	163	88.1	48	3.0		
No Response	3	1.8	5	2.7	3	5.4		
Out of Residence at Noon:								
Never	38	22.8	29	15.7	10	17.9	32.649	<.001*
Rarely	51	30.5	32	17.3	20	35.7		
Sometimes	70	41.9	85	45.9	19	33.9		
Always	6	3.6	35	18.9	5	8.9		
No Response	2	1.2	4	2.2	2	3.6		
Frequency Walking to Mosque:								
Never	46	27.5	15	8.1	6	10.7	99.790	<.001*
Rarely	34	20.4	8	4.3	6	10.7		
Sometimes	24	14.4	18	9.7	6	10.7		
Often	24	14.4	27	14.6	11	19.6		
Frequently	23	13.8	112	60.5	23	41.1		
No Response	16	9.6	5	2.7	4	7.1		
Carrying Heavy Objects:								
No	135	80.8	122	65.9	37	66.1	15.512	.017*
Sometimes	28	16.8	42	22.7	12	21.4		
Always	3	1.8	14	7.6	5	8.9		
No Response	1	0.6	7	3.8	2	3.6		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 6. Distribution of Participants by Nationality and Practices Related to Excessive Heat Exposure

Variables	Educational Level				X ²	P
	Below University (n = 162)		University (n = 232)			
	n	%	n	%		
Type of Clothes:					5.657	.130
Cotton Only	72	44.4	126	54.3		
Synthetic Fabrics	9	5.6	8	3.4		
Cotton with Synthetic Fabrics	43	26.5	61	26.3		
No Response	38	23.5	37	15.9		
Wearing Head Cover:					6.505	.164
Never	41	25.3	68	29.3		
Rarely	15	9.3	25	10.8		
Sometimes	59	36.4	84	36.2		
Always	38	23.5	52	22.4		
No Response	9	5.6	3	1.3		
Use of Umbrella:					5.288	.259
Never	56	34.6	60	25.9		
Rarely	21	13.0	30	12.9		
Sometimes	64	39.5	113	48.7		
Always	14	8.6	23	9.9		
No Response	7	4.3	6	2.6		
Frequency of Taking Showers:					2.920	.404
Daily	104	64.2	156	67.2		
2-3 Times/Week	44	27.2	65	28.0		
<Once/Week	7	4.3	4	1.7		
No Response	7	4.3	7	3.0		
Drinking Water during Hajj:					10.693	.014*
Less than Usually	9	5.6	7	3.0		
Same as Usually	17	10.5	23	9.9		
More than Usually	128	79.0	201	86.6		
No Response	8	4.9	1	0.4		
Out of Residence at Noon:					9.600	.048*
Never	32	19.8	45	19.4		
Rarely	33	20.4	68	29.3		
Sometimes	69	42.6	100	43.1		
Always	25	15.4	17	7.3		
No Response	3	1.9	2	0.9		
Frequency Walking to Mosque:					11.914	.036*
Never	24	14.8	43	18.5		
Rarely	17	10.5	30	12.9		
Sometimes	12	7.4	35	15.1		
Often	23	14.2	38	16.4		
Frequently	74	45.7	73	31.5		
No Response	12	7.4	13	5.6		
Carrying Heavy Objects:					11.466	.009*
No	103	63.3	182	78.4		
Sometimes	43	26.5	38	16.4		
Always	11	6.8	10	4.3		
No Response	5	3.1	2	0.9		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 7. Distribution of Participants by Educational Level and Practices Related to Excessive Heat Exposure

Variables	Exposure to Heat at Work				χ ²	P
	NO (n = 254)		YES (n = 126)			
	n	%	n	%		
Type of Clothes:					6.925	.074
Cotton Only	132	52.0	60	47.6		
Synthetic Fabrics	12	4.7	6	4.8		
Cotton with Synthetic Fabrics	71	28.0	27	21.4		
No Response	39	15.4	33	26.2		
Wearing Head Cover:					2.684	.612
Never	69	27.2	38	30.2		
Rarely	24	9.4	14	11.1		
Sometimes	96	37.8	46	36.5		
Always	58	22.8	22	17.5		
No Response	7	2.8	6	4.8		
Use of Umbrella:					4.024	.403
Never	74	29.1	36	28.6		
Rarely	29	11.4	21	16.7		
Sometimes	124	48.8	51	40.5		
Always	22	8.7	15	11.9		
No Response	5	2.0	3	2.4		
Frequency of Taking Showers:					1.348	.718
Daily	161	63.4	86	68.3		
2-3 Times/Week	79	31.1	32	25.4		
<Once/Week	7	2.8	4	3.2		
No Response	7	2.8	4	3.2		
Drinking Water during Hajj:					0.567	.904
Less than Usually	10	3.9	5	4.0		
Same as Usually	24	9.4	11	8.7		
More than Usually	215	84.6	106	84.1		
No Response	5	2.0	4	3.2		
Out of Residence at Noon:					8.067	.089
Never	57	22.4	18	14.3		
Rarely	67	26.4	30	23.8		
Sometimes	106	41.7	58	46.0		
Always	20	7.9	19	15.1		
No Response	4	1.6	1	0.8		
Frequency Walking to Mosque:					0.858	.973
Never	43	16.9	18	14.3		
Rarely	28	11.0	16	12.7		
Sometimes	29	11.4	14	11.1		
Often	42	16.5	19	15.1		
Frequently	96	37.8	50	39.7		
No Response	16	6.3	9	7.1		
Carrying Heavy Objects:					10.748	.013*
No	189	74.4	89	70.6		
Sometimes	45	17.7	28	22.2		
Always	18	7.1	3	2.4		
No Response	2	0.8	6	4.8		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 8. Distribution by Exposure to Heat at Work and Practices Related to Excessive Heat Exposure

Variables	Comorbidity				X ²	P
	NO (n = 273)		YES (n = 114)			
	n	%	n	%		
Type of Clothes:					8.922	.030*
Cotton Only	126	46.2	70	61.4		
Synthetic Fabrics	15	5.5	2	1.8		
Cotton with Synthetic Fabrics	79	28.9	23	20.2		
No Response	53	19.4	19	16.7		
Wearing Head Cover:					3.690	.450
Never	73	26.7	36	31.6		
Rarely	28	10.3	11	9.6		
Sometimes	102	37.4	36	31.6		
Always	62	22.7	24	21.1		
No Response	8	2.9	7	6.1		
Use of Umbrella:					12.022	.017*
Never	72	26.4	35	30.7		
Rarely	39	14.3	15	13.2		
Sometimes	133	48.7	45	39.5		
Always	25	9.2	10	8.8		
No Response	4	1.5	9	7.9		
Frequency of Taking Showers:					6.498	.090
Daily	181	66.3	74	64.9		
2-3 Times/Week	78	28.6	29	25.4		
<Once/Week	4	1.5	7	6.1		
No Response	10	3.7	4	3.5		
Drinking Water during Hajj:					4.206	.240
Less than Usually	10	3.7	4	3.5		
Same as Usually	25	9.2	15	13.2		
More than Usually	235	86.1	91	79.8		
No Response	3	1.1	4	3.5		
Out of Residence at Noon:					9.543	.049
Never	46	16.8	29	25.4		
Rarely	81	29.7	18	15.8		
Sometimes	112	41.0	51	44.7		
Always	30	11.0	14	12.3		
No Response	4	1.5	2	1.8		
Frequency Walking to Mosque:					13.562	.019*
Never	51	18.7	13	11.4		
Rarely	38	13.9	5	4.4		
Sometimes	31	11.4	15	13.2		
Often	40	14.7	22	19.3		
Frequently	95	34.8	53	46.5		
No Response	18	6.6	6	5.3		
Carrying Heavy Objects:					22.753	<.001*
No	211	77.3	69	60.5		
Sometimes	46	16.8	31	27.2		
Always	15	5.5	6	5.3		
No Response	1	0.4	8	7.0		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 9. Distribution of Studied Pilgrims in Relation to Their Comorbidities and Practices Related to Excessive Heat Exposure

Variables	One-Time Visit (n = 281)		Two Visits & More (n = 123)		χ^2	P
	n	%	n	%		
Type of Clothes:					1.397	.706
Cotton Only	143	50.9	63	51.2		
Synthetic Fabrics	13	4.6	5	4.1		
Cotton with Synthetic Fabrics	68	24.2	35	28.5		
No Response	57	20.3	20	16.3		
Wearing Head Cover:					6.182	.186
Never	85	30.2	27	22.0		
Rarely	27	9.6	13	10.6		
Sometimes	103	36.7	47	38.2		
Always	55	19.6	34	27.6		
No Response	11	3.9	2	1.6		
Use of Umbrella:					1.781	.776
Never	82	29.2	31	25.2		
Rarely	40	14.2	15	12.2		
Sometimes	125	44.5	58	47.2		
Always	25	8.9	13	10.6		
No Response	9	3.2	6	4.9		
Frequency of Taking Showers:					1.172	.760
Daily	186	66.2	79	64.2		
2-3 Times/Week	76	27.0	37	30.1		
<Once/Week	9	3.2	2	1.6		
No Response	10	3.6	5	4.1		
Drinking Water during Hajj:					4.062	.255
Less than Usually	14	5.0	3	2.4		
Same as Usually	28	10.0	10	8.1		
More than Usually	230	81.9	109	88.6		
No Response	9	3.2	1	0.8		
Out of Residence at Noon:					6.674	.154
Never	46	16.4	30	24.4		
Rarely	73	26.0	29	23.6		
Sometimes	121	43.1	53	43.1		
Always	35	12.5	11	8.9		
No Response	6	2.1	0	0.0		
Frequency Walking to Mosque:					7.699	.174
Never	47	16.7	20	16.3		
Rarely	35	12.5	14	11.4		
Sometimes	27	9.6	21	17.1		
Often	40	14.2	21	17.1		
Frequently	117	41.6	38	30.9		
No Response	15	5.3	9	7.3		
Carrying Heavy Objects:					9.366	.025*
No	192	68.3	100	81.3		
Sometimes	62	22.1	20	16.3		
Always	20	7.1	2	1.6		
No Response	7	2.5	1	0.8		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 10. Distribution of Studied Pilgrims in Relation to the Number of Hajj Visits and Practices Related to Excessive Heat Exposure

Variables	Awareness about Mecca's weather				χ^2	p
	NO (n = 50)		YES (n = 332)			
	n	%	n	%		
Type of Clothes:					9.550	.023*
Cotton Only	18	36.0	172	51.8		
Synthetic Fabrics	3	6.0	15	4.5		
Cotton with Synthetic Fabrics	12	24.0	90	27.1		
No Response	17	34.0	55	16.6		
Wearing Head Cover:					6.163	.187
Never	20	40.0	86	25.9		
Rarely	5	10.0	31	9.3		
Sometimes	12	24.0	131	39.5		
Always	11	22.0	75	22.6		
No Response	2	4.0	9	2.7		
Use of Umbrella:					3.279	.512
Never	16	32.0	90	27.1		
Rarely	8	16.0	44	13.3		
Sometimes	22	44.0	156	47.0		
Always	2	4.0	35	10.5		
No Response	2	4.0	7	2.1		
Frequency of Taking Showers:					4.257	.235
Daily	30	60.0	223	67.2		
2-3 Times/Week	15	30.0	96	28.9		
<Once/Week	3	6.0	6	1.8		
No Response	2	4.0	7	2.1		
Drinking Water during Hajj:					4.919	.178
Less than Usually	4	8.0	11	3.3		
Same as Usually	4	8.0	33	9.9		
More than Usually	40	80.0	284	85.5		
No Response	2	4.0	4	1.2		
Out of Residence at Noon:					4.521	.340
Never	13	26.0	57	17.2		
Rarely	14	28.0	83	25.0		
Sometimes	20	40.0	146	44.0		
Always	3	6.0	39	11.7		
No Response	0	0.0	7	2.1		
Frequency Walking to Mosque:					4.826	.438
Never	12	24.0	51	15.4		
Rarely	5	10.0	39	11.7		
Sometimes	5	10.0	38	11.4		
Often	9	18.0	53	16.0		
Frequently	14	28.0	131	39.5		
No Response	5	10.0	20	6.0		
Carrying Heavy Objects:					2.528	.470
No	38	76.0	239	72.0		
Sometimes	11	22.0	66	19.9		
Always	1	2.0	20	6.0		
No Response	0	0.0	7	2.1		

Al Mayahi © 2019 Prehospital and Disaster Medicine

Table 11. Distribution of Studied Pilgrims in Relation to Their Awareness of Mecca's Weather and Practices Related to Excessive Heat Exposure

the perception of, and coping practices used to cope with, excessive heat exposure among Arab pilgrims.

The present study found that most participants were educated, and only one-third of them experienced heat exposure at work. Generally, pilgrims' level of awareness concerning Mecca's weather and problems resulting from heat exposure requires improvement. The percentage of pilgrims with comorbidities in this study was similar to that identified in a previous study, conducted in 2008.²⁴ Moreover, hypertension and diabetes are the most common comorbidities in the present study, and the same finding was found in a previous, similar study.²³ In the present study, the majority of participants were performing Hajj for the first time. Three previous studies showed almost the same percentage of pilgrims who had performed Hajj for the first time as was found in the present study.^{20-22,24}

The Role of Age

People aged above 65 years are more likely to develop heat-related illnesses, as previous studies have found.¹²⁻¹⁵ In this study, pilgrims over 40 years old showed better health-related practices, including greater use of head cover and drinking more water. However, they also tended to carry heavy objects, go out at noon, and visit the Masjid Al Haram more frequently, all of which may expose them to health hazards arising from the heat and humidity of Mecca City during the Hajj.

The Role of Nationality

There was clear variation between the three nationality groups (African, Asian, and Saudi) into which pilgrims were divided, in terms of their practices for coping with excessive heat exposure in Mecca. For instance, wearing suitable clothes and using head cover were strategies prominent among pilgrims from African countries. However, members of this group were also more likely to go outside their residence at noon. Saudis were the least likely to carry heavy objects during Hajj rituals. A previous study in 2002 revealed similar findings, whereby those who walked between holy places were mostly from the Indian sub-continent, sub-Saharan Africa, and Arabs other than those from countries in the Gulf Co-operation Council (GCC; Riyadh, Saudi Arabia).²³ These differences reflect the various independent ideologies, cultures, and customs of many nationalities.

The Role of Education

A 1995 study found no association between educational level and heat exhaustion.²⁰ However, the study presented in this paper suggests that pilgrims did have different responses to heat exposure based on their level of education. Those with a high-level of education had a higher water intake and appeared more inclined to stay within their residence at noon, when the heat is extremely high. This may indicate that a higher level of education is associated with awareness of risks and greater compliance with proper coping strategies than is the case for those less-educated.

The Role of Heat Exposure at Work

Pilgrims who experienced heat exposure at their work places showed better health practices in terms of carrying heavy objects while moving between the holy places in Mecca. It seems that those usually exposed to excessive heat at work had well-established coping strategies that they had adopted in order to continue work while exposed to high temperatures, and when in Mecca, these individuals were more likely to adopt the same strategies to cope with high temperatures during Hajj.

The Role of Comorbidities

The ability of human beings to dissipate heat from the body resides mainly in the effective cardiovascular system.¹⁶ However, many chronic medical problems increase the adverse effects of heat stress, and prominent among these are diabetes mellitus and malnutrition. Results from this study show that pilgrims with comorbidities appear to have adopted better health practices in some aspects; for example, they tended to wear suitable clothes and to make greater use of umbrellas. Unexpectedly, they also appeared to carry heavy objects more frequently than pilgrims without chronic medical issues, which could be a risk factor exposing them to more stress and elevated risk of dehydration than would otherwise have been the case.

Previous Visits to Mecca and Awareness of Mecca's Climate

As might be expected, pilgrims who had previously visited Mecca managed themselves better in terms of practices beneficial to health in the face of heat exposure. Thus, it seems that their previous experiences and knowledge had conveyed benefits. Experienced visitors to Mecca travelled on foot less often and preferred not to carry any heavy objects while performing Hajj rituals. They were also more inclined than less-experienced travelers to wear cotton clothes. Understandably, new comers to Mecca are not yet familiar with the walkways and streets in Mina, in particular, and sometimes lose their way. This echoes a previous study which showed that pilgrims who lose their way in Mina are at higher risk of heat exhaustion.²⁰

Pilgrims' use of protective coping strategies was primarily influenced by age, nationality, education, and comorbidities, while other factors had less effect.

The available literature, although limited, does indicate that there is an increasing risk of excessive heat exposure world-wide, and particularly in places with a hot climate. Mass gatherings and highly congested areas are believed to increase the risk of those present acquiring illnesses secondary to heat exposure. The average temperature globally has been slowly increasing for a long time, and this heat increase is in addition to the heat dissipated from other resources. Global warming, whereby extra heat is released from burning fossil fuels such as coal, oil, and natural gas, is also causing average temperatures to increase.^{6,25,26}

If pilgrims are to be protected from the damaging effects of heat, the Hajj season in Mecca should be assessed thoroughly and appropriate measures should be taken to minimize heat exposure. Simultaneously, the level of awareness among interested parties must be improved. For example, pilgrims need to understand — in depth — the complications that may arise from excessive heat exposure, and to learn to deploy appropriate, healthy behaviors.

Previous studies have shown that older people and those with comorbidities are at higher risk of developing illnesses and complications of heat exposure.¹²⁻¹⁶ This study suggests that by improving the perception and coping levels of pilgrims, many cases of morbidity and mortality could be avoided.

In light of this study and its findings, the following action are recommended:

1. Hajj pilgrims should, before coming to Mecca, be informed and educated about its climate, geography, and the distribution of camps, walkways, and exits.
2. The dangers and complications of exposure to excessive heat, particularly among older people and those with comorbidities, should be emphasized and explained to all coming pilgrims.

3. Health providers in pilgrims' home countries, travel agents, and Hajj authorities should recommend the use of appropriate behaviors. For example, pilgrims should be advised to wear light clothes and cover the head, to use umbrellas, drink sufficient water, stay protected from direct sunlight, and not to carry unnecessarily heavy objects. And,
4. A positively healthy culture could be encouraged by distribution of posters throughout Mecca, but particularly inside the camps in Mina. Posters should encourage healthy behaviors in the face of heat exposure.

Limitations of the Study

Results from this study reflect the experiences of male Arabic pilgrims when dealing with excessive heat exposure in Mecca. Therefore, results may not be generalized to pilgrims from outside the Arabic region.

This survey-based research was subjected to unknown errors related to pilgrims' various perceptions towards Hajj services in Mecca, social media effects, cultural and background differences,

missing of data, and stressful activities and rituals during pilgrimage season.

Conclusion

There is a clear and pressing need for improvement of Hajj pilgrims' knowledge of, and behavior in the response to, excessive heat exposure. This study shows that their coping strategies were influenced mainly by age, nationality, level of education, and the presence or otherwise of comorbidities.

Acknowledgment

The lead author would like to thank all the advisors in the Field Epidemiology Training Program: Dr. Randa Nooh, Dr. Abdel Jamil Choudhry, Dr. Fahad Alswaidi, Dr. Hassan El Bushra, and Dr. Mohammed Nageeb for their close supervision, support, and guidance to complete this research.

Also, gratitude to all colleagues in the training program: Dr. Ahmed Alghumgham, Dr. Mohammed Al Semayen, Dr. Mohammed Al Essa, and Dr. Hassan Al Hawaj. The support of Mecca's Health directorate was also appreciated greatly.

References

1. Lindstrom S, Nagalingam V, Newnham H. Impact of the 2009 Melbourne heat wave on a major public hospital. *Intern Med J*. 2013;43(11):1246–1250.
2. Lowe D, Ebi K, Forsberg B. Heat wave early warning systems and adaptation advice to reduce human health consequences of heat waves. *Int J Environ Res Public Health*. 2011;8(12):4623–4648.
3. Rocklöv J, Forsberg B. The effect of temperature on mortality in Stockholm 1998–2003: a study of lag structures and heat wave effects. *Scand J Public Health*. 2008; 36(5):516–523.
4. Toloo G, FitzGerald G, Aitken P, Verrall K, Tong S. Evaluating the effectiveness of heat warning systems: systematic review of epidemiological evidence. *Int J Public Health*. 2013;58(5):667–681.
5. Williams S, Nitschke M, Parton K, Weinstein P, Bi P. The impact of summer temperatures and heat waves on mortality and morbidity in Perth, Australia 1994–2008. *Environ Int*. 2012;40:33–38.
6. Karl T, Melillo J, Peterson T, (eds). *Global Climate Change Impacts in the United States*. New York USA: Cambridge University Press; 2009.
7. Mo W, Gao X, Liu GP, et al. Heat-related illness in Jinshan District of Shanghai: a retrospective analysis of 70 patients. *World J Emerg Med*. 2014;5(4):286–290.
8. Simon H. Hyperthermia. *N Eng J Med*. 1993;329(7):483–487.
9. Sithinamsuwan P, Piyavechviratana K, Kitthaweesin T, et al. Exertional heatstroke: early recognition and outcome with aggressive combined cooling — a 12-year experience. *Mil Med*. 2009;174(5):496–502.
10. Centers for Disease Control and Prevention. *Climate Change and Extreme Heat Events*. <http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf>. Accessed April 28, 2016.
11. National Centers for Environmental Information. *Global Climate Report — Annual 2015*. <http://www.ncdc.noaa.gov/sotc/global/201513>. Accessed July 26, 2016.
12. United States Environmental Protection Agency. *Excessive Heat Events Guidebook*. Washington, DC USA: Environmental Protection Agency; 2006.
13. Basu R, Samet J. Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. *Epidemiol Rev*. 2002;24(2):190–202.
14. Matthies F, Bickler G, Marin N, Hales S, (eds). *Heat Health Action Plans: Guidance*. Copenhagen: World Health Organization; 2008.
15. Centers for Disease Control and Prevention. *Climate Change and Extreme Heat Events*. <https://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf>. Accessed June 22, 2018.
16. Khogali M. Epidemiology of heat illnesses during the Makkah Pilgrimages in Saudi Arabia. *Int J Epidemiol*. 1983;12(3):267–273.
17. Al-Nsour M, Fleischer A. Public health considerations for mass gatherings in the Middle East and North Africa (MINA) region. *East Mediterr Health J*. 2013;19(Suppl 2):S42–S47.
18. Noweir M, Bafaal A, Jomoah I. Study of heat exposure during Hajj (pilgrimage). *Environ Monit Assess*. 2008;147(1–3):279–295.
19. Becker J, Stewart L. Heat-related illness. *Am Fam Physician*. 2011;83:1325–1330.
20. Al-Zahrani A, Al-Sulaiman M, El Bushra H. Risk factors for heat exhaustion among pilgrims to Makkah, Saudi Arabia, 1415. *Saudi Epidemiol Bull*. 1995;2(4):1–4.
21. Al-Faify SK. Behavioral risk factors for pilgrims to Makkah. *Saudi Epidemiol Bull*. 1998;5(1):3–7.
22. Al-Rabeah AM, El-Bushra HE, Al-Sayed MO. Behavioral risk factors for disease during Hajj: the second survey. *Saudi Epidemiol Bull*. 1998;5(3–4):19–20.
23. Al-Madhderi Y, Al-Joudi A, Choudhry A, Al-Rabeah A, Ibrahim M, Turkistani A. Behavioral risk factors for diseases during Hajj, 1422. *Saudi Epidemiol Bull*. 2002; 9(3):19–20.
24. Alfaraj N, Choudhry A, Alhayani O. Behavioral risk factors for diseases during Hajj 1428. *Saudi Epidemiol Bull*. 2008;15(4):28–31.
25. National Research Council. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. Washington, DC USA: National Academies Press; 2011.
26. Solomon S, Qin D, Manning M, et al. (eds). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press; 2007.