

Hajj abattoirs in Makkah: risk of zoonotic infections among occupational workers

Malak Almasri*, Qanta A. Ahmed[†], Abdulhafeez Turkestani[‡] and Ziad A. Memish^{§,¶} 

*Public Health Directorate, Ministry of Health, Riyadh, Kingdom of Saudi Arabia, [†]Division of Pulmonary Disease and Critical Care Medicine, Department of Medicine, Winthrop University Hospital, Mineola, New York, USA, [‡]Makkah regional Health Directorate, Ministry of Health, Makkah, Kingdom of Saudi Arabia, [§]Infectious Diseases Division, Department of Medicine & Department of Research, Prince Mohamed Bin Abdulaziz Hospital, Ministry of Health, College of Medicine, Alfaisal University, Riyadh, Kingdom of Saudi Arabia and [¶]Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, Georgia, USA

Abstract

At completion of Hajj, the Islamic pilgrimage to Makkah, pilgrims give thanks for the blessing, and acceptance, of Hajj, marking the end of the pilgrimage by sacrificing an animal and distributing the sacrificial meat to the poor. With over two million Muslims making Hajj, each Hajj, more than 1.2 million heads of cattle: sheep, goats and camels are slaughtered. Over 16 000 abattoir workers work around the clock to sacrifice and process the cattle in keeping with Islamic law and public health guidelines. Because of their proximity to high densities of cattle and cattle meat, Makkah's abattoir workers are at risk of zoonosis. This was a longitudinal study aimed at determining the risk of some zoonotic diseases among male permanent abattoir workers during Hajj. Specifically, seroprevalence of antigens for Brucella, Crimean–Congo haemorrhagic fever (CCHF), Alkhurma haemorrhagic fever (AHF) and Rift Valley Fever (RVF) were determined, among the study participants. An enrolment questionnaire, and a follow-up questionnaire, with provision of 10 mL blood for testing 2 days before intense Hajj animal exposure, up to 20 days after intense animal exposure and between 30 and 42 days after Hajj butchering exposures. While working with livestock, study participants were interrogated on hand hygiene and personal protection. Eighty male permanent abattoir workers participated in the study. Majority, 96.25% ($n = 77$) declared washing their hands with soap and water, most 98.75% ($n = 79$) never used eye protection, few occupational workers dressed in personal protective clothing or footwear. All workers tested negative for CCHF and RVF, one was positive for AHF and six for Brucella. The risk of some zoonotic infections like Brucella and AHF is low among permanent occupational workers in the slaughtering house in Makkah during Hajj 2013. No serological evidence for CCHF and RVF viruses, even though workers showed low compliance with use of personnel protective equipment.

Keywords: Hajj, Abattoirs, zoonotic infections, Rift valley fever, Brucellosis, Alkhurma virus, Crimean–Congo Haemorrhagic Fever, Saudi Arabia.

Correspondence: Ziad A. Memish, Riyadh, Kingdom of Saudi Arabia. E-mail: zmemish@yahoo.com

Overview: Hajj and animal sacrifice

Each year, Saudi Arabia hosts over 10 million Muslim pilgrims from over 185 nations. While Muslims travel year-round to the Two Holiest Cities of Islam – Makkah and Medina – most arrive during ‘Hajj season’ – the final 3 months of the Islamic calendar either to perform Umrah (the minor pilgrimage) or Hajj (the major pilgrimage) (Memish *et al.* 2012, 2014; Steffen *et al.* 2012).

At completion of Hajj, pilgrims give thanks for the blessing, and acceptance, of Hajj, marking the end of the pilgrimage by sacrificing an animal and distributing the sacrificial meat to the poor – a divinely instructed rite enacting Prophet's Abraham's absolute faith in God in readiness to sacrifice his son Ishmael, before God spared his child's life. Hence, in the final 4 days of Hajj, millions of Muslims must sacrifice livestock in memory of the Prophet's unwavering faith.

The modern Makkah abattoir is massive and motorized

Historically, pilgrims either personally slaughtered the animal, or oversaw the animal's slaughtering, exposing the pilgrim and the environment to various risks (Rahman *et al.* 1999; Memish 2001; Basturk *et al.* 2016). In 1983, to streamline the ritual slaughter so many Muslims needed to complete and to limit spread of zoonosis, the Saudi Arabian government established The Saudi Project for Utilization of Hajj Meat, under the aegis of the Islamic Development Bank (IDB).

The Makkah abattoirs are an astonishingly automated and massive operation (The Saudi Project for Utilization of Hajj Meat, 2013; Sacrificial Meat of One Million Sheep to Be Distributed. AlRiyadh, 2015). The Mina abattoir is the largest in the world capable of handling 300 000 herds daily – annually this abattoir handles an entire capacity equivalent to New Zealand's entire meat processing industry, considered a global giant in the field.

At full capacity during Hajj, over 16 000 abattoir workers working 12-h shifts handle the livestock and meat. Over 14 000 of these workers can be accommodated on-site in designated accommodations. At the \$125 million Al-Moaissim Model slaughterhouse, near Mina, 26 veterinarians examine the animals before and after slaughtering to ensure the animals are healthy and their meat is suitable for human consumption (Ali 2006; Dickinson 2013).

Banks of jets at King Abdulaziz International airport in Jeddah await the fresh frozen Hajj meat to ship to the poor and needy around the world, often in conflict zones and areas of environmental crisis. The IDB states over 700 veterinarians and 400 religious experts are employed by the Kingdom to assure religious and public health integrity of Hajj meat each year with a total workforce of 40 000 including the abattoir workers, administrators, Islamic butchers and other personnel.

Zoonosis exposure in Hajj abattoir workers

Each Hajj, more than 1.2 million heads of cattle: sheep, goats, and camels are slaughtered. To meet

demand Saudi Arabia imports over 3 million head of cattle during the Hajj Season – almost one million imported from Sudan, Somalia and Djibouti, the remaining 2 million procured domestically. To handle these massive numbers of livestock, the Kingdom hires 15 000 expatriate butchers for Hajj from Syria, Egypt and Turkey to assist the nearly 300 permanent Saudi butchers. These workers must be protected from zoonosis during the intense and prolonged work of preparing Hajj meat in massive quantities over the short Hajj timeframe.

The imported livestock do arrive from countries where some zoonosis is endemic including pathogens such as Brucella, Crimean-Congo haemorrhagic fever (CCHF) and Rift Valley Fever (RVF). In Hajj 2006–2007, an RVF outbreak in Somalia compelled the Kingdom to ban all import of livestock from Somalia during Hajj season until the outbreak was contained (NA 2007).

Today, zoonotic viruses may also be circulating among Kingdom livestock. RVF and Alkhurma haemorrhagic fever (AHFV) now found in the Kingdom were likely introduced into Saudi Arabia through livestock importations (Al-Tawfiq & Memish 2017).

The mass slaughtering of so many livestock is an intense and difficult task exposing abattoir workers to public health risks. Butchers work in close contact with the livestock and are exposed to the blood and other body fluids from the animals. With these risks in mind, we studied the permanent local occupation workers in the Kai'ah slaughtering house in Hajj 2013 for evidence of zoonotic disease infection to understand the potential risk of such zoonosis.

Hajj pilgrimage increases the risk of zoonotic diseases due to the massive slaughter of livestock within a short period of time. Employing 'One Health' approaches relating to both Hajj and Umrah with continuous serological surveillance is necessary to detect and quickly control potential outbreaks of zoonosis. Using 'One Health' principle to perform a prospective sero-epidemiological pilot study we evaluated for serological evidence of Brucella, CCHF, RVF and AHF among permanent occupational abattoir workers. We sought to assess the risk factors, and to describe the demographical characteristics of

the abattoir workers at pre-exposure, acute exposure and at the convalescent exposure period for each zoonosis.

Material and methods

Study settings

This was a longitudinal study where permanent abattoir workers were recruited from only one of the eight abattoirs in Mecca -AlKai'ah. Some of the slaughterhouses are specified for slaughtering certain types of animals (e.g. camels and cows, or small ruminants only), Kai'ah slaughtering house was chosen because it processes all kinds of animals and is operated by an estimated total of 150 butchers with many of them having multiple years of butchering experience. And because the participation in the study was voluntary, all who volunteered were recruited and completed an informed consent document, an enrolment questionnaire, a follow-up questionnaire and provided 10 ml blood collections 2 days before intense Hajj animal exposure in terms of the number of Hajj animals slaughtered (enrolment sample), up to 20 days after intense animal exposure (acute sample) and between 30 and 42 days after Hajj butchering exposures (convalescent sample).

Participants were enrolled, interviewed and phlebotomized by specially trained Saudi Arabian Ministry of Health (MoH) staff. A public health team composed of a veterinarian, public health officer and phlebotomist were dispatched to the slaughterhouses and to their residence to complete the questionnaires and blood sampling. Questionnaires captured demographic data, animal and other exposure histories, and recent reported symptoms or illnesses. Blood samples were centrifuged within 12 hours of drawing and separated into aliquots. Aliquots were stored at -80°C for laboratory assessments.

Laboratory tests

All testing occurred in the Makkah regional laboratory. We used serological assays to identify target pathogens for antibodies on enrolment

specimens, acute specimens and convalescent specimens. We used the enzyme-linked immunosorbent assay (ELISA) test for Brucella IgG and IgM (Vircell, SL, Barcelona Spain), and the polymerase chain reaction (PCR) from Roche Diagnostic run on the light cycler machine for RVF, AHFV and CCHF viruses.

Statistics

After a thorough cleaning and validation of the data, statistical tests for associations and comparisons were conducted using Epi Info 7 to evaluate the risk factors for the carriage and infection of the studied pathogens and to identify demographical characteristics of the participants.

Results

On October 13th, 2013, eighty male permanent workers from one slaughtering house – AlKai'ah – were recruited for the study. Mean age was 37 years old, 95% ($n = 76$) were married. The majority, 81% ($n = 65$) were from Bangladesh, 17% ($n = 14$) from Egypt and one subject's nationality was unknown. The median number of household contact for each subject was 10 persons.

Seventy-seven subjects (96.25%) had no medical history, three (3.75%) were known to have diabetes under treatment and 70% ($n = 56$) were smokers. Within 12 months of the study, 11% ($n = 9$) reported a febrile illness (fever, cough and sore throat). The median duration of exposure to livestock was 7 years.

Occupational exposure varied depending on the role of the worker in the abattoir within 12 months prior to study enrolment. Forty five per cent ($n = 36$) of subjects were engaged in slaughtering animals, 51% ($n = 41$) performed ancillary roles – cleaning barns, trucks and disposal of animal waste, disinfecting equipment and areas exposed to livestock, raw meat products, 2.50% ($n = 2$) were involved in veterinarian work – examining and treating livestock and obtaining blood and/or other specimens from livestock, one person 0.25% ($n = 1$) worked as an air conditioning technician.

While working with livestock, participants were interrogated on hand hygiene and personal protection (Table 1). The vast majority, 96.25% ($n = 77$) declared washing their hands with soap and water, most 98.75% ($n = 79$) never used eye protection, only 15% ($n = 12$) habitually used surgical face-masks, the remaining never using any kind of masks. Few occupational workers dressed in personal protective clothing or footwear. Most never wore aprons or protective outer garments. However, more than half 57.5% ($n = 47$) endorsed habitual use of washable footwear. A larger number 40% ($n = 32$) endorsed wearing washable footwear most of the time. Hand protection was noted to be adopted much less frequently. Only 8% ($n = 7$) workers endorsed habitual leather glove usage, and only 17.5% ($n = 14$) admitted to wearing leather gloves 'most' (i.e. more often than not) of the time.

Acute exposure

Longitudinal follow-up was limited by study participation. Only 67.5% (54 out of 80) workers agreed to participate in the first visit follow-up scheduled 15 to 18 days after the enrolment date. During the Hajj, all the participants worked 8 hours daily every weekday. Workers processed a median number of 22 animals daily. No workers complained of respiratory or gastrointestinal illness, only one participant

complained from sore throat, arthralgia and fever (38°C).

Convalescent exposure

Attendance of enrolled subjects improved over time. A total of 68.75% ($n = 55$) workers participated in the second follow-up between 30 and 32 days after the acute phase. No participants were found to have any systemic symptoms including fever nor gave history of respiratory or gastrointestinal illness.

Laboratory results

All workers were found negative for CCHF virus and RVF by serology. At enrolment, one occupational worker – a cleaner – was positive for AHFV and showed negative serology at acute and convalescent period.

One butcher from Bangladesh was positive for Brucella IgG and IgM at enrolment, in the acute and convalescent period, he processed 25 animals a day and he had no history of systemic, respiratory or gastrointestinal symptoms in all study phases. Two abattoir occupational workers – a cleaner – and a veterinarian were found to be positive for Brucella IgM at enrolment but lost follow-up. Another cleaner tested positive for Brucella IgM at enrolment and convalescent phase. Two more participants

Table 1. Description of the behavioural characteristics of the butchers

PPE (Per cent/Frequency)	Always	Most of the time	Never	Rarely	Sometimes	Total
Eye protection	0	1.2% (1)	98.7% (79)	0	0	100% (80)
Eye glass	0	0	98.7% (79)	0	1.2% (1)	100% (80)
Dust mask	1.2% (1)	5% (4)	88.7% (71)	0	5% (4)	100% (80)
Filter mask	1.2% (1)	0	98.7% (79)	0	0	100% (80)
Surgical mask	15% (12)	11.2% (9)	72.5% (58)	0	1.2% (1)	100% (80)
Apron	21.2% (17)	5% (4)	66.2% (53)	5% (4)	2.5% (2)	100% (80)
Outer garments	15% (12)	42.5% (34)	42.5% (34)	0	0	100% (80)
Sandal	0	0	100% (80)	0	0	100% (80)
Sport shoes	1.2% (1)	0	98.7% (79)	0	0	100% (80)
Disposable shoes	0	0	97.5% (78)	1.2% (1)	1.2% (1)	100% (80)
Washable boots	57.5% (46)	40% (32)	2.5% (2)	1.2% (1)	0	100% (80)
Disposable gloves	3.7% (3)	0	92.5% (74)	3.7% (3)	0	100% (80)
Cotton gloves	0	0	98.7% (79)	0	1.2% (1)	100% (80)
Leather gloves	8.7% (7)	17.5% (14)	71.2% (57)	0	2.5% (2)	100% (80)
Handwash	96.2% (77)	1.2% (1)	0	1.2% (1)	1.2% (1)	100% (80)

showed positive for Brucella IgM at enrolment, in acute phase but negative at convalescent phase (Table 2).

Discussion

Zoonotic infections are pathogens that are transmitted from vertebrate animals to human and they account for more than 60% of infectious diseases in man. A long list of zoonotic pathogens including brucellosis, CCHF, RVF and AHFV. These pathogens are transmitted to humans through close contact with the following possible routes: inhalational, ingestion, physical injury like bites or accidental inoculation during slaughtering/dressing of the animals for consumption or through very close physical contact. Among the high-risk occupations that increase the risk of zoonotic infections are veterinarians, farmers, culling personnel, slaughterhouse workers and farmers. The importance of protecting against risky exposures among slaughter house workers rely on education about risks of zoonotic disease transmission and limiting risky exposure during slaughtering by wearing protective attire and applying good hygienic practices. Brucellosis is a bacterial zoonosis usually transmitted to humans by contact with infected animals: goats (*Brucella melitensis*); cattle (*Brucella abortus*); and other livestock. The

organism is easily aerosolized, and the infectious dose is usually very small ranging from 10 to 100 microorganisms. The disease is unique due to its long incubation period and diverse clinical presentations. Occupational workers in slaughtering houses are known to be high risk for contracting brucellosis (Corry & Hinton 1997; Memish 2001)

Although blood culture for Brucella is the gold standard definitive diagnostic test, the test requires special laboratory biosafety and can take up to 21 days to show positivity. Brucella-specific agglutination tests involve direct agglutination of bacterial antigens by specific antibodies. Agglutination tests detect IgM, IgG and IgA antibody classes. IgM antibodies predominate in acute infection but rapidly decline within weeks (Osoba *et al.* 2001; CDC, 2017). Relapses are accompanied by transient elevations of IgG and IgA antibodies but not IgM. Butchers sera was tested by Brucella ELISA for Brucella IgM and IgG antibodies. Many occupation workers had positive brucellosis – either the IgG or IgM antibody classes indicating old or recent infection respectively.

In our study like previous reports we showed that Brucella was the most common zoonotic disease transmitted to slaughterhouse workers. Overall six cases of brucella were documented in this group of abattoirs. Two of them had positive results on enrolment but were lost to follow-up, so it is hard to

Table 2. Laboratory result of positive cases for Brucella and AHFV

Participants demographic information			Enrolment's results			Acute's results			Convalescent's results		
Age	Nationality	Occupation	AHFV	Brucella IgG	Brucella IgM	AHFV	Brucella IgG	Brucella IgM	AHFV	Brucella IgG	Brucella IgM
41	Bangladesh	Cleaner	positive	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
42	Bangladesh	Cleaner	Negative	positive	Negative	Negative	positive	positive	Negative	positive	Negative
41	Bangladesh	Butcher	Negative	positive	positive	Negative	positive	positive	Negative	positive	positive
40	Bangladesh	Cleaner	Negative	positive	Negative	Negative	positive	Negative	Negative	positive	Negative
36	Bangladesh	Butcher	Negative	positive	Negative	Negative	positive	Negative	Negative	Negative	Negative
41	Egypt	Cleaner	Negative	positive	Negative	Negative	positive	positive	Negative	Negative	Negative
48	Bangladesh	Cleaner	Negative	Negative	positive	Negative	Negative	Negative	Negative	Negative	Negative
31	Bangladesh	Cleaner	Negative	Negative	positive	Negative	Negative	Negative	Negative	Negative	positive
0	Bangladesh	Cleaner	Negative	Negative	positive	Negative	Negative	positive	Negative	Negative	Negative
25	Egypt	Medicine	Negative	Negative	positive	Negative	Negative	Negative	Negative	Negative	Negative
36	Bangladesh	Cleaner	Negative	Negative	positive	Negative	Negative	positive	Negative	Negative	Negative

AHFV: Alkhurma haemorrhagic fever virus

Bold text indicates the positive results

determine the source of the infection. The remaining four cases had at least two results on enrolment and acute sampling indicating an occupationally acquired infection from the 2013 Hajj season. Due to the low number of positive reactors, statistical analysis has not really taken place.

AHF, a tick-borne virus of the Flavivirus family endemic in Saudi Arabia transmitted through ticks and exposures to blood of infected animal. In our study one subject tested AHF positive at enrolment but negative in both the acute and convalescent period indicating an infection acquired prior to participation in the hajj season. The subject was a 41-year-old abattoir cleaner from Bangladesh. The worker reported using a facemask and disposable gloves 'most of the time', to habitually wear washable boots and to habitually wash his hands with soap and water. At no stage of the study did he report any systemic or respiratory or gastrointestinal symptoms.

Overall, we demonstrated low serological evidence for Brucella, and AHF. We found no serological evidence for CCHF and RVF viruses among permanent occupational workers in the Kai'ah slaughtering house in Makkah during Hajj 2013, even though workers showed low compliance with use of personal protective equipment.

Important study limitations must be noted. Subjects were recruited from permanent occupational workers from only one of the eight abattoirs in Mecca. Temporary abattoir workers from overseas were not represented in this study even though they represent the majority of Hajj season workforce in the abattoirs. Blood cultures or serum agglutination tests were not used on the workers which are more accurate due to cost and biosafety concerns in the laboratory. Finally, the sample size was small, and we lost some workers during the follow-up despite our best efforts.

Acknowledgement

We thank all staff at the Makkah laboratory where the testing was done.

Source of funding

Saudi Ministry of Health.

Conflicts of interest

None of the authors declare any conflict of interest.

Ethical statement

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to and the appropriate ethical review committee approval has been received.

Contributions

MA & ZAM developed the research idea, and MA, ZAM & AT executed the study and All authors contributed to the drafting and reviewing of paper.

References

- Ali S.F. (2006) Arab News Publication Date. Available at: <http://www.arabnews.com/node/278842>
- Al-Tawfiq J.A. & Memish Z.A. (2017) Alkhurma hemorrhagic fever virus. *Microbes and Infection* **19**, 305–310.
- Basturk M., Katirci Y., Ocak T., Yurdakul M.S., Duran A. & Baspinar I. (2016) Patients admitted to emergency units with injuries related to the four Hajj-associated annual animal sacrifice feasts from 2010 to 2013. *Annals of Saudi Medicine* **36**, 139–142.
- Centers for Disease Control and Prevention (2017). National Center for emerging and zoonotic diseases. Brucellosis reference guide: exposure, testing, and prevention.
- Corry J.E. & Hinton M.H. (1997) Zoonoses in the meat industry: a review. *Acta Veterinaria Hungarica* **45**, 457–479.
- Dickinson E (2013) The National Newspaper Flash freezing takes care of surplus meat from Haj sacrifice. Available at: <https://www.thenational.ae/world/flash-freezing-takes-care-of-surplus-meat-from-haj-sacrifice-1.310668>
- Memish Z. (2001) Brucellosis control in Saudi Arabia: prospects and challenges. *Journal of Chemotherapy* **13** (Suppl 1), 11–17.
- Memish Z.A., Stephens G.M. & Steffen Ahmed Q.A. (2012) Emergence of medicine for mass gatherings: lessons from the Hajj. *The Lancet Infectious Diseases* **12**, 56–65.
- Memish Z.A., Zumla A., Alhakeem R.F., Assiri A., Turkestani A., Al Harby K.D. *et al.* (2014) Hajj: infectious disease surveillance and control. *The Lancet*. **383**, 2073–2082.

- NA.(2007) Outbreaks of rift valley fever in Kenya, Somalia and United Republic of Tanzania. *Weekly Epidemiological Record* **82**, 169–178.
- Osoba A., Balkhy H., Memish Z., Khan M., Al-Thagafi A., Al Shareef B. *et al.* (2001). Diagnostic value of Brucella ELISA IgG and IgM in bacteremic and non-bacteremic patients with brucellosis. *Journal of Chemotherapy (Florence, Italy)* **13**, 54–59.
- Rahman M.M., Al-Zahrani S. & Al-Qattan M.M. (1999) “Outbreak” of hand injuries during Hajj festivities in Saudi Arabia. *Annals of Plastic Surgery* **43**, 154–155.
- Sacrificial Meat of One Million Sheep to Be Distributed. AlRiyadh. (2015). Available at: <http://sites.alriyadh.com/en/article/779947/Sacrificial-Meat-of-One-Million-Sheep-To-Be-Distributed>
- Steffen R., Bouchama A., Johansson A., Dvorak J., Isla N., Smallwood C. & Memish Z.A. (2012) Non-communicable health risks during mass gatherings. *The Lancet Infectious Diseases* **12**, 142–149.
- The Saudi Project for Utilization of Hajj Meat. (2013) Available at: <http://www.adahi.org/English/MediaCenter/Articles/Pages/Article2.aspx>