Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/15664
DOI URL: http://dx.doi.org/10.21474/IJAR01/15664

RESEARCH ARTICLE

HAJJ RELATED MORTALITY: A REVIEW ARTICLE

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Manuscript Info

Manuscript History
Received: 10 September 2022
Final Accepted: 14 October 2022
Published: November 2022

Key words:-
Hajj, Pilgrims, Death, Causes, Mass Gathering, Mortality, Pilgrimage, Mecca

Abstract

The Hajj is a pilgrimage conducted yearly in Mecca, a city located in the western province of Saudi Arabia where over 2.5 million Muslims gather from over 160 countries at the same place and time. This mass gathering is considered one of the largest mass gatherings worldwide. Performance of the Hajj is physically and emotionally demanding, therefore pilgrims could undergo great physical and emotional strain. As a consequence, morbidity and mortality rates rise as the demands arise. It is important to identify the common causes of death and injury to help prevent them and reduce their incidence. This study aims to identify the most common causes of mortality during Hajj. This is a review article that has been conducted by reviewing articles discussing the causes of death in Hajj. We found that the majority of the studies concludedthat cardiovascular diseases were the most common causes of death followed by respiratory, specifically pneumonia, which is most commonly caused by Mycobacterium tuberculosis. Also, cerebrovascular accidentswere reported in some studies to be the 3rd most common cause of death. Furthermore, old age was identified to be the most significant risk factor for dying in hajj.

Introduction:-

Hajj or pilgrimage is a religious event and festival that is obligated from every physically fit, able-bodied adult Muslim for at least once in a lifetime. The Hajj takes place in Mecca in the 12thmonth of the Islamic calendar. Approximatelytwomillion Muslim pilgrims gather annually from different parts of the world to perform the holy pilgrimage. This duty requires a significant amount of physical exertion.Therefore,it could put a huge burdeneven on healthy individuals. This mass gathering of pilgrims may compromise the health system of Saudi Arabia since it is the host country of Hajj.[1]When the pilgrims arrive in Mecca,they must make seven circumambulations around the Kaaba. The pilgrim then leaves to Arafat, which is about a few kilometers east of Mecca, to recite prayers during the "Day of Standing". He/she will make a stop in Mina on the way to Arafat and Muzdalifah. When the pilgrims are returning to Mina, they must stop at a place called"Jamarat" to throw stones to the pillars that represent the devil. The pilgrim then must sacrifice an animal by slaughtering a sheep to ask God to accept his/her Hajj. Then, before leaving Mecca, the pilgrims perform the farewell Tawaf.[2]Although the visit to Medina is not vital for Hajj, millions decided to visit.

This mass migration constitutes one of the most important public health problems in the world. Sucha mass gathering of people allows infectious diseases to turn into epidemics. Mass gatheringsare defined by the World Health Organization (WHO) as "an occasion, either organized or spontaneous where the number of people attending

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is sufficient to strain the planning and response resources of the community, city, or nation hosting the event" (WHO, 2008).[3]Leading causes of death among mass gatherings,in general,are non-communicable diseases followed by injuries mainly due to heatstroke and stampedes.[4] Cardiovascular events are an important cause of death in mass gatherings.These mass gatherings could have a lot of consequences, especially health-related consequences. An important example is Hajj Stampede in Mina that happened in 2015 which cost about two thousand lives among pilgrims from about 30 nationalities. This was not the first stampede incidents that happened in Hajj, it happened many times in the past years and it's explained by the huge mass gathering that happens every year in Hajj season as it is the world's largest annual gathering of people, but this one is considered as the most serious incident due to the large number of casualties.[5]Causes of death in hajj are not merely limited to such stampede incidents and traumas. A variety of other causes are reported in the literature, including communicable and non-communicable diseases, heat strokes, and many others.

Every new year in Hajj, improvements in themanagement of Hajj health protocols takes place by the authorities. The government of Saudi Arabia makes huge improvements in providing healthcare services to pilgrims irrespective of their nationality, color, or ethnicity, which is free of charge to all pilgrims. In 2013, the ministry of health allocated 24 hospitals with a total bed capacity of 4964 beds and 136 healthcare centers all equipped with the latest technology in addition to 17,609 healthcare personnel to provide healthcare.[6]There are also increased precautions implemented by the ministry of health during times of pandemics such as the H1N1 pandemic in 2009 and the Covid19 pandemic in 2019. These measures, especially in 2009, where the government mandated that all pilgrims be vaccinated against influenza vaccine and recommended that pilgrims above 65 refrain from performing Hajj. These precautions led to the lowest mortality rate that year.[7]In Hajj 2016, Saudi took measures on various fronts to decrease the mortality rate in Hajj. In association with the Global Center for Mass Gatherings, the government augmented infrastructure and logistics and reduced the pilgrim's numbers from four million to three million.[8]

Articles published in the literature are reporting and discussing variable causes of death during Hajj. Hence, comes the importance of our study to gather all significant published data into one comprehensive article that facilitates the understanding of such an important national public health event.

Methodology:-

Study design

This is a review article that has been conducted by reviewing articles discussing the causes of death in Hajj.

Inclusion Criteria:

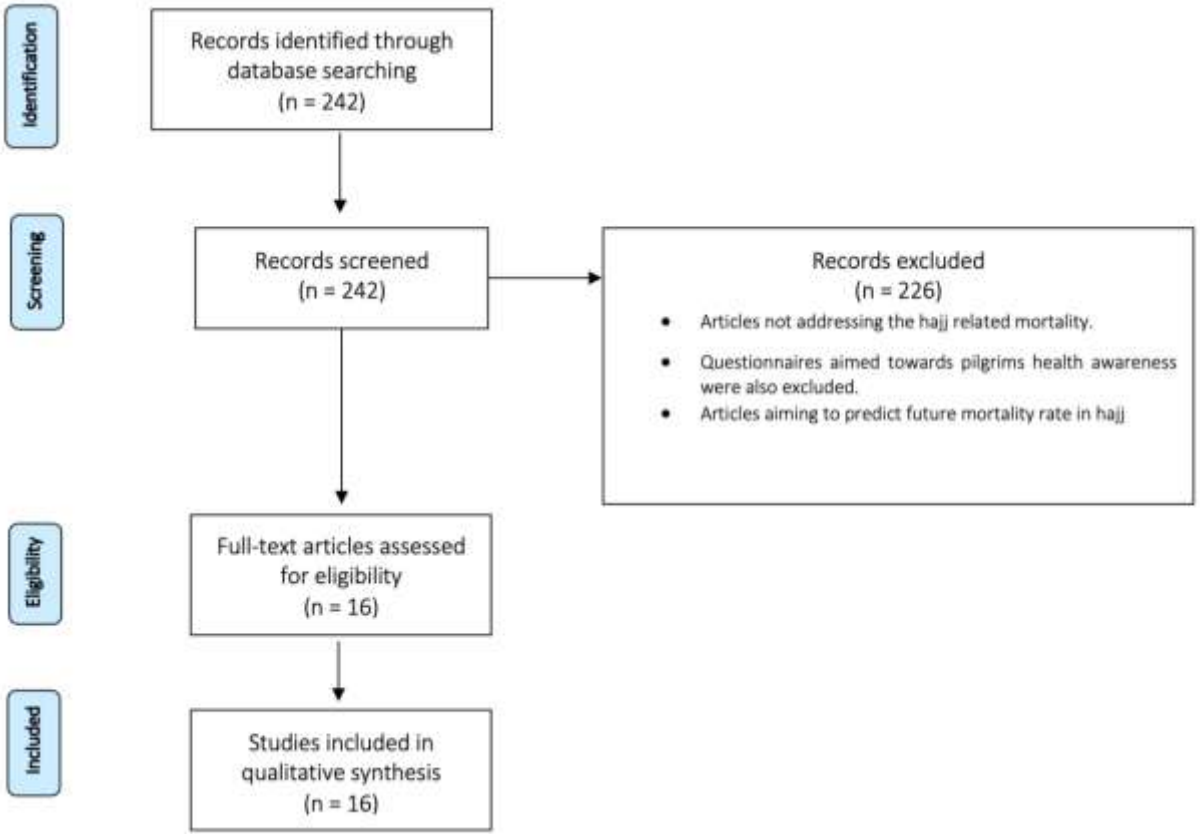
1. All studies in English conducted from inception to 2020 will be included in this review article.
2. Articles indexed in Pubmed
3. Articles related to Hajj mortality
4. Cross-sectional studies, case reports, case series, and cohort studies will be included.

Exclusion Criteria:

1. Articles not addressing the hajj related mortality.
2. Review articles and meta-analyses are excluded

A literature-based review was performed using the Pubmed search engine of the National Library of Medicine. The search strategy included a combination of the following keywords: (Hajj OR pilgrimage) AND (death OR mortality). The identifiedarticles were screened and judged based on their titles and abstracts, in case of uncertainty, full texts were screened. All studies meeting our inclusion/exclusion criteria were carefully studied, the results of all included articles were analyzed, and a conclusion was withdrawn to highlight the most significant causes of death among pilgrims and its associated risk factors. 242Articles identified, among them only 16 were reviewed[1,8,10,11,13,14,15,16,17,18,19,21,22,23,24,31] (Table1) and included in accordance with our inclusion criteria.Besides, some articles were excluded as they were aiming to predict future mortality rate in hajj, in addition to the questionnaire- based studies that aimed towards pilgrims health awareness were also excluded. (Figure1)

Figure 1:- Flowchart of the search strategy showing the method of including & excluding articles:



Results:-

In the past, infectious disease used to be the leading cause of mortality, but this changed mostly because of mandatory vaccination programs as well as a change in epidemiology. Among the 16 included papers, we found thatboth death certificates and verbal autopsies confirmed that cardiovascular diseases were the most common causes of death followed by respiratory, specifically pneumonia, which is most commonly caused by Mycobacterium tuberculosis.Also,cerebrovascular accidentswere reported in some studies to be the 3rd most common cause of death.Furthermore, old age was identified to be the most significant risk factor for dying in hajj. Another finding is that there is a delay in the transfer of patients to hospitals, as indicated by one study that revealed that 36% of pilgrim deaths occurred in accommodations even though most, if not all, of Hajj campaigns have accompanying physicians and nurses.

Table 1:- summarizing all the sixteen included articles, highlighting their most significant findings.

renc e	Year of publication	Study design	Sample size	Results and findings
17	2003	Retrospective Cohort	105 cases	Out of 105 cases of meningococcal disease, 64% had meningitis while 36% had meningococcemia and meningitis. The mortality rate was 34%, and risk factors that increased the risk of mortality were delayed diagnosis, delayed antibiotic administration, elderly age, as well as the presence of medical comorbidities
8	2018	Retrospective Cohort	400,000	The most common direct cause of death was cardiorespiratory arrest. The risk factors associated with an increased chance of death are increased age as well as the presence of comorbidities. The mortality rate in this study was 11.99/10,000 in 2016 compared to 27.02/10,00 in 2015.
21	2007	Cross-sectional study	140 patients	The study showed that15 patients (10.7%) died. Among those 15 patients, 15% were between 21 to 40, 33.3% from 61 to 80, and 13.3% older than 80. Also, among those 15 patients, 7 of them died because of acute myocardial infarction, 2 because of acute pulmonary edema, 2 because of pneumonia, 1 because of diabetic ketoacidosis, and 1 because of trauma.

16	2012	Prospective Cohort	110 patients	The study reported a mortality rate of 6.4%, mortality causes were as follow: 2.7% as cardiac arrest and ventricular tachycardia, 1.8% as pneumonia which was complicated by sepsis, 0.9% as myocardial infarction, and also 0.9% as cerebrovascular accident.
11	2017	Retrospective Cohort	1059	331 (31%) of the patients admitted to ICU, and 728 (69%) were admitted in the ward. The mortality rate was estimated by 2.4% among patients admitted to the ward, and an estimation of 21.45% of patients that were admitted in the ICU.
I. 16	2006	Prospective Cohort	689	140 patients (16.5%) died, with the most common causes including pneumonia in 28 patients, followed by acute coronary syndrome in 21, and finally stroke in 20 patients. Moreover, the authors concluded that older age was the most common risk factor for higher mortality rate, followed by chronic lung diseases as second
24	2017	Cross-sectional	186	Authors here showed an incidence of 8.9 stroke cases in each 100,000, and the top nationality was Saudi's in 17.2% of the cases, with a mean age of 60 years approximately, with a mortality rate of 11.1% of the cases during hospitalization
13	2012	Prospective Cohort	452	A total of 123 patients (27.2%) developed a pneumonia- related critical illness. The etiologies of such an illness were identified in 73 of the cases (59.4%), with gram-negative organisms involved in 22 of the cases (18%), followed by gram-positive organisms in 13 of the cases (10.6%), followed by fungus and Mycobacterium organisms involved in (1.6%) and (4.2%) of the cases. Viral cases were isolated and confirmed by PCR in (24.4%) of the cases. Yet, co-morbidities play a huge role in the pathogenesis of such cases, as the authors found that (41.5%) of the cases were experiencing at least two other active diseases, with cardiovascular diseases as the most common co-morbidities. Finally,the authors concluded a 16.2% mortality rate among all critically ill patients during Hajj
14	2004	Retrospective Cohort	64	46 out of the 64 patients (72%) established the diagnosis of pneumonia. Also, 20% of the 72% are confirmed Mycobacterium tuberculosis cases which are,in turn, the most common causeof pneumonia in this setting, followed by gram-negative organisms which included 18.8% of the cases, followed by Streptococcus pneumonia in only 10% of the cases, and finally, Legionella pneumophilia, Mycoplasma pneumonia, and viruses are all only accounting for 6% of the cases each.The mortality among this group of patients was reaching up to 17%
31	2015	Retrospective Cohort	211	Most health problems reported were Bronchial asthma as the most common, followed by injuries as the second most common, and out of the 33 injuries, 8 of them were serious in nature. However, out of the 211 patients, only two patients reported dead, as both of the patients died as a cause of heatstroke. Also, 6 patients were referred to other hospitals, they included three RTA's, one peritonitis case, one cerebrovascular accident, and finally 1 with chronic renal failure; the remaining 192were successfully discharged in a stable condition
1	2019	Retrospective Cohort	200,000	The mortality rate from 2004-2011 ranged from 149 to 337 per 100,000 Hajj pilgrims. The top two causes of death were cardiovascular followed by respiratory. Associated risk factors for death were elderly age as well as the presence of comorbidities.
10	2013	Observational study	206,831	The mortality rate was 1968 deaths per 100,000 with most deaths occurring in Mecca (68%) and Medinah (24%). The mortality rate peaked earlier for those pilgrims who traveled to Mecca first (p=0.002). Most deaths were cardiac (66%) followed by respiratory (28%).
23	2019	Population-based, before and after study	15,272,304	Evidence-based intensive bundle care intervention reduced cardiac mortality for pilgrims. Before this intervention, cardiac deaths accounted for 52% of all in-hospital deaths. The mortality rate decreased significantly from 52% to 43.3%, 32.5%, and 19.7% in the years 2009,2010, and 2011, respectively.
22	2006	Comparative	30,037	The two most common disease leading to mortality in Hajj 2004 and 2005 were cardiac followed by respiratory. The mortality rate in Hajj 2004 was 47 per 100,000 compared to 24 per 100,000 in Hajj 2005.
18	2000	Retrospective Cohort	27 patients	The study reported a rare strain of Meningococcal W135 infection epidemics that were associated with the pilgrimage to Mecca in 2000, where 25 confirmed and 2 probable cases were identified; the reported mortality among this group was 18%.
19	2000	Case series	4 cases	reporting four cases of a rare strain of Neisseria Meningitidis Serogroup W135 infection related to Hajj in 2000. one out of the four has passed away due to the infection with a 25% mortality rate.

Discussion:-

Prolonged stays at Hajj, mass gatherings, along with excessive heat facilitate the transmission of infectious disease. Traffic jams along with improperly stored food are also risk factors that may compromise the health of pilgrims.[9] The elderly age of most pilgrims increases the risks of mortality and morbidity as a result of the presence of multiple medical comorbidities. Thus, they are therefore prone to cardiovascular disease, electrolyte abnormalities, respiratory diseases as well as infectious disease.[9] A major health concern regarding mass gatherings is the

transmission of communicable diseases. Before when respiratory infections used to be the major cause of hospital admission during Hajj, meningitis and cholera were the main causes of mortality; the improvement in hygiene and enhanced pilgrim awareness are the main reasons for the reduction in the incidence of these infectious diseases.[8]

Due to the elevated mortality risk for Hajj pilgrims, information on mortality causes and associated risk factors is vital to enhance the overall health and well-being of Muslim pilgrims. The major limitation of the reporting of deaths in Hajj is that all deaths are reported under a broad ICD-10 category due to the death certificates and verbal autopsy methods. If other sources of data can be linked, then knowledge gaps can be filled and interventions to reduce mortality can be implemented. In 2008, the Saudi government introduced verbal autopsy to better identify and analyze the causes of death among pilgrims. Verbal autopsy investigates the cause of death by a structured questionnaire. Verbal autopsy is recommended by WHO in cases where most deaths occur outside hospitals. Studies have shown that verbal autopsy helps investigate the cause of death and is commonly used in developing countries. The verbal autopsy is standardized by the WHO and includes questions regarding signs and symptoms, past medical history, as well as circumstances of the death. Usually, the verbal autopsy is conducted by the treating physician along with the deceased relatives who accompanied him/her during Hajj. All doctors in Hajj are trained in filling out verbal autopsy forms. These forms must be filled out by 1 week after the death of the pilgrim and must be analyzed by 2 different physicians. If there is a discrepancy between the 2 physicians, they must compare their analysis to achieve consensus.[10]

The reported cases of death can be categorized into three main categories, communicable disease, non-communicable diseases, and deaths related to injuries. Each includes further subdivisions for the sake of understanding.

In general, a retrospective cohort study that was conducted in Al-Ansar hospital, Medina, Saudi Arabia, described the emergency department visits among pilgrims from December of the year 2004 until November of the year 2013. A total number of 1059 patients were involved in the study with a male to female ratio of 3:1, and a mean age of 56.8 years approximately. 331 (31%) of the patients admitted to ICU, and 728 (69%) were admitted in the ward, all from different nationalities, with Pakistan on the top, followed by India, Bangladesh, Indonesia, and North African countries. However, the mortality rate was estimated by 2.4% among patients admitted to the ward, and an estimation of 21.45% of patients that were admitted in the ICU.[11]

An interesting finding in an Indonesian study is that 36% of deaths occurred in accommodations provided to pilgrims. This highlights the fact that many pilgrims were not referred to hospitals at the appropriate time, despite the presence of accompanying healthcare professionals on the trip.[1]

Communicable diseases

Respiratory infections:

Respiratory related infections are thought to be the most common cause of mortality among communicable diseases as reported by an Indonesian study which concluded that one-third of deaths among Indonesian pilgrims were due to respiratory disease.[1] Pneumonia is a common respiratory disease that is fatal for elderly patients with comorbidities such as hypertension and diabetes.[11] Such conclusion was supported by another two studies which have shown that pneumonia is the main cause of illness during Hajj and causes include gram-negative organisms, Streptococcus pneumonia, and Mycobacterium tuberculosis.[12,13]Furthermore, a study was conducted at King Saud University in May of the year 1998 to clarify the incidence of Pneumonia and Tuberculosis among Pilgrims during Hajj season, and to determine the mortality rate among this group of patients. The study included two hospitals in Mecca and enrolled a total of 64 patients, 47 patients (75%) were men with a mean age of 63 years. 46 out of the 64 patients (72%) established the diagnosis. Also, 20% of the 72% are confirmed Mycobacterium tuberculosis cases which are,in turn, the most common cause of pneumonia in this setting, followed by gram-negative organisms which included 18.8% of the cases, followed by Streptococcus pneumoniae in only 10% of the cases, and finally Legionella pneumophila, Mycoplasma pneumonia, and viruses are all only accounting for 6% of the cases each. However, the mortality among this group of patients was reaching up to 17%, which in turn raises the concern about this condition in specific.(14)In another study conducted in Al-Noor Specialist Hospital in Mecca for 5 weeks starting from January 3rd to February 6th of the year 2005, including all pilgrims who were admitted under the Internal Medicine department. 689 patients were included from 49 different nationalities, with a mean age of 62 years, a male to female ratio of 1.8:1. The study reported that 140 patients (16.5%) died, and concluded that the most common cause of death was pneumonia in 28 patients, followed by acute coronary syndrome in 21, and finally

cerebrovascular accidents in 20 patients. Moreover, the authors concluded that older age was the most common risk factor for higher mortality rate, followed by chronic lung diseases at second.(15)In addition to a prospective cohort study which was conducted in Riyadh Military Hospital, which included all critically ill patients from 40 different nationalities, admitted in 15 hospitals in two cities, for 2 consecutive Hajj seasons in the years 2009 and 2010. The aim was to identify the number of cases, and then the co-morbidities, severity of illness, and the utmost clinical outcome. The study resulted in a total of 452 critically ill patients, and the mean age was 64 years, with 64.6% of the patients being males. A total of 123 patients (27.2%) developed a pneumonia-related critical illness. Also, the etiologies of such an illness were identified in 73 of the cases (59.4%), with gram-negative organisms involved in 22 of the cases (18%), followed by gram-positive organisms in 13 of the cases (10.6%), followed by fungus and Mycobacterium organisms involved in (1.6%) and (4.2%) of the cases. However, viral causes were isolated and confirmed by PCR in (24.4%) of the cases. Yet, comorbidities play a huge role in the pathogenesis of such cases, as the authors found that (41.5%) of the cases were experiencing at least two other active diseases, with cardiovascular diseases as the most common comorbidities. At last, the authors concluded a 16.2% mortality rate among all critically ill patients during Hajj, with primary infections being at the top causes of death in this setting, followed by septic shock, lung abscesses, ARDS, hypoxia, and cardiac arrhythmias being at last.(13)In another cross-sectional study which included all patients admitted to intensive care unit in Mena and Arafat in the Islamic year 1424 (2004). 140 patients were admitted to intensive care unitduring the period from January 28 to February 3. 60% of the patients showed one acute medical problem, 36.4% showed two medical problems and 3.6% showed three medical problems on admission to intensive care unit. The most common diagnosis on intensive care unit admission was myocardial infarction (25.0%) followed by pneumonia (22.1%), pulmonary edema, COPD, and bronchial asthma. only 7.1% of the cases were admitted for surgical diseases (trauma and acute abdomen). For the prognosis, 45.0% had a complete recovery, 28.6% were transferred to tertiary hospitals in Mecca and 10.7%(15 patients) died. Among those 15 patients, 15% were between 21 to 40, 33.3% from 61to 80, and 13.3% older than 80. Also among those 15 patients, 7 of them because of acute myocardial infarction, 2 because of acute pulmonary edema, 2 because of pneumonia, 1 because of diabetic ketoacidosis, and 1 because of trauma. We can conclude that most of the patients were older than 40 (92%) and 54.0% older than 60. Also, the risk of complication and mortality increases with ages in which the highest risk was noticed in people older than 80. Most of the cases were admitted to ICU due to cardiac causes (64%), 26.4% were due to infectious diseases.[16]

CNS infections:

Regarding the CNS infections related mortality, a study was conducted in 2000 at King Faisal Hospital, Mecca, Saudi Arabia, this study aims to address the epidemiological, clinical, and laboratory aspects of meningococcal disease and also the factors responsible for its morbidity and mortality among the pilgrims. They reported 105 confirmed cases of meningococcal disease, among those patients 72.38% were Hajj and Umrah pilgrims. Regarding nationalities, 18.09% were Pakistani, 15.24% were Indians and 12.38% were Indonesians. 18.08% of the patients had associated co-morbiditylike diabetes, hypertension, ischemic heart disease, and renal failure. Regarding outcomes, 64.76% have improved while 34.28% have died and 0.95% had residual damage. For the case fatality rate (CFR) among nationalities as follows: 31.58% were Pakistani, 37.50% were Indian, 30.77% were Indonesians. CFR among meningitis was 29.83% and meningococcemia was 42.10%. CFR was 41.30% among females and 28.81% among males. Patients who encountered delays of antibiotic administration had CFR of 66.66%.[17]In addition to the above study, another article published in France reported a rare strain of Meningococcal W135 infection epidemics that were associated with the pilgrimage to Mecca in 2000, where 25 confirmed and 2 probable cases were identified; the reported mortality among this group was 18%. In further analysis of these cases, people aged over 50 years represented more than half of the cases with 66%. Four cases occurred among 19,100 pilgrims (attack rate 21/100,000), the infection was not confined only to those who attended the Hajj session, where 9 among persons living with pilgrims were reported, in addition to7 among people directly in contact with pilgrims but not living with them, and 7 among persons who had no identifiable contact with pilgrims. Interestingly there wasn't a single case to be reported among those who received rifampicin chemoprophylaxis.[18]Around the same year, another study was published in Mauritius reporting four cases of the same strain of Neisseria Meningitides Serogroup W135. Epidemiologic information and typing results indicate that these recent cases probably followed the introduction of Neisseria meningitidis W135 in Mauritius by pilgrims returning from the Hajj in 2000 and 2001. Among these 4, one has passed away due to the infection. Also, the same article reported five Mauritians who passed away in Saudi Arabia during the Hajj session due to meningitis of unspecified type, nothing was mentioned about their prophylaxis status whether they have received rifampicin or any vaccine.[19]

Non- communicable

Cardiovascular

In the past, infectious disease used to be the leading cause of mortality, but this changed mostly because of mandatory vaccination programs as well as a change in epidemiology. Over the last decade, cardiovascular diseases have been the main cause of hospital admission and the leading cause of mortality during the Hajj.[20]Currently, cardiovascular disease is the leading cause of death which represent 43% of death during the Hajj.[9] Many patients have cardiac arrests outside the hospitals during the Hajj. Although response workers are emergency medical service teams supported by the ambulance, pilgrims are rarely resuscitated. Hajj is burdensome even for healthy adults. Pilgrims with underlying cardiac disease are prone to ischemia because of the physical stress encountered in Hajj.A study showed that 64% of all admissions to an ICU in Mecca were due to CVD.[21] Most of the deaths were due to cardiovascular diseases by death certificate compared to verbal autopsy method ($p<0.001$). More deaths were due to ill-defined causes when verbal autopsy was performed ($p<0.001$).[10]A study conducted in 2004 and 2005 revealed that the most common diseases during those two pilgrimages were respiratory and the incidence in 2005 was double that of 2004.[22] The prevalence of cardiovascular diseases among pilgrims in Hajj 2004 was 288 per 10,000 compared to 142 per 10,000 in 2005. The mortality rate in 2005 was 24 deaths per 100,000 compared to 47 per 100,000 in 2004.[22] In 2008, a study conducted on 206,831 Indonesian pilgrims revealed that the mortality rate in Hajj 2008 was 216 deaths per 100,000 pilgrims. The highest mortality rates were among those who were 60 and older which increased significantly as age increased ($p<0.01$). Most deaths were due to cardiovascular (66%) followed by respiratory (28%).[10] In this study, there were only 4 deaths in the 18-40 year-old group half of them were males. Based on the death certificates, 3 had a cardiac arrest and one had asphyxia due to active TB. Most of the deaths occurred at hospitals (57%), but a large number of deaths occurred in apartments and sleeping areas (36%).[10]The in-hospital mortality rate in 2009, 2010, and 2011 was 4.7%, 4.6%, and 3.0%, respectively. Before intervention in 2009, cardiac mortality accounted for 52% of all in-hospital deaths in Hajj. This number decreased significantly to 43.3%, 32.5%, and 19.7% in 2009, 2010, and 2011, respectively. According to the Saudi Ministry of Health, cardiovascular causes were responsible for 51.8%, 50.8%, and 53.2% of deaths among pilgrims in 2006, 2007, and 2008 respectively. A possible cause for the increased prevalence of cardiac deaths is the lack of efficient acute cardiac care. This study showed the annual mortality rate per 100,000 to range between 17.3 and 30.5 with the lowest in 2009 and 2010 and the highest in 2007 and 2011. An interesting finding was that the rate of hospital admissions due to STEMI peaked around the 11th day of Hajj, which coincides with the mass gathering of pilgrims in Mena in overcrowded and extreme conditions.[23] The crude mortality rate among Indian pilgrims was 11.99 per 10,000 in 2016 compared to 27.02 per 10,000 in 2015. Out of 163 deaths, the most common direct cause of death was cardiorespiratory arrest.[8]

A bundle care intervention that consists of several well equipped coronary units, catheterization labs at two hospitals in Mecca, land and air transportation, along with well-equipped and trained healthcare professionals, managed to reduce the mortality rate due to acute coronary syndrome by about 7.5 per 100,00 during Hajj 2009-2011. This intervention was successful because the increase in catheterization labs resulted in an increase in the number of catheterization procedures from 183 in 2009 to 550 in 2011. This resulted in a decrease in CVD-related deaths from 43.7% in 2009 to 16.7% in 2011.[23]

The responsibility is on the pilgrim to avoid the Hajj if they have cardiac diseases, and clinicians must encourage this preventative measure. Cardiac patients planning for the Hajj should consult with their family physicians before the journey; ensure an adequate supply of medications. They should try their best to avoid crowds, perform rituals by proxy, and report to the closest hospital for any cardiac symptoms such as chest pain and shortness of breath. The study recommended that when patients suffering from severe cardiovascular disease were prohibited from attending Hajj and others with mild forms of cardiovascular diseases performed Hajj but were compliant with appropriate medications and were monitored during the pilgrimage, mortality rates significantly decreased. This advocates the need for pre-departure health screening to be conducted by all pilgrims from all countries, excluding terminally ill patients from performing Hajj, and providing appropriate medications and monitoring patients during Hajj to reduce the risk of death.[22]

Cerebrovascular accidents

A cross-sectional study was carried out in 2015. A total of 186 cerebrovascular accident cases were included, the authors reported an incidence of 8.9 cerebrovascular accident cases in each 100,000,with a mean age of 60 years. Also, the authors declared the most common risk factor for cerebrovascular accidents to be hypertensionas the most common risk factor (57%), followed by diabetes (40.9%). Moreover, patients were transported via emergency in

48.5% of the cases, and by private transport in 36.4% of the cases. Only five patients were given tPA, and the most common reason for not giving tPA was a delay in arrival to the hospital in 72.2% of the cases, followed by contraindications to tPA therapy in 19% of the cases. a mortality rate of 11.1% was reported among this group.[24]In addition to what we already discussed under the respiratory infections section, Khan and et al reported that cerebrovascular accidentswere the 3rd most common cause of death according to his study.[15]

Injuries

Heatstroke

Both heat exhaustion and heatstroke are major causes of morbidity and mortality during Hajj, especially during summer, and the Arafat period, which is a time where there is a high risk of stroke due to long- standing hours. Heatstroke has a mortality rate of 6.3% while heat exhaustion has a mortality rate of 0.0%.[25]Therefore, it is necessary to drink lots of fluids and avoid excessive sun exposure. It is worth mentioning that hospitals in Mecca and Medina are well-equipped with cooling units that are specialized for the management of heatstroke.[26,27]In a study conducted at Nimra Hospital that assessed 211 patients who required medical care during the day of Arafat, only 2 died both as a result of heatstroke.[28]

Mechanical injuries

In a prospective study on 713 pilgrims who sustained injuries during Hajj, 248 (35%) were admitted to surgical care and intensive care units. However, trauma injuries are not restricted to holy sites, motor vehicle accidents play a major role in Hajj-related trauma, and are almost inevitable.(29)

Stampede is yet another feared hazard and is a major contributor to casualties and fatalities. At the Hajj 2015, stampedes occurred due to pilgrims tripping over each other, resulting in 717 deaths. A dangerous area for stampedes to occur is the Jamarat area, where crowds gather to stone the pillars that represent the devil. As an attempt by the Saudi authorities to prevent stampedes from occurring, the cylindrical pillars have been replaced with elliptical ones to increase the surface area available for stoning.[30]

A devastating event occurred in 1997, where Mina tents were set on fire by an open stove. This event has resulted in 343 unfortunate deaths and more than 1500 injuries. Since then all camping tents have been replaced by fiberglass installations. Consequently, no pilgrim is allowed to set up his/her tent. Additionally, smoking and cooking are forbidden to minimize the risk of starting a fire.[31]

Conclusion:-

In the past, infectious disease used to be the leading cause of mortality, but this changed mostly because of mandatory vaccination programs as well as a change in epidemiology.We found thatcardiovascular diseases were the most common causes of death followed by respiratory. Also, cerebrovascular accidentswere reported in some studies to be the 3rd most common cause of death. Furthermore, old age was identified to be the most significant risk factor for dying in Hajj.

Recommendations:-

1- We recommend that patients suffering from severe medical conditions to be discouraged from performing Hajj, and patients who have mild conditions should be monitored during Hajj and be well-equipped with medications and strongly encouraged to be compliant with them.

2- We also recommend the need for pre-departure health screening to be conducted on pilgrims from all nationalities.

3- As we discussed in our study, there was a delay in transferring patients to hospitals in Mecca during Hajj, thus affecting their survival chances, which further increases the mortality rate. Thus, we recommend more investigation to be done in this area to find the appropriate solution.

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