

**The 19<sup>th</sup> Scientific Forum  
for Hajj, Umrah and  
Madinah Visit Research**

**The Scientific Bulletin**

**English Part**



# **Scientific Papers**



In the name of Allah, the Most Gracious, the Most Merciful

# Introduction

The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University, organizes the 19th Scientific Forum for Hajj, Umrah and Madinah Visit Research Under the patronage of the Custodian of the Two Holy Mosques, King Salman Bin Abdul Aziz Al Saud. This year, the event will be held in Almadinah Almunawarah in cooperation with Taibah University. The forum is an annual scientific event where specialists, officials and workers in the field of Hajj and Umrah meet to present the summary of their research, studies and proposals. During this forum, they exchange views and the latest scientific global technologies so as continuously apply them in the development of the services being provided to the pilgrims and visitors to complete their Hajj and Umrah rituals perfectly and safely.

The forum aims to invite specialized researchers from the Saudi universities and research institutes, who are interested in Hajj and Umrah research. Additionally, representatives of government agencies, private and third sectors are also invited to present their own experiences and studies through the forum's themes. The forum's themes include; social and administration sciences, economics, and humanities, environment and health, urbanization and Engineering, technology and its applications, awareness and media as well as the theme of achievements and initiatives of the services being provided for Makkah pilgrims and Madinah visitors. This theme highlights the efforts of service providers to maintain the quality of service provided to the pilgrims, which will enable them to perform their rituals in a comforting and safe environment.

The forum's scientific committee received a number of scientific papers from various academic, public, private, and third sectors. The forum articles have been reviewed in two stages; the first stage (internal review only) focuses mainly on matching the articles with its appropriate forum's theme, while the second phase (external and internal review) focuses on reviewing the scientific content of the different articles by specialists in the different fields of the forum themes. Accepted papers, are being presented in the forum will be published in this bulletin.

The Scientific Committee of the 19<sup>th</sup> Scientific Forum for Hajj and Umrah Research would like to express its gratitude and thanks to all those who contributed in providing both material and moral support, headed by their Excellences; the Minister of Education, the University Director, the Dean of the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, the Chairman of the Organizing Committee of the Forum. Thanks, is also extended to all the reviewers for their valuable comments and efforts to improve the quality of materials presented in the forum.

**Scientific Committee of the 19<sup>th</sup> Scientific Forum  
of Hajj, Umrah and Madinah Visit Research**

**The Scientific Committee of the 19th Scientific Forum of Hajj, Umrah and  
Madinah Visit Research**

**The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research –  
Umm Al-Qura University**

**29 - 30 Jumada al-Akhira 1440 / 6 - 7 March 2019**

**Email:** [multaqa@uqu.edu.sa](mailto:multaqa@uqu.edu.sa)

**Website:** [hajj.uqu.edu.sa/multaqa](http://hajj.uqu.edu.sa/multaqa)

*P.O. Box: 6287- Postal Code: 21955 Makkah Al-Mukaramah*

**Chairman of the Committee**

Prof. Atif H Asghar

**Confidant of the Committee**

Mr. Rami A. Almwari

**Committee members**

Dr. Fadel M. Y. Othman

Dr. Waleed A. EL-Saoud

Dr. Essam A. Khan

Dr. Osman B. Gazzaz

Dr. Mazin I. Alshamrani

Dr. Ibrahim A. Alkaldy

Prof. Fathy F. Shaaban

Dr. Omar B. Ahmed

Dr. Safwat S. Gabr

Eng. Naif M. Bashraf

.....

# Table of Contents

<b>Introduction</b> .....	
<b>Second Theme: Environment and Health</b> .....	<b>2</b>
Adherence to influenza vaccination and reasons of hesitance to get the vaccine among Umrah and Hajj attendants, Makkah, 1439 .3	
Nutrition among Umrah Visitors with Chronic Diseases .....	13
Core Competencies required of Health care Providers During Mass Casualty Incidents (MCIs) in Saudi Arabia: Implications for Hajj .....	22
The Potentiality of Biogas from Landfilling of Solid Waste in Madinah, KSA .....	28
Effect of Fasting on the Physical Effort of Pilgrims .....	41
Evaluation of antimicrobial effect of Chitosan and acetic acid during thawing of frozen chicken .....	49
Service Availability and Readiness Assessment of Health Facilities in Mina and Arafat during the 2017 Hajj .....	56
Assessment of the risks of landslides in Thawr Mountain in Makkah by measuring slope stability factors and geographic information system .....	66
Prevalence and Determinants of Influenza-like illness among Pilgrims in Makkah, during Hajj Season 1439 H.....	80
<b>Third Theme: Urbanization and Engineering</b> .....	<b>90</b>
High-Efficient and Low Cost Hybrid Renewable Energy Systems Configuration for Mina Region .....	91
Trenchless Technology: The Right Method for Sustainable Construction & Maintenance of Urgent Infrastructure Projects within Crowded Vicinities.....	102
A new proposed substance to resist ignition and fire for use in Hajj and Umrah seasons .....	114
<b>Fourth Theme: Technology and its applications</b> .....	<b>122</b>
Towards Smart Camps in Mina Holy Place: Exploiting IoT Technologies.....	123
Using Convolution Neural Network for Crowd Density Estimation for The Holy Masjed .....	133
Crowd Congestion Assessment using Multi-Resolution Clustering .....	142
User Preferences- based Recommendation Algorithm Case Study: Hajj and Umrah Agencies .....	149
Multi-Level Multi-Stage Agent-Based Simulation Model of Crowd Dynamics in last Floor of Al- Haram Al-Sharif.....	159
Using a multi-agent architecture to handle the negotiation between the Hajj authorities and the Hajj travel agents.....	168
<b>Fifth Theme: Awareness and media</b> .....	<b>175</b>
Using Printable Integrated Multimedia Maps for telling Islamic Heritage Sights in Al-Madinah Al-Monawarah.....	176
Applying game-based learning system to facilitate the Manasik of Hajj and Umrah.....	185
Requirements for achieving psychological security for pilgrims through religious awareness.....	193



## **Second Theme**

# **Environment and Health**

# Adherence to influenza vaccination and reasons of hesitance to get the vaccine among Umrah and Hajj attendants, Makkah, 1439

Hassan Kasim Haridi<sup>(1)</sup>, Ibrahim Hussein Abbd EL-Rahim<sup>(2)</sup>, Tariq Al-Malki<sup>(3)</sup>,  
Wael Hamzah Motair<sup>(4)</sup>, Arwa Al-Malki Atiah<sup>(5)</sup>

<sup>(1)</sup> General Directorate of Health Affairs, Hail Region

<sup>(2)</sup> The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University

<sup>(3)</sup> Preventive Medicine Saudi Board resident, Makkah

<sup>(4)</sup> Directorate of Health Affairs, Makkah

<sup>(5)</sup> Graduate physician under training

## مدى التزام الحجاج والمعتمرين بالتطعيم بلقاح الإنفلونزا ، وأسباب عدم تلقي اللقاح للعام ١٤٣٩ هـ بمكة المكرمة

حسن قاسم هريدي<sup>(١)</sup>، إبراهيم حسين عبد الرحيم<sup>(٢)</sup>، طارق عطية المالكي<sup>(٣)</sup>، وائل بن حمزة مطير<sup>(٤)</sup>، أروى عطية المالكي<sup>(٥)</sup>  
<sup>(١)</sup> المديرية العامة للشئون الصحية بمنطقة حائل  
<sup>(٢)</sup> معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة والزيارة – جامعة أم القرى  
<sup>(٣)</sup> البرنامج المشترك لطب المجتمع بمكة المكرمة  
<sup>(٤)</sup> مديرية الشئون الصحية بمكة المكرمة  
<sup>(٥)</sup> طبيبة تحت التدريب

### ملخص البحث (Abstract):

خلفية الدراسة: يعتبر التجمع الكبير للمعتمرين وحشود الحجاج بيئة مناسبة لانتشار عدوى فيروس الأنفلونزا مع مضاعفاته الخطيرة. وقد أثبت لقاح الأنفلونزا فعاليته في الوقاية من المرض أو التخفيف من مضاعفاته.  
أهداف الدراسة: تقييم مدى التزام الحجاج والمعتمرين بمكة المكرمة بالتطعيم ضد الإنفلونزا، وكذلك التعرف على أسباب عدم تلقي اللقاح بين غير المطعمين.

منهجية الدراسة: هي دراسة مقطعية مسحية تم إجراؤها على عينة من الحجاج والمعتمرين البالغين القادمين لمكة المكرمة خلال عام ١٤٣٩.

نتائج الدراسة: تم إجراء ٩٩٧ مقابلة ناجحة، منها ٩١٢ للقادمين من خارج المملكة بنسبة ٩١,٥%. بلغ عدد المشاركين القادمين للعمر ٣٩٨ بنسبة ٣٩,٩%، وللحج ٥٩٩ بنسبة ٦٠,١%. بلغ عدد المشاركين من الدول العربية، جنوب شرق آسيا، جنوب آسيا إفريقيا، الدول الغربية الأعداد والنسب التالية على الترتيب: ١٧٣ (١٧,٤%)، ٤٠٢ (٤٠,٣%)، ٢١١ (٢١,٢%)، ١١١ (١١,١%)، و ١٠٠ (١٠,٠%). وقد بلغ عدد الإناث المشاركات ٢٩٣ بنسبة ٢٩,٤%.

أظهرت النتائج تلقي لقاح الأنفلونزا لدى ٧٠,٩% من إجمالي المشاركين بنسبة تغطية ٧١,١%. ووجد فارقا كبيرا في نسب التغطية باللقاح بين الحجاج (٩١,١%) وبين المعتمرين (41.8%) (p<0.001). كانت غالبية المشاركين (٨٠,٣%) على دراية بلقاح الأنفلونزا بنسبة ٨٠,٩%. وأن ٥٠,٣% منهم (٦١,٧%) لديهم معرفة جيدة حول مرض الأنفلونزا ولقاحه.

كشفت نتائج تحليل الانحدار اللوجستي متعدد المتغيرات أن فئات المشاركين من داخل المملكة، والقادمين للحج، والقادمين من جنوب شرق آسيا وأفريقيا والدول الغربية والحاصلين على تعليم جامعي، ومن لديهم دراية بلقاح الإنفلونزا، كانت عوامل ذات ارتباط مستقل منبئة بتلقي لقاح الأنفلونزا بين المشاركين.

وكشفت الدراسة أن عدم الدراية باللقاح (٥٩,٧٪)، وعدم معرفة متى ينبغي التطعيم به (٣٣,٧٪)، وكونه مكلفًا (٢٩,٥٪)، وعدم معرفة كيفية الحصول عليه (٢٢,٢٪)، وعدم معرفة أن اللقاح موصى به (١٥,٦٪) هي أهم أسباب عدم التطعيم. الخلاصة: أن نسبة الالتزام بتلقي لقاح الانفلونزا بين القادمين للحج كانت جيدة، ولكنها كانت ضعيفة بين القادمين للعمرة، والقادمين من بلدان جنوب آسيا. وكان عدم معرفة اللقاح وتكلفته والحصول عليه أهم عوائق تلقي اللقاح. الكلمات الدالة: لقاح الانفلونزا؛ الالتزام؛ الحج؛ العمرة

**Background:** Mass gathering in Makkah during Umrah and Hajj is coincidental to the spread of influenza virus infection with its serious complications. Influenza vaccine proved effective in disease prevention or mitigating its complications.

**Objectives:** To assess adherence to influenza vaccination among Muslims visiting Makkah to perform Umrah and Hajj, and to explore reasons behind hesitancy to receive the vaccine among the unvaccinated.

**Methods:** This work was a cross-sectional interview survey carried out on a conventional sample of adult Muslims coming to Makkah for Umrah/Hajj during 1439.

**Results:** Overall, 997 successful interviews were completed, of them 912 (91.5%) were coming from outside Saudi Arabia; 398 (39.9%) were coming for Umrah and 599 (60.1%) for Hajj. Participants affiliated to Arab, Southeast Asia, South Asia, African and Western countries were 173 (17.4%), 402 (40.3%), 211 (21.2%), 111 (11.1%) and 100 (10.0%) respectively. Females (293) constituted 29.4%.

Overall, 709 (71.1%) were influenza vaccinated with high difference in coverage between Umrah and Hajj attendants (41.8% vs 91.1%;  $p < 0.001$ ) respectively. Majority 803 (80.9%) were aware about the vaccine and 503 (61.7%) of the participants have good knowledge about influenza disease and vaccine.

Multivariate logistic regression analysis revealed that, participants who are KSA domestic, coming for Hajj, coming from Southeast Asia, Africa and Western countries, university educated and aware about influenza vaccine, were independently associated with receiving the vaccine. Important reasons for not vaccinating were being not aware about the vaccine (59.7%), not aware when to receive the vaccine (33.7%), the vaccine is costly (29.5%) had no access (22.2%) and not aware that the vaccine is recommended (15.6%).

**Conclusion:** Despite good vaccination coverage among participants coming for Hajj, influenza vaccination was poor among Umrah attendants. Likewise, poor vaccination among participants coming from south Asian countries. Vaccine unawareness, cost and access were important barriers to receive the vaccine.

**Key Words:** influenza Vaccine; adherence; Hajj; Umrah

## Introduction

Mass gathering in Hajj and Umrah increase the risk of acquisition and transmission of respiratory tract infections including influenza; which remains a major concern and common health hazard for pilgrims. [1] Since 2005, Ministry of Health recommends that international pilgrims be vaccinated against seasonal influenza before arrival into the Kingdom of Saudi Arabia, particularly those at increased risk of severe influenza diseases, including pregnant women, children under 5 years, the elderly, and individuals with underlying health conditions such as HIV/AIDS, asthma, and chronic heart or lung diseases. [2,3] At least one-fourth of the pilgrims suffer from one or more of these risk factors. [4,5] This recommendation is also applying for internal pilgrims, particularly those at risk described above, and all health-care workers in the Hajj premises. [2,3]

Pooled estimates from observational studies indicate that influenza vaccine is effective against laboratory-proven influenza among Hajj pilgrims. [6] Influenza vaccination also has been shown in several studies to reduce severity of illness in people who get vaccinated but still get sick. Influenza vaccination reduced deaths, intensive care unit (ICU) admissions, ICU length of stay, and overall duration of hospitalization among hospitalized influenza patients. [7] Among adults hospitalized with influenza, vaccinated patients were 59 percent less likely to be admitted to the ICU than those who had not been vaccinated. Among adults in the ICU with influenza, vaccinated patients on average spent 4 fewer days in the hospital than those who were not vaccinated. [8] Therefore, influenza vaccination is recommended, and important to be monitored frequently among pilgrims from different countries.

### **Research aims**

The aim of this work is to assess adherence to influenza vaccination among Muslims visiting Makkah to perform Umrah and Hajj, and to explore reasons behind hesitancy to receive the vaccine among the unvaccinated.

### **Research methodology**

#### **Study design and participants**

This work was a cross-sectional interview survey carried out on a conventional sample of adult Umrah and Hajj attendants during the year 1439. Participants, during their stay in Makkah to attend Umrah or Hajj, were asked to participate in the study after explanation of the study objective. Those who agreed to participate were interviewed after taking a verbal consent. Participants were recruited randomly from those who were available at hotel lobbies around and near Haram after prayers in the day time. Inclusion criteria were: being adult man or woman  $\geq 18$  years, coming for Umrah or Hajj, from any country including domestic participants and have no contraindication for influenza vaccination.

#### **Data collection tool**

Upon inclusion, the participants were interviewed by two investigators (male and female) using a standardized questionnaire that collected information on: (1) demographics, (2) influenza vaccination status, (3) knowledge about influenza disease and vaccine, (4) reasons receiving/not receiving influenza vaccine. Those who reported receiving seasonal influenza vaccine before coming to Umrah or Hajj by at least two weeks were considered having a valid vaccination.

#### **Statistical analysis**

Differences in the proportions were tested by Pearson's chi-square, or Fisher's exact tests when appropriate. Student's t-test was used to test for differences in means. Knowledge scale was created for the 8 knowledge questions, where correct answers scored 1 and incorrect or don't know scored 0, with a maximum score of 8 points. Univariate and multivariate logistic regression model were used to examine factors associated with influenza vaccine receipt among participants. Any variable resulting in a value  $\leq 0.25$  in the univariate analysis was included in the multivariable model. The variables included in the model were then subjected to a backward selection to determine the significant independent predictors for the vaccine receipt. The results of the logistic regression analysis are presented as odds ratios (ORs) and 95% confidence intervals (CIs). All statistical tests were two-sided and P value for all tests  $< 0.05$  was considered significant.

Statistical analysis was undertaken using Epi Info 7.1.3 (CDC, Atlanta, GA, USA) and Statistical Package for the Social Science (SPSS), Version 30 for Windows.

### **Ethical consideration**

The study done under collaborative umbrella of Saudi Community Board of Postgraduate studies, the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University, and Ministry of Health in Makkah. The study was performed in accordance with the Declaration of Helsinki and its amendments. All participants provided oral informed consent.

## **Results and discussion**

### **Results**

Table 1 describe characteristics of the participants and their influenza vaccination status. Overall, 997 successful interviews were completed, of them 398 (39.9%) were coming for Umrah, and 599 (60.1%) were coming for Hajj. The majority 912 (91.5%) came from outside Saudi Arabia. The mean age (SD) of the participants in our sample was 37.7 (8.82) distributed as 17.0, 40.3, 33.4 and 9.3 percentages for the age groups <30, 30-39, 40-49 and ≥50 years respectively. Females (293) constituted 29.4%. More than forty percent (45.5%) of the participants were university educated. Participants belongs to Arab countries, Southeast Asia, south Asia, Africa and western countries were 17.4, 40.3, 21.2, 11.1 and 10.0% respectively. More than forty percent (43.3%) of the participants frequently attended Umrah and most of them (76.7%) came for Hajj first time. About seventy percent (71.1%) of the participants reported influenza vaccination before coming to attend Umrah and/or Hajj, with significant difference in coverage between Umrah and Hajj attendants (41.8% vs 91.1%;  $p<0.001$ ) respectively. Majority 803 (80.9%) of the participants were aware about influenza vaccine. More than sixty percent (503; 61.7%) have good knowledge about influenza disease and vaccine, they attained 6 points or higher on a scale of 8 points maximum. However, a high difference between vaccinated (86.0%) and unvaccinated (14.0%) was there. Figure 1 depicts a histogram of participants' knowledge score as a continuous variable. Important sources of participant's information were social media (71.0%), Internet sites (31.4%), flu vaccination campaigns (10.7%) (Table 2).

The highest vaccine uptake (90.4) was reported among domestic participants compared to 69.9% for those coming from outside KSA ( $p<0.001$ ) and those who were coming for Hajj (91.1%) compared to 41.8% for participants coming for Umrah ( $p<0.001$ ). Females have higher vaccination rate (82.9%) compared to males (66.9%;  $p<0.001$ ). The uptake of the vaccine was higher among older age groups with statistically significant rising trend; vaccination coverage was 44.6%, 65.3%, 85.2% and 96.8% for the age groups <30, 30-39, 40-49 and ≥50 years respectively ( $p<0.001$ ). The highly educated participants reported higher vaccine uptake, with statistically significant up trend; the uptake among ≤ primary, middle, secondary and ≥ university education participants were 17.8%, 38.6%, 81.3% and 97.8% respectively. The vaccine uptake was also higher (86.3%) among aware participants about the vaccine compared to very low uptake (13.7%) among unaware ( $p<0.001$ ) and among those who possessed higher knowledge score (≤ 6 points) about influenza vaccine and disease (86.0%) compared to participants with lower knowledge score (14.0%;  $p=0.004$ ) (Table1).

Table 3 presents results of multivariate logistic regression analysis carried out to explore the association between influenza vaccine uptake and different characteristics of the participants. Both crude and adjusted Odds ratio were estimated and factors independently affecting the vaccine uptake were revealed. Participants who are KSA domestic (OR=5.60, 95% CI 1.97-15.96;  $p<0.01$ ); coming for Hajj (OR=4.14, 95% CI 2.02-8.49;  $p<0.001$ ); coming from southeast Asia (OR=25.06, 95% CI 5.06-124.16;  $p<0.001$ ), south Asia (OR=0.37, 95% CI 0.15-0.94,  $p<0.01$ ), African countries (OR=4.75, 95% CI 2.36-9.54;  $p<0.001$ ) and western countries (OR=8.12, 95% CI 2.21-29.86;  $p<0.01$ ) compared to Arab countries; those who attained secondary (OR= 2.64, 95% CI 1.18-5.93;  $p<0.05$ ) or  $\geq$ university education (OR=8.98, 95% CI 2.95-27.29;  $p<0.001$ ) compared to  $\leq$ primary education; as well as participants aware about influenza vaccine (OR= 5.72, 95% CI 2.45-13.31;  $p<0.001$ ) were independently associated with receiving the vaccine. The coefficient of determination  $R^2$  of linear correlation that measured the strength and the direction of a linear relationship between influenza vaccine uptake and other predictor variables in the model was 0.72, which indicates that 72% of the total variation in influenza vaccine uptake among participants can be explained by these predictor variables in the model (not shown in tables).

Table 4, enlists the important reasons cited by the participants for not receiving influenza vaccine. Being not aware about the vaccine (60.1%), the vaccine is costly (30.2%), had no access to receive the vaccine (22.4%) and rely on self-natural immunity (13.2.6%).

## Discussion

The role of the influenza vaccine has been established in reducing mortality and morbidity of influenza. Pooled estimates from observational studies indicate that influenza vaccine is effective against laboratory-proven influenza among Hajj pilgrims. [6,9] Studies showed a low rate of influenza among vaccinated pilgrims compared to an unvaccinated. [10-14]

Our study uncovered high difference in the vaccine coverage between Umrah and Hajj attendants; being much higher among Hajj compared to Umrah attendants, which comes in line with other studies highlighted a high influenza vaccination coverage among Hajj pilgrims. [15] This can be explained by the well-organized efforts of the governments and Hajj groups organizers to aware their pilgrims with the importance of receiving influenza vaccine as an important preventive measure and to comply with the Saudi Arabia health regulations, which highly recommend influenza vaccine uptake for pilgrims before coming.

The markedly lower influenza vaccination coverage among Umrah attendants imply the need to increase efforts to raise awareness with the importance of receiving the vaccine and strongly emphasize on the vaccine uptake recommended by Saudi health authority for all travelers intend to come for Umrah. Being not aware about the vaccine (60.1%) was the most frequent factor reported by participants in our study to describe their hesitance to receive influenza vaccine. Alqahtani et al in 2016, reported also a similar result, where 56% of Australians pilgrims cited "not being aware of vaccine" as the main reason for influenza vaccine non-receipt. [16].

Recent pre-Hajj vaccine-related studies have measured pilgrims' knowledge, attitudes, and practice, with the results indicating a significant continuing lack of Hajj vaccination awareness among pilgrims. [15] Those who obtained pre-travel advice were twice as likely to be vaccinated as those who did not seek advice. [16]

The high influenza vaccine uptake (90.4%) among domestic participant in our study, confirms the escalating trend of the vaccine uptake in Saudi Arabia in the last years. Alfelali et al. in 2018, reported vaccination rates for the years 2013, 2014 and 2015 were 21.4%, 48.2% and 58.1%, respectively. [17]

Compared to participants coming from Arab countries, south Asian, Western and African countries participants, reported higher influenza vaccine uptake, but on the other side, participants coming from south Asia have reported very low uptake. This marked variation denote different degrees of commitment among countries to ensure their citizens' vaccination. This imply the need to send this information to countries with deficient influenza vaccine coverage, emphasizing on the Saudi health authority's recommendations and requirements for vaccination to those who intend to attend Umrah and/or Hajj.

Important reasons cited by the participants as barriers to receive influenza vaccine were cost (30.2%) and access to the vaccine (22.4%). This indicate the importance to making the vaccine free and providing an easy access to receive the vaccine. We think that Saudi health authority can apply an initiative of providing the vaccine in Saudi embassies or consuls at the time of applying for Hajj or Umrah visa, especially in countries with low vaccine uptake.

Results of the present study also highlighted the important role of social media as a tool for health information seeking behavior. Compared to other sources, by far participants (71.0%) cited social media as their source of information regard influenza vaccine compared to navigating internet (31.4%) or through flu vaccination campaigns (10.7%). This implies the need to consider this important tool by health authorities and governments. For example, sending health awareness messages to all who apply for Umrah or Hajj visa, emphasizing on the recommended health regulation. A well designed short scientific videos can be rapidly spread to millions through social media and can specially targeting Hajj and Umrah attendants.

#### **Study Limitations**

The findings in this report are subject to at some limitations. First, all results are based upon self-report, and vaccination status was not validated with medical records; and respondents might not have accurately reported which vaccine(s) they received. Second, survey bias might have resulted from the unbalanced sample participants according their country and demographic criteria compared to characteristics of the actual Hajj population and interviewers' selection bias.

#### **Summary and conclusion**

Despite the convenient influenza vaccination coverage among participants coming for Hajj, vaccination among Umrah attendants was inadequate. A special concern about influenza vaccine uptake among participants coming from south Asian countries. Unawareness about the vaccine, cost and access to the vaccine were the important barriers to receive the vaccine. The study revealed the importance of social media and internet sites as preferable sources for knowledge seeking behavior about flu vaccine.

#### **Recommendations**

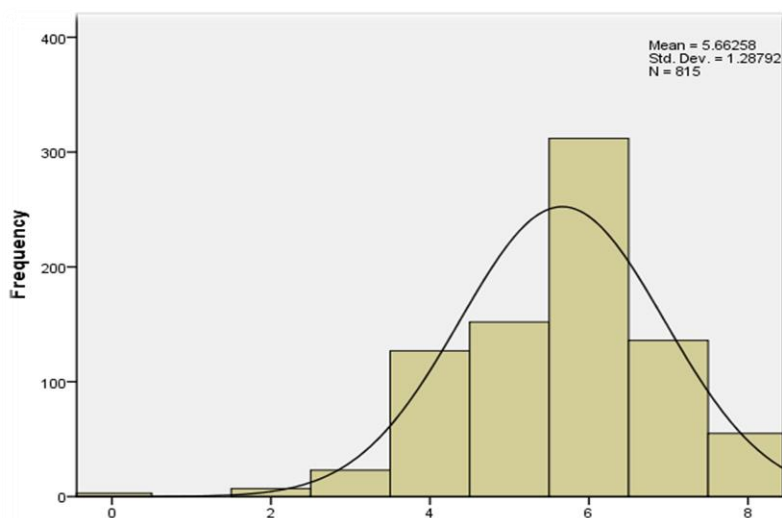
- 1- Mandatory influenza vaccination could be a good choice to ensure high vaccination coverage.
- 2- Communication with countries with deficient influenza vaccine coverage, emphasizing on the Saudi health authority's recommendations and requirements for vaccination to those who intend to attend Umrah and/or Hajj.
- 3- Considering influenza vaccination service in Saudi embassies or consuls at the time of applying for Hajj or Umrah visa, especially in countries with low vaccine uptake.
- 4- Utilization of social media to increase awareness with the importance of influenza vaccination among pilgrims.

Table 1: characteristics of the participants and their influenza vaccination status (n=997)

Participants	Overall n (%)	Vaccination Status n (%)		p
		Vaccinated	Unvaccinated	
<b>All Participants</b>	997 (100.0)	709 (71.1)	288 (28.9)	
<b>Coming from</b>				< 0.001
- KSA	85 (85.5)	75 (90.4)	8 (9.6)	
- Outside KSA	911 (91.5)	634 (69.9)	273 (30.1)	
<b>Coming for</b>				< 0.001
- Umrah	398 (39.9)	164 (41.8)	228 (58.2)	
- Hajj	599 (60.1)	545 (91.1)	53 (8.9)	
<b>Nationalities</b>				< 0.001
- Arab countries	175 (17.4)	114 (67.5)	55 (32.5)	
- Southeast Asia	402 (40.3)	400 (99.5)	2 (0.5)	
- South Asia	211 (21.2)	19 (9.1)	189 (90.9)	
- African countries	111 (11.1)	80 (72.1)	31 (27.9)	
- Western countries	100 (10.0)	96 (96.0)	4 (4.0)	
<b>Gender</b>				< 0.001
- Male	704 (70.6)	446 (66.9)	231 (33.1)	
- Female	293 (29.4)	243 (82.9)	50 (17.1)	
<b>Age in years</b>				< 0.001
- <30	169 (17.0)	74 (44.6)	92 (55.4)	
- 30-39	402 (40.3)	263 (65.3)	137 (34.3)	
- 40-49	333 (33.4)	282 (85.2)	49 (14.8)	
- ≥50	93 (9.3)	90 (96.8)	3 (3.2)	
Mean (SD)	37.7 (8.82)	39.7 (8.59)	32.8 (7.31)	< 0.001
<b>Education level</b>				< 0.001
- Primary	177 (17.8)	31 (17.8)	143 (82.2)	
- Middle	141 (14.3)	54 (38.6)	86 (61.4)	
- Secondary	225 (22.6)	182 (81.3)	42 (18.8)	
- University/Higher	453 (45.5)	441 (97.8)	10 (2.2)	
<b>Umrah frequency</b>				< 0.001
- Once	564 (56.7)	431 (76.6)	132 (23.4)	
- Frequent	431 (43.3)	277 (65.2)	148 (34.8)	
<b>Hajj frequency</b>				< 0.001
- None	131 (13.2)	53 (41.4)	75 (58.6)	
- Once	762 (76.7)	571 (75.2)	188 (24.8)	
- Frequent	101 (10.2)	84 (84.0)	16 (16.0)	
<b>Aware about influenza vaccine</b>				< 0.001
- Yes	803 (80.9)	693 (86.3)	110 (13.7)	
- No	190 (19.1)	12 (6.3)	178 (93.7)	
<b>Knowledge score about influenza and vaccine</b>				0.004
- ≤5 points	312 (38.3)	243 (78.1)	68 (21.9)	
- 6-8 points	503 (61.7)	430 (86.0)	70 (14.0)	
Mean (SD)	5.66 (1.92)	5.77 (1.26)	51.13 (1.26)	< 0.001

\*Knowledge score of maximum 8 points





**Figure 1: Histogram of Knowledge score about influenza vaccine/disease among study participants, Umrah and Hajj season, Makkah, 1439.**

Table 2: Sources of knowledge about influenza vaccine of Umrah and Hajj participants, Makkah, 1439.

Knowledge source*	Frequency	Percent (95% CI)
- Social Media	708	71.0 (68.1-73.8)
- Internet sites	313	31.4 (28.5-34.4)
- Health campaigns	107	10.7 (8.9-12.9)
- Healthcare staff	44	4.4 (3.3-5.9)
- Friends	35	3.5 (2.5-4.9)

Abbreviations: CI, confidence interval;

\*Participants may cite more than one knowledge source.

Table 3: Logistic regression analyses for background information and other potential factors associated with influenza vaccine receipt among Umrah and Hajj attendants in Makkah, 1439.

Factors	cOR (95% CI)	aOR (95% CI)
<b>Coming from</b>		
- KSA	4.04 (1.92-8.48)***	5.60 (1.97-15.96)**
- Outside KSA	1	1
<b>Coming for</b>		
- Umrah	1	1
- Hajj	14.30 (10.11-20.21)	4.14 (2.02-8.49)***
<b>Nationalities</b>		
- Arab countries	1	1
- Southeast Asia	96.50 (23.22-400.94)***	25.06 (5.06-124.16)***
- South Asia	0.05 (0.03-0.09)***	0.37 (0.15-0.94)*
- African countries	1.25 (0.74-2.10)	4.75 (2.36-9.54)***
- Western countries	11.58 (4.05-33.11)***	8.12 (2.21-29.856)**
<b>Gender</b>		
- Male	1	
- Female	2.41 (1.71-3.39)***	
<b>Age in years</b>		
- <30	1	
- 30-39	2.39 (1.65-3.45)***	

- 40-49	7.16 (4.65-11.01)***	
- ≥50	37.30 (11.34-122.64)***	
<b>Education level</b>		
- ≤ Primary	1	1
- Middle	2.90 (1.73-4.85)***	0.84 (0.38-1.84)
- Secondary	20.00 (11.97-23.39)***	2.64 (1.18-5.93)*
- University/Higher	203.43 (97.32-425.22)***	8.98 (2.95-27.29)***
<b>Umrah frequency</b>		
- Once	1	
- Frequent	0.57 (0.43-0.76)***	
<b>Hajj frequency</b>		
- None	1	
- Once	4.30 (2.91-6.34)***	
- Frequent	7.45 (3.92-14.85)***	
<b>Aware about influenza vaccine</b>		
- No	1	1
- Yes	95.34 (51.31-177.16)***	5.72 (2.45-13.31)***
<b>Knowledge score# about influenza and vaccine</b>		
- ≤5 points	1	
- 6-8 points	1.72 (1.19-2.48)**	

Abbreviations: cOR, crude odds ratio; aOR, adjusted odds ratio; CI, confidence interval;

Final -2\*Log-Likelihood: 282.51; Likelihood Ratio: 455.57; Model *P*-Value: <0.001.

\* < 0.05; \*\* < 0.01; \*\*\* < 0.001;

# Maximum 8 points Score.

Table 4: Frequent reasons cited for non-adherence to influenza vaccination among Umrah and Hajj participants, Makkah, 1439.

<b>Reason*</b>	<b>Frequency</b>	<b>Percent (95% CI)</b>
- Not heard about the vaccine	169	60.1 (54.2-65.9)
- The vaccine is costly	85	30.2 (24.9-36.8)
- The vaccine not available	63	22.4 (17.7-27.8)
- Rely on self-natural immunity	37	12.2 (9.4-17.7)

Abbreviations: CI, confidence interval;

\*Participants may cite more than one reason.

## References

- [1] Gautret P, Benkouiten S, Al-Tawfiq JA, Memish ZA. Hajj-associated viral respiratory infections: a systematic review. *Travel Med Infect Dis.* 2016; 14: 92-109
- [2] WHO. Health conditions for travellers to Saudi Arabia for the pilgrimage to Mecca (Hajj), 2015. *Wkly Epidemiol Rec* 2015;90(31):381–92.
- [3] Memish ZA, Al Rabeeah AA. Health conditions for travellers to Saudi Arabia for the Umra and pilgrimage to Mecca (Hajj)—2014. *J Epidemiol Glob Health.* 2014; 4: 73-75
- [4] Deris, ZZ, Hasan, H, Ab Wahab, MS, Sulaiman, SA, Naing, NN, Othman, NH. The association between pre-morbid conditions and respiratory tract manifestations amongst Malaysian Hajj pilgrims. *Trop Biomed* 2010;27:294–300
- [5] Memish, ZA, Assiri, AM, Hussain, R, Alomar, I, Stephens, G. Detection of respiratory viruses among pilgrims in Saudi Arabia during the time of a declared influenza A(H1N1) pandemic. *J Travel Med* 2012;19:15–21
- [6] Alqahtani AS, Rashid H, Heywood AE. Vaccinations against respiratory tract infections at Hajj. *Clin Microbiol Infect.* 2015; 21: 115-127
- [7] Arriola C, Garg S, Anderson EJ, Ryan PA, George A, Zansky SM, et al. Influenza Vaccination Modifies Disease Severity Among Community-dwelling Adults Hospitalized With Influenza. *Clin Infect Dis.* 2017 Oct 15;65(8):1289-1297. doi: 10.1093/cid/cix468
- [8] Thompsona G, NevilPierseb, Sue Huang Q, Prasad N, Duquead J, Newbern E, et al. Influenza vaccine effectiveness in preventing influenza-associated intensive care admissions and attenuating severe disease among adults in New Zealand 2012–2015. *Vaccine.* Volume 36, Issue 39, 18 September 2018, Pages 5916-5925
- [9] Nichol KL, Nordin J, Mullooly J, Lask R, Fillbrandt K, Iwane M. Influenza vaccination and reduction in hospitalizations for cardiac disease and stroke among the elderly. *N Engl J Med.* 2003;348:1322–32.
- [10] Rashid H, Shafi S, Haworth E, El Bashir H, Memish ZA, Sudhanva M, et al. Viral respiratory infections at the Hajj: Comparison between UK and Saudi pilgrims. *Clin Microbiol Infect.* 2008;14:569–74.
- [11] Adler A, Eames K, Funk S and Edmunds W. Incidence and risk factors for influenza-like-illness in the UK: online surveillance using Flu survey. *BMC Infectious Diseases.* 2014;14:232. <https://doi.org/10.1186/1471-2334-14-232> 10.
- [12] Eames KT, Brooks-Pollock D, Paolotti D, Perosa M, Gionannini C, Edmunds WJ: Rapid assessment of influenza vaccine effectiveness: analysis of an internet-based cohort. *Epidemiol Infect.* 2012, 140 (7): 1309-1315. 10.1017/S0950268811001804.
- [13] Razavy S, Dabiran S, Ziaee H Ardekani. The incidence of influenza like illness and determination of the efficacy of Flu vaccine in Iranian pilgrims during Hajj Pilgrimage. *Acta Medica Iranica* 2004; 42(6):397-401.
- [14] Alfelali M, Barasheed O, Tashani M, Irfan Azeem M, Heron L, Khandaker G, et al. Changes in the prevalence of influenza-like illness and influenza vaccine uptake among Hajj pilgrims: A 10-year retrospective analysis of data. *Vaccine.* Volume 33, Issue 22, 21 May 2015, Pages 2562-2569
- [15] Abd El Ghany M, Sharaf H, Hill-Cawthorne G. Hajj vaccinations—facts, challenges, and hope. *International Journal of Infectious Diseases.* 2016;47:29–37.
- [16] Alqahtani AS, Wiley KE, Tashani M, Willaby HW, Heywood AE, BinDhim NF, et al. Exploring barriers to and facilitators of preventive measures against infectious diseases among Australian Hajj pilgrims: cross-sectional studies before and after Hajj. *Int J Infect Dis.* 2016 Jun;47:53-9. doi: 10.1016/j.ijid.2016.02.005. Epub 2016 Feb 10.
- [17] Alfelali M, Barasheed O, Badahdah AM, Bokhary H, Azeem MI, Habeebullah T, et al. Influenza vaccination among Saudi Hajj pilgrims: Revealing the uptake and vaccination barriers. *Vaccine.* 2018 Apr 12;36(16):2112-2118. doi: 10.1016/j.vaccine.2018.03.007. Epub 2018 Mar 16.

# Nutrition among Umrah Visitors with Chronic Diseases

Omar Bashir Ahmed<sup>(1)</sup>, Tariq Atiah Al Malki<sup>(2)</sup>

<sup>(1)</sup> The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University

<sup>(2)</sup> Public health program, Makkah

## التغذية بين ذوي الأمراض المزمنة من المعتمرين

د. عمر بشير أحمد<sup>(1)</sup>، د. طارق عطية المالكي<sup>(2)</sup>

<sup>(1)</sup> معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة - جامعة أم القرى

<sup>(2)</sup> زمالة طب المجتمع مكة المكرمة

### ملخص البحث (Abstract):

تنتشر الأمراض المزمنة بين عدد كبير من الحجاج والمعتمرين إلى درجة أنه يمكن أن يواجه المعتمر المصاب عدة مشاكل صحية أثناء تواجده بمكة المكرمة ولكن إذا خطط لرحلته ببساطة ومهد لها جيدا فحينها يمكنه أن يتعايش مع المرض المزمن ويستمتع بشعائر العمرة. هدفت الورقة إلى دراسة انتشار الأمراض المزمنة بين معتمري ١٤٣٩هـ وتوصيفها ديموغرافيا وتقييم الأنظمة الغذائية التي يتبعها المعتمر أثناء رحلته وقد بينت الدراسة أن ٨٠,٨% من بين ٤٠١ مريض يستخدم أدوية، وأن أكثرهم يعاني من مرض السكر (41.74%) يليه ضغط الدم (31.9%) فالأمراض التنفسية المزمنة (18.5%) ثم مرض القلب المزمن (٦,٥%). وقد وجد أن (٤٤,٩%) كان يؤدي شعيرة عمرة للمرة الثانية خلال ١٤٣٩هـ وأن ٥٩,٦% منهم يتبع نظاما غذائيا محددًا. وقد وجدت الدراسة أن هناك فرقا معنويا (معنوية اقل من ٠,٠٥) بين اعمار المعتمرين وأنواع الامراض المزمنة كما أنه لم تتوفر علاقة معنوية بين انتشار الامراض المزمنة بالنسبة للنوع (الذكور والاناث) وبين أنواع الطعام المتوفر (معنوية أعلى من ٠,٠٥). وخلصت الدراسة إلى أن ضرورة أن يستشير المعتمر طبيبا متخصصا في أمراض السفر ليتزود بأهم ما يفيد من معلومات ونصائح عن مرضه أثناء السفر، كما تنصح الدراسة بتوفير طعام صحي خاص بأصحاب الأمراض المزمنة في أماكن خدمة إطعام المعتمرين. كلمات مفتاحية: المعتمرون، أمراض مزمنة، التغذية.

Chronic conditions are thought to affect high number of the general population of pilgrims and Umrah visitors. With a little planning and preparation, people with chronic illnesses should have safe and enjoyable Umrah rituals. The study aimed to characterize association between chronic diseases and dietary regimens among Umrah visitors. Data collection questionnaire was designed for recording of the most expected diseases among Umrah visitors. The results showed that out of 401 Umrah visitors suffering from chronic diseases, 80.8% of them were on medication. The most disease was diabetes mellitus (41.4%) followed by blood hypertension (31.9%), chronic respiratory disease (18.5%) and chronic heart diseases (6.5%). Also 44.9% of them were doing Umrah for second time of their life and 59.6% of the patients had special food program. There was statistical significant between age and the type of chronic disease ( $p$ -value < 0.05), while there was no significant difference between the existing chronic disease in male and female and with the type of the food taken by Umrah visitors ( $p$ -value > 0.05). It could be concluded that those with chronic diseases should obtain a great deal of information and advice from a travel specialist doctor, and it is worthy that healthy foods should be promoted of at the visitors food services sites.

**Keyword:** Umrah visitors, Chronic Diseases, Nutrition.

### Introduction

Chronic diseases are a disease that persists for 3 months or more [1]. Generally, there are slow in progression and long in duration. There are many types of chronic diseases are diabetes, cardiovascular such as heart attacks and stroke,

cancers diseases in addition to chronic respiratory condition such as chronic obstructed pulmonary disease (COPD) and asthma diseases [2]. Generally, they cannot be prevented by vaccines or cured by medication. Furthermore, chronic diseases cannot be communicated from person to person [3]. Travel medicine is a specialty that needs highly specialization in travel-related diseases. It needs an up-to-date knowledge of the worldwide epidemiology of diseases or conditions [4]. Worldwide, rates of international travel are growing continuously, about 1 billion travelers worldwide crossing international boundaries yearly [5]. In Saudi Arabia, the number of pilgrims in 2018 attracted more than 3 million pilgrims from 184 countries [6]. Increasing globalization in travel lead to increase the risk of travel-related illnesses and progress pre-existing health problems such as chronic disease. A traveler's health depend on a providing pre-travel counseling on appropriate interventions to promote health and prevent adverse health outcomes during travel [7,8]. Unfortunately, a small number of travelers will seek pre-travel health advice. Lack of awareness among travelers is not insured under health plans. Furthermore, those travelers who are consulting practitioners who are not eligible and specifically trained to recommend patients on travel [9,10,11,12]. Some studies suggest that pre-travel care should achieved by practitioners who are certificated in the field of travel medicine (i.e. provided by local or international society of travel medicine) [13]. Progressive of chronic disease may kill three in five people worldwide and then becomes a leading cause of mortality in the world by representing 60% of all deaths. Moreover, it cause great socioeconomic problems within all countries, particularly developing nations [2,14]. In developed countries such as United State, 88% of Americans over 65 years have at least one chronic disease [1]. On the other hand, poor diet is a major contributor cause of chronic disease and death in America [15]. Nutritional treatment in early stages of chronic kidney disease could prolong life [16]. Malnutrition and protein-energy wasting has been demonstrated to be strongly related to mortality in chronic kidney disease patients [17] [18]. During traveling, chronic disease care has become more complicated because easily access to highly processed foods and low consumption of freshly food [19]. The increasing physical activity and reducing intakes of highly rich foods with drinks in sugars, can prevent unhealthy weight gain. More recent studies have not shown much improvement in the low prevalence of healthy lifestyle practices [20,21]. Moreover, studies have shown that clinicians' knowledge and counseling about healthy diets are lacking [22]. May be it is not easy to diabetic patients to find the recommended nutrient intakes described within dietary guidelines. The efforts of individuals and their healthcare providers, strategies to increase the nutritional quality of prepared foods could gain improved widespread benefits [23] [24]. Finally, CDC (Centers for Disease Control and Prevention) provide health Information for International Travel commonly called the Yellow Book published every two years as a reference for health professionals providing care to international travelers [25]. The study aimed to characterize association between chronic diseases and dietary regimens among Umrah visitors during the first Umrah season in 1439.

### **Research aims**

The study aimed to characterize association between chronic diseases and dietary regimens among Umrah visitors during the first Umrah season in 1439.

### **Research methodology**

The study was conducted at Holy City of Makkah Al Mukarramah, during Umrah season that at the first months of 1439 ( 1st September till 31th of December 2017). Inclusion criteria was Simple random 401 travelers (Umrah visitors) using data collection questionnaire designed for recording of the most expected chronic diseases among Umrah visitors, while

the non-Umrah visitors were excluded. Socio-demographic characteristics: such as age, level of education, job, marital status, education, job, socio economic status, Medical history and nutritional survey (Weather participant take white or brown rice and bread, low or whole dairy products, low fat meat or chicken, low or regular sugar beverage, fresh or canned salty food, well-cooked or raw food). Data entry and statistical analysis was done using SPSS 21.0 statistical software package.

## Results and discussion

Travel to Makkah can be relaxing and rewarding, but people with chronic may face unique challenges when they travel overseas, but sometimes the physical demands of travel can be stressful. the of most common chronic diseases and their dietary regimens during the first Umrah season in 1439 after Hajj 1438H (2017). In the present study, four hundred and one were the Umrah visitors who were declared that they had chronic diseases, most of them (65.8.3%) were male (Figure1) while (90.3.8%) married (Figure2). About 60.6% of the patients were from the age group 21-40 years old, none were more than 80 years (Figure3). The present study, showed that most of the Umrah visitors with educational secondary school level ( 62.1%) while 37.4% of them were of university educational level of or higher (Figure.4). The commonest nationality of Umrah visitors with chronic diseases was Saudi (21.7%), followed by Bangladesh (19.7%) and Egyptian (14.4%)(Figure.5). The results of the present study was closed to previous studies (28) which showed Saudi citizens represented 42.5% of the total patients where the incidence in Saudi patients was more than that in other nationalities. The present study showed that the commonest chronic disease encountered among Umrah visitors was Diabetes Mellitus (41.4%), followed by blood hypertension (31.9%), chronic respiratory disease (18.5%) and chronic heart disease (6.5%) inflammatory bowel syndrome (1%)(Figure.6).

In other study, it was reported that residents with a history of migration with a higher prevalence of chronic diseases such as cardiac diseases, hypertension, and diabetes (26). Statistically, the present study showed significant association between age and the type of chronic disease ( $p$ -value  $<0.05$ ), also there was no significant association between the chronic diseases and the gender ( $p$ -value  $> 0.05$ ). Diabetes leads to increased risk of heart disease, kidney disease, stroke and infections. Cardiovascular diseases are major etiologic morbidity factors in the world due to unbalanced diets and physical inactivity. More than half of international travelers to developing countries become ill during their trip, and very low numbers look for medical care for a travel-associated illness either during their travel (27). So any chronic illness, such as diabetes, blood pressur or kidney disease may add challenges to the traveler. Advance planning is the key to a successful Umrah visit trip. Bone diseases a problem of older people. Adequate intakes of calcium and vitamin D in patients with high osteoporosis rates may help to reduce fracture risk. Also the sun exposure and physical activity may strengthen bones and muscles. The highest frequency of Umrah visits (44.9%) among Umrah visitors was for the second time per year and 24.4% had an average annual visit frequency of 3 times (Figure.7). In the present study 80.8% of the patients on medication (Figure 8). In the present study (39.9%) the Umrah visitors travelled to Makkah without consulting a specialist doctor, also 31.7% of them used to make regular medical check only one time before travelling while 28.4% of them used make medical check for two times (Figure9). Most participants (72.1%) used to do periodic laboratory and measurement tests (Figure10). Each Umrah visitor needs to schedule an appointment with a travel specialist doctor as soon as possible and may need additional health and travel needs and medical investigation, in addition to bring extra medication packed in visitors carry-on luggage. Medications purchased abroad may not meet

Saudi standards. All medications and supplies. Also, the study showed, most of the visitors were on medication. So it is very important to consider bringing copies of visitors prescriptions, wearing a medical alert bracelet and a first aid kit packed with over the counter medications approved by the physician. Also, 59.6% of the patients had diet food program (Figure11). Also, 78.3% used only white bread/rice for eating (Figure.12) and while 71.1% and 28.9% had chicken/meat with regular and low fat in their meals, respectively (Figure.13), also 62.3% and 37.7% of them were had regular and low fat a dairy product with in their meals, respectively (Figure.14) and 71.1% and 28.9% of them were had regular and low sugar beverage product, respectively (Figure 15). The rapidly increasing burden of chronic diseases is a key determinant of global public health. For healthy diets, healthy foods should be promoted of at Umrah visitors food services. For diabetic patients, overweight and obesity and physical inactivity may raise the rates of type 2 diabetes. During travelling, increased physical activity and maintaining a healthy weight can prevent and help the treatment of diabetes. Risk of chronic diseases such as heart disease and stroke, is reduced by eating low saturated fats, enough amounts of fruits and vegetables and low salt. In addition by practicing physical activity and controlling weight. Reduction of salt intake helps reduce blood pressure and consequently a reducing cardiovascular diseases. Dietary modifications are common treatment plans for patients with different chronic diseases. It was found that the patient who read labels on the food packages used less energy, low saturated fat, carbohydrates, and sugar, and more fibers than those who did not (29). Such findings reflect the value of dietary counseling in chronic disease management (29). The present study showed no significant association between the chronic diseases and type of the food taken by Umrah visitors ( $p$ -value > 0.05). It could be concluded that chronic diseases among Umrah visitors are variable. Those with chronic disease should obtain a great deal of information and advice from a travel specialist doctor and may need to carry an extra medication. Healthy foods should be promoted of at Umrah visitor's food services.

### **Summary and conclusion**

It could be concluded that chronic diseases among Umrah visitors are variable. Those with chronic disease should obtain a great deal of information and advice from a travel specialist doctor and may need to carry an extra medication.

### **Recommendations**

1. Umrah visitors with chronic disease should obtain a great deal of information and advice from a travel specialist doctor e
2. Healthy foods should be promoted at Umrah visitor's food services.

Figures and Tables:

**Gender %**

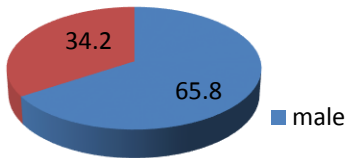


Figure1. Frequency of gender

**Marital status %**

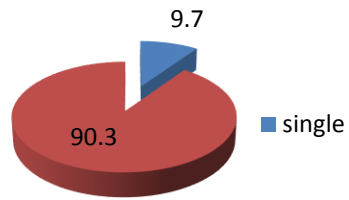


Figure.2 Frequency of married patients

**Age group %**

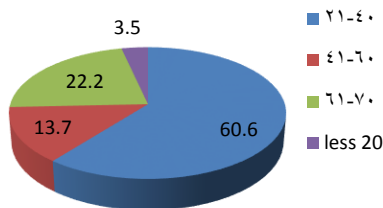


Figure 3. Frequency of Age group

**Education %**

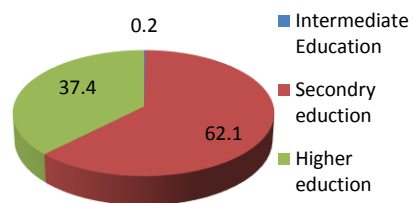


Figure 4. Frequency of Education level

**% Nationality**

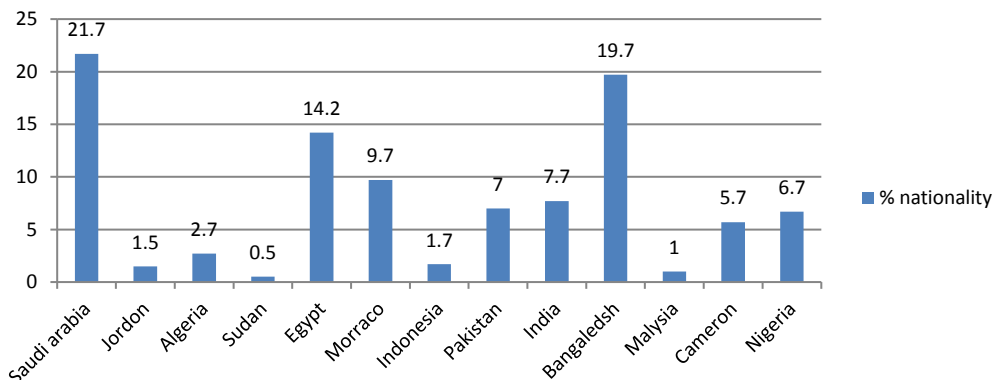


Figure.5 Distribution of chronic diseases according to nationality



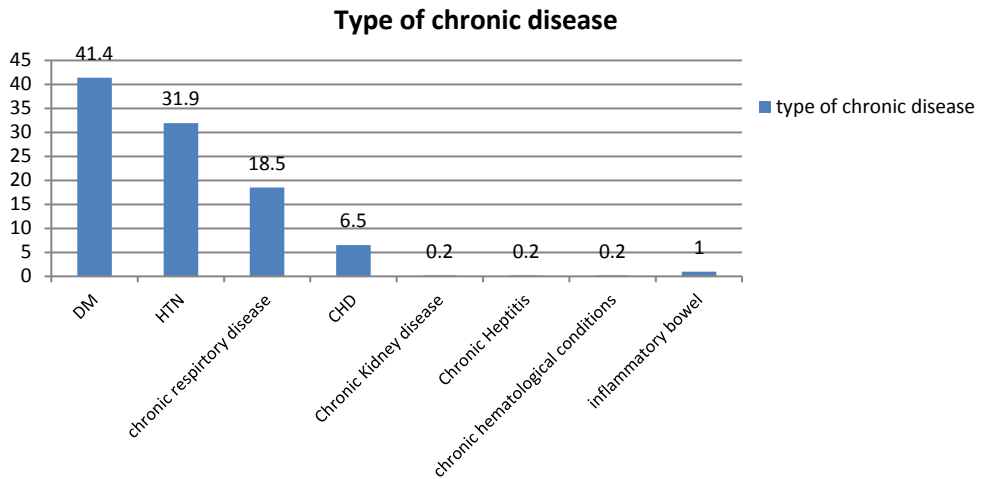


Figure.6 Distribution of chronic diseases among Umrah visitors.

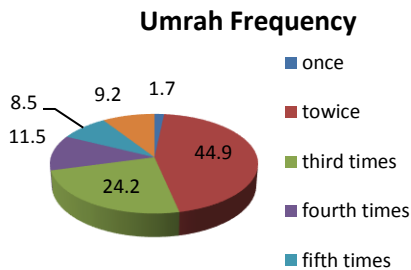


Figure.7 Frequency of Umrah visits frequency

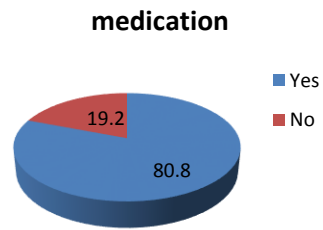


Figure.8 Frequency of patients on medication

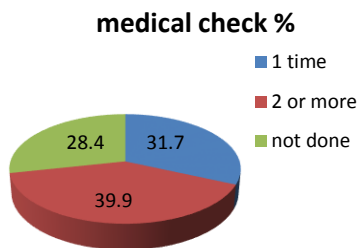


Figure.9 Frequency of medical check

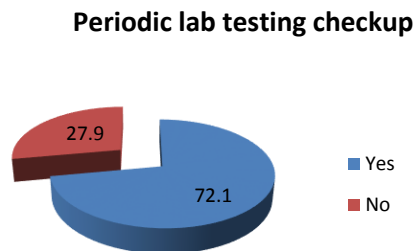


Figure.10 Periodic test checkup

**Taking special meals**

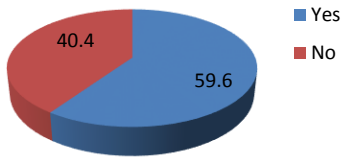


Figure.11 Special food program

**Type of rice and bread**

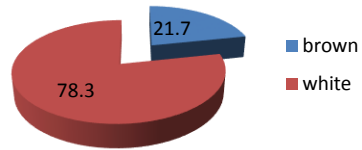


Figure.12 Type of rice/bread used

**Meat and chicken**

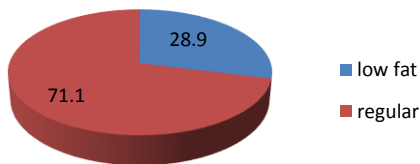


Figure.13 Meat /chicken type

**Dairy product**

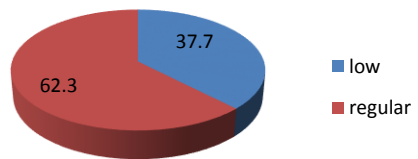


Figure.14: Dairy product type

**beverage type %**

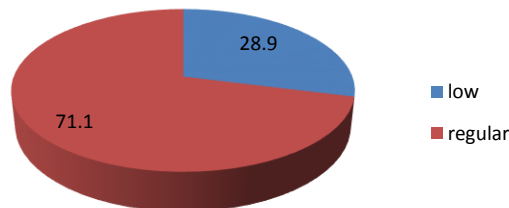


Figure.15 Beverage product type

**References:**

1. Medicinenet. Definition of chronic disease (2016).available from :<http://www.medicinenet.com/script/main/art.asp?articlekey=33490>
2. United Nations General Assembly (2011) Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Diseases. New York: United Nations.
3. WHO.NONCOMMUNICABLE DISEASE (2016).AVAILABLE FROM : [http://www.who.int/topics/noncommunicable\\_diseases/en/](http://www.who.int/topics/noncommunicable_diseases/en/)

4. Brian Aw ,Sunil Boraston , David Botten ,Darin Cherniwchan ,Hyder Fazal , Timothy Kelton ,Michael Libman ,Colin Saldanha ,Philip Scappatura ,Brian Stowe;Travel medicine What's involved? When to refer?;2014 Dec; 60(12): 1091–1103.
5. United Nations World Tourism Organization. UNWTO tourism highlights: 2013 edition. Madrid, Sp: World Tourism Organization; 2013.Available from:www.wtoelibrary.org/content/hq4538/fulltext.pdf. Accessed 2014 Oct 14.
6. Memish ZA, Zumla A, Alhakeem RF, Assiri A, Turkestani A, Al Harby KD, Alyemni M, Dhafar K, Gautret P, Barbeschi M, McCloskey B, Heymann D, Al Rabeeah AA, Al-Tawfiq JA. Hajj: infectious disease surveillance and control.2014 Jun 14;383(9934):2073-2082. doi: 10.1016/S0140-6736(14)60381-0. Epub 2014 May 20 .
7. Keystone JS, Dismukes R, Sawyer L, Kozarsky PE. Inadequacies in health recommendations provided for international travelers by North American travel health advisors. *J Travel Med* 1994;1(2):72-
8. Bui YG, Trépanier S, Milord F, Blackburn M, Provost S, Gagnon S. Cases of malaria, hepatitis A, and typhoid fever among VFRs, Quebec (Canada) *J Travel Med* 2011;18(6):373-8. Epub 2011 Oct 12.
9. Van Herck K, Van Damme P, Castelli F, Zuckerman J, Nothdurft H, Dahlgren AL, et al. Knowledge, attitudes and practices in travel-related infectious diseases: the European airport survey. *J Travel Med* 2004;11(1):3-8.
10. Hamer DH, Connor BA. Travel health knowledge, attitudes and practices among United States travelers. *J Travel Med* 2004;11(1):23-6.
11. Boggild AK, Castelli F, Gautret P, Torresi J, von Sonnenburg F, Barnett ED, et al. Vaccine preventable diseases in returned international travelers: results from the GeoSentinel Surveillance Network. *Vaccine* 2010;28(46):7389-95.
12. Committee to Advise on Tropical Medicine and Travel. Guidelines for the practice of travel medicine. An Advisory Committee Statement (ACS). *Can Commun Dis Rep* 2009;35 (ACS-8):1-14.
13. Hill DR, Ericsson CD, Pearson RD, Keystone JS, Freedman DO, Kozarsky PE, et al. The practice of travel medicine: guidelines by the Infectious Diseases Society of America. *Clin Infect Dis* 2006;43(12):1499-539.
14. WHO: What are noncommunicable diseases and their risk factors (2017).AVAILABLE FROM : <http://www.who.int/chp/en/>
15. Lin JS, O'Connor E, Whitlock EP, Beil TL. Behavioral counseling to promote physical activity and a healthful diet to prevent cardiovascular disease in adults: systematic review for the U.S. Preventive Services Task Force. *Ann Intern Med*. 2010; 153:736-750
16. Raphael, K.L.; Zhang, Y.; Wei, G.; Greene, T.; Cheung, A.K.; Beddhu, S. Serum bicarbonate and mortality in adults in NHANES III. *Nephrol. Dial. Transplant*. 2013, 28, 1207–1213.
17. Kalantar-Zadeh, K. Recent advances in understanding the malnutrition-inflammation-cachexia syndrome in chronic kidney disease patients: What is next? *Semin. Dial*. 2005, 18, 365–369.
18. Kalantar-Zadeh, K.; Supasyndh, O.; Lehn, R.S.; McAllister, C.J.; Kopple, J.D. Normalized protein nitrogen appearance is correlated with hospitalization and mortality in hemodialysis patients with Kt/V greater than 1. *J. Ren. Nutr*. 2003, 13, 15–25.
19. Reeves MJ, Rafferty AP. Healthy lifestyle characteristics among adults in the United States, 2000. *Arch Intern Med*. 2005;165:854-857.

20. Bambs C, Kip KE, Dinga A, Mulukutla SR, Aiyer AN, Reis SE. Low prevalence of "ideal cardiovascular health" in a community-based population: the heart strategies concentrating on risk evaluation (Heart SCORE) study. *Circulation*. 2011;123:850-857.
21. World Health Organization. *International travel and health, 2012*. Geneva, Switz: World Health Organization; 2012.
22. Kolasa KM, Rickett K. Barriers to providing nutrition counseling cited by physicians: a survey of primary care practitioners. *Nutr Clin Pract*. 2010;25:502-509.
23. Asaad G, Chan CB. *Appl Physiol Nutr Metab*. 2017 Aug 3:1-7. doi: 10.1139/apnm-2017-0266
24. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med*. 1997;336:1117-1124
25. Centers for Disease Control and Prevention. *CDC health information for international travel 2014*. New York, NY: Oxford University Press; 2014.
26. Hameed S S , Kutty V R , Vijayakumar K ,Kamalasanan A. Migration Status and Prevalence of Chronic Diseases in Kerala State, India. *International Journal of Chronic Diseases*. Volume 2013 (2013), Article ID 431818, 6 pages.
27. Steffen R, Rickenbach M, Wilhelm U, Helminger A, Schar M. Health problems after travel to developing countries. *J Infect Dis*. 1987;156:84–91.
28. Fatani M I, Al-Afif K A, Hussain H. Pattern of skin diseases among pilgrims during Hajj season in Makkah, Saudi Arabia. *International journal of dermatology*. 2000; 39 (7) ;493–496.
29. Post RE, Mainous AG, Diaz VA, Matheson EM, Everett CJ. Use of the nutrition facts label in chronic disease management: results from the National Health and Nutrition Examination Survey. *J Am Diet Assoc*. 2010 Apr;110(4):628-32.

# Core Competencies required of Health care Providers During Mass Casualty Incidents (MCIs) in Saudi Arabia: Implications for Hajj

Dr.Fatmah Alsolami<sup>(1)</sup>, Dr.Abdullellah Al Thobaity<sup>(2)</sup>

<sup>(1)</sup> Nursing Faculty, Medical and Surgical Nursing, Umm Al-Qura University

<sup>(2)</sup> Applied Medical Sciences, Nursing Department, Emergency and Disaster Nursing, Taif University

## المهارات اللازمة للممارسين الصحيين للاستجابة الفعالة للكوارث في المملكة العربية السعودية، تطبيقات لموسم الحج

د. فاطمة جبر السلمي<sup>(1)</sup>، د. عبدالإله الثبتي<sup>(2)</sup>

<sup>(1)</sup> كلية التمريض، تمريض باطني-جراحي، جامعة أم القرى

<sup>(2)</sup> كلية العلوم الطبية التطبيقية، قسم التمريض، تمريض الطوارئ والكوارث، جامعة الطائف

### ملخص البحث (Abstract):

المهارات اللازمة للممارسين الصحيين للاستجابة الفعالة للكوارث في المملكة العربية السعودية: تطبيقات لموسم الحج المقدمة أكثر من مليوني حاج مسلم يجتمعون سنويا لأداء الحج سنويا في المشاعر المقدسة. في السنوات الماضية كان هناك عدة عوامل لها تأثير على سلامة وصحة الحجاج مثل السيول والحرائق والتدافع. وبما ان جميع الممارسين يلعبون دور هام جدا في التخطيط والاستجابة الفعالة لكل حالات الطوارئ والكوارث إضافة الى النقص الشديد في البراهين والأدلة لإثبات قائمة المهارات اللازمة للممارسين الصحيين في الاستجابة للكوارث لا قدر الله أثناء الحج يستدعي من الباحثين تحديد أهم المهارات اللازمة لهم وذلك من خلال تحليل الدراسات السابقة والتي سلطت الضوء على الإصابات خلال التجمعات الكبيرة مثل الحج والكوارث المتعلقة بالمجال الصحي الهدف تحديد المهارات اللازمة للممارسين الصحيين في الاستجابة للكوارث من اجل تطبيقها على الممارسين الصحيين المشاركين في موسم الحج لخدمة الحجاج. المنهج تحليل الدراسات السابقة التي عملت في المملكة العربية السعودية في مجالات الكوارث واستجابة الفرق الصحية في المملكة العربية السعودية النتائج اثبت التحليل بأن تركيز الدراسات السابقة يختلف من حيث طبيعة ومنهج البحث. كما كان هناك عدة دراسات ركزت على استجابة الفرق الصحية للكوارث والإصابات الناتجة عن التجمعات الكبيرة مثل الحج. على سبيل المثال: دراسة واحدة ركزت على تقييم خطط الكوارث في مستشفيات مكة المكرمة. بينما ٣ دراسات ركزت على تمريض الكوارث وعدة دراسات ركزت على صحة الحجاج أثناء الحشود في المشاعر المقدسة. بناء على التحليل تم استخراج قائمة من أهم المهارات اللازمة لكل ممارس مشارك في الحج والتي تشمل التخطيط والتحضير والاستجابة للكوارث. إضافة الى ذلك هذا التحليل سلط الضوء على أهم المعوقات التي تعيق الممارسين الصحيين من الاستجابة الفعالة للكوارث والتي تشمل نقص التعليم في هذا المجال ونقص التدريب ونقص شديد في الأبحاث الملخص من المهم توفر المهارات اللازمة لكل الممارسين الصحيين المشاركين في الحج مع ضرورة التركيز على التعليم والتدريب وزيادة الأبحاث في هذا المجال وذلك من أجل رفع درجة تأهب الممارسين الصحيين والاستجابة لجميع انواع الكوارث.

### Background

More than 2 million Muslims gather in one space in the city of Makkah in Saudi Arabia every year. In the past, many factors, such as flooding, fire, and human stampedes, have affected the lives and wellbeing of pilgrims. Healthcare providers play a critical role in planning and responding to mass casualty incidents (MCIs) and disasters. The lack of evidence of the abilities of

healthcare providers to respond to MCIs during Hajj makes it necessary to examine the most important core competencies required of healthcare providers during Hajj by analyzing existing evidence related to MCIs and disasters in Saudi Arabia .

#### **Aim**

This scoping review aims to summarize the core competencies required of healthcare providers during MCIs in Saudi Arabia .

#### **Methodology**

This scoping review includes all studies published in Saudi Arabia investigating issues related to disasters and MCIs in the country.

#### **Findings**

The focuses of these studies varied in terms of purpose and methodology. Several studies were found that focused on disasters and MCI responses in Saudi Arabia during Hajj. One focused on evaluating the disaster plans of Makkah hospitals, three focused on disaster management for nursing, and two others investigated healthcare responses during Hajj mass gatherings. The extracted core competencies of healthcare providers are presented in this paper, and they involve all phases of disaster management: planning for, preparing for, responding to, and recovering from disasters. This review highlights the barriers preventing healthcare providers from responding appropriately to disasters. A lack of education, training, and research is one such barrier.

#### **Conclusion**

This scoping review indicates that all healthcare providers who respond to a MCI must be equipped with essential knowledge, skills, and attitudes. Further, these aspects must be required of all healthcare providers willing to work during Hajj. More education, training, and research will enhance their degree of preparedness.

#### **Introduction**

Makkah is the capital holy city of the Kingdom of Saudi Arabia (KSA) and it is located in the west between Taif and Jeddah cities. During Hajj, the Ministry of Health (MOH) plays a significant role in ensuring that the health and safety of pilgrims remain at an optimal level during the seasons of Hajj (Alotaibi et al., 2017). Every year, the MOH increases their efforts to be ready to serve more than 3 million pilgrims by preventing diseases, providing treatment, and maintaining safety (Alaska, Aldawas, Algerian, Memish, & Suner, 2017). For instance, public health sector at the MOH ensures that all pilgrims meet all health requirements before they come to Saudi Arabia by sending letters to all countries that send pilgrims for Hajj via the World Health Organization or via activating the health-monitoring centers at the entry points of the pilgrims. Furthermore, the public health sector ensures there are an adequate number of insolation rooms with full facilities and medical equipment (moh.gov, 2016), as well as the activation of vaccination campaigns and distribution of pamphlets and instructions to pilgrims during Hajj. In addition to public health services, the MOH provides a high level of patient care and treatment through: (1) more than 25 hospitals in Arafat, Mina, Makkah City, and Madinah Munawara, with more than 5,000 beds: 500 beds for intensive care and 550 beds for Emergency care; (2) more than 100 primary health centers in Arafat, Mozdalifa, Mina, Makkah City, and Madinah Munawara; and (3) more than three emergency centers (moh.gov, 2016).

In addition, the MOH has a major plan and goals to be achieved by 2030 for the purpose of improving and continuing the provision of high-quality health services. More specifically, one of the major goals for the MOH is to improve the quality of health services in both diagnosis and treatment via increasing the scope of training for all healthcare providers, particularly during Hajj, as the MOH plays a significant role in it. Furthermore, one of the major goals of the MOH is to increase the level of preparedness of the healthcare system and of healthcare providers to respond effectively to hazards and all types of emergencies and disasters, which is applicable to Hajj, as it is a major mass gathering in the Middle East (National

Transformation Program, 2018). Holy places have been affected several times by various types of disasters, such as epidemics, fires, stampedes, and floods due to heavy rains (Alamri, 2010). For example, around 700 pilgrims in October 2015 died (Fadhlullah, 2016) due to a crush and stampede.

During Hajj, more than 800 doctors and nurses in rare medical specialties from Saudi Arabia or from outside the country increase the performance of the health facilities located in these holy places. Therefore, all healthcare providers must be ready and equipped with essential skills to ensure they are ready to provide a good quality of healthcare during that time and, more specifically, during emergencies and disaster situations. Despite the fact that some studies investigated the level of disaster preparedness and core competencies of healthcare providers in the country, the problem is that research on mass gatherings during Hajj is highly limited. Thus, this scoping review aims to summarize the core competencies required of healthcare providers during mass casualty incidents (MCIs) in Saudi Arabia for implications for Hajj and to highlight the major barriers related to this topic.

### **Methodology**

This scoping review includes all studies published in Saudi Arabia investigating issues related to disasters and MCIs in the country. An extensive search was conducted in the following electronic databases using the electronic Saudi Digital Library: (1) ScienceDirect, (2) ProQuest, (3) BMJ best practice and clinical skills, (4) ERIC, and (5) Scopus. The keywords used in the search were as follows: Mass Causality Incidents; Hajj; Saudi Arabia; Disaster; Competencies; Response; Healthcare providers; Knowledge and skills; and Barriers. The selection criteria included the following: (1) the article should aim to identify core competencies, including knowledge, skills, attitude, preparedness, barriers, or disaster plans; (2) the study must be conducted in Saudi Arabia; (3) the study must involve specialty healthcare providers as participants; (4) the study must be published in a peer review journal; and (5) the study must be published in Arabic or English. After the articles were selected for review, the criterion for extracting information was as follows: (1) extract knowledge; skills and attitudes (2) extract factors. Finally, the findings summarized and discussed.

### **Findings**

The focus of these reviewed studies varied in terms of purpose and methodology. Several studies were found that focused on disasters and MCI responses in Saudi Arabia during Hajj. One focused on evaluating the disaster plans of Makkah hospitals, three focused on disaster nursing, and two others investigated healthcare responses during Hajj mass gatherings. The extracted core competencies of healthcare providers are presented in this paper, and they involve all phases of disaster management: planning for, preparing for, responding to, and recovering from disasters. This review highlights the barriers preventing healthcare providers from responding appropriately to disasters. A lack of education, training, and research is one such barrier. The methodologies of these studies are similar: Five studies were descriptive with a quantitative design, while only one study was conducted with a rigorous methodology using factor analysis methods. Furthermore, this review revealed that the scope of the studies focused mainly on nursing and medicine, while the other specialties, such as paramedics, were not considered. In terms of core competencies, there are many skills, attitudes, and knowledge levels that all healthcare providers must have to respond to a disaster, and these include protocols and standards of preparedness, awareness of the disaster plan, knowledge of their roles, and the ability to activate the disaster plan and to participate in conducting a disaster plan. Many factors or barriers might affect the responses of healthcare providers to a MCI, more specifically, a lack of formal education and training. The key findings are presented in table 1.

Table 1 core competencies and barriers of disaster response in Saudi Arabia

Author	Aim	Method	Findings	Factors
(Shalhoub, Khan, & Alaska, 2017)	Examine in-depth and describe hospital disaster preparedness	Cross-sectional survey in Riyadh. 13 private hospitals with a capacity of more than 100 beds	Not all hospitals cover internal and external disaster in their plans.	Preparedness, including training, education, and conducting drill exercises Planning for staff workers Facilities management Dealing with extremal hospitals and other agencies
(Alzahrani & Kyratsis, 2017)	Preparedness for MCI during Hajj	Cross-sectional online survey 106 emergency nurses participated in the study	The findings of this study indicate that nurses have a low preparedness level for MCIs and they are not fully aware of their roles.	Awareness and knowledge of disaster management Disaster education and training Previous experiences
(Al-Shareef et al., 2017)	To assess the hospital disaster plan in Makkah	Survey N = 14 hospitals	This study explored the importance of: Reviewing the disaster plan regularly Conducting disaster plan drill exercises every two years Ability to increase the hospital capacity during disaster Preparedness for infection control Educate and train healthcare providers about the current hospital disaster plan	Writing a hospital disaster plan Reviewing the hospital disaster plan An effective disaster plan must include surge capacity and infection control Education and training Conducting disaster drills based on the hospital disaster plan
(Nofal, Alfayyad, Khan, Al Aseri, & Abu-Shaheen, 2018)	The study aims to investigate nurses' preparedness for emergencies and disasters.	Cross-sectional study N = 36 physicians and N = 153 Emergency nurses)	Patients believed that healthcare providers need training Healthcare providers scored low in disaster management knowledge	Knowledge about disaster management Conducting a disaster drill Disaster-related training or simulation experience Disaster management training in curriculum Role awareness and skills
(Al Thobaity, Plummer, Innes, & Copnell, 2015)	To evaluate the level of nurses' knowledge in Saudi Arabia regarding disaster preparedness	Quantitative survey N = 600	Nurses have inadequate preparedness Nurses are willing to learn more about disaster management	Knowledge about disaster preparedness Lack of formal education in nursing curriculum Resources about disaster management (access to literature, textbooks) Training and drills
(Al Thobaity, Williams, & Plummer, 2016)	The aim of this study was to explore the core competencies of disaster nursing, including roles and barriers	PCA With sample size = 158	The findings of this study indicated that there are many competencies nurse in disaster management should be trained for. Additionally; there are some vital barrier that could affect the development of the disciplines such as: Lack of formal educational Ineffective training Lack of evaluation instruments Lack of support Lack of expert staff Restricting roles in disaster management Lack of research studies	Educational resources Training opportunities Evaluation instruments Health organization support Training programs in the workplace Expert staff Roles in disaster management Research studies
(Ibrahim, 2014)	To evaluate nurses' competencies in disaster management	Cross-sectional descriptive study N = 252 Nurses	Lack of disaster preparedness in terms of knowledge and attitudes	Disaster preparedness courses not included in the curricula Need to integrate education and training in disaster preparedness



## Discussion

More than 2 million Muslims gather in one space in Makkah every year. In the past, many factors, such as flooding, fire, and human stampedes, have affected the lives and wellbeing of pilgrims. Healthcare providers play a critical role in planning and responding to MCIs and disasters. The lack of evidence of the abilities of healthcare providers to respond to MCIs during Hajj makes it necessary to examine the most important core competencies required of healthcare providers during Hajj by analyzing existing evidence related to MCIs and disasters in Saudi Arabia. This review indicated that all healthcare providers in Saudi Arabia or those who have active roles and duties in the hospitals and health centers must have essential knowledge. However, studies conducted in Saudi Arabia among healthcare workers have identified the competences required of healthcare workers to perform an active role in disaster management. These competencies mainly focused on healthcare workers' preparedness for disaster management and included knowledge, training, and attitudes.

In Saudi Arabia, the gap in knowledge regarding disaster management has been revealed among healthcare workers equally. Al Thobaity et al.'s (2015) study focused on nurses' perceptions of their knowledge of disaster management, and they highlighted the need for formal education among nurses. Education required to equip healthcare workers for disaster management in Saudi Arabia is deficient (Al Thobaity et al., 2014; Nofal et al., 2018; Alzahrani & Kyratsis, 2016; Shalhoub, Khan, & Alaska, 2017). Thus, preparation for disaster management can take the form of formal education, as provided in the curriculum at medical or applied health colleges, or informal education, as provided in continued education programs in healthcare facilities. The role of education is significant in preparing healthcare workers, as it will increase their level of awareness and orientation about what is required to master in disastrous situations. For instance, the literature in Saudi Arabia indicates that healthcare providers must be aware of disaster plans, protocols, and policies and procedures related to disaster management. However, this must be supported by information sources, such as access to databases, relevant literature, textbooks, and other forms of education materials. However, while most healthcare providers who work during Hajj come from Saudi hospitals, it is highly essential to train them by providing essential knowledge via education courses, such as short courses that cover all competency domains and all areas of disaster management.

Concerning training, healthcare workers in Saudi Arabia lacked the required training, which is an important element for staff preparation in disaster management. Training in hospital settings is simply applied in the form of mock drills or simulations of disastrous situations, where healthcare workers have hands-on experience in managing the disaster-related consequences. Although healthcare facilities ensure that they have written disaster management plans, they direct little attention to disaster management plans that focus on training. This is because there is a rare possibility of a disaster happening at the only mass gathering event in Saudi Arabia, which occurs every 12 months, but there is a high chance that disasters will happen during that event. Continued training sessions are highly required for healthcare workers, as the essence of disaster management plans is preparedness at all times, and this is applicable to healthcare providers who provide health services and care to pilgrims during Hajj.

The attitudes of healthcare workers in disaster management are important. Insufficient preparation, knowledge, and training among these staff to battle real disaster situations leads to a lack of understanding of their real role during

disastrous situations (Nofal et al., 2018). Particularly during Hajj, all healthcare providers must understand what they do in the MCIs, and this can be enhanced by education and training.

### **Limitation**

Despite the fact that this scoping review has a rigorous methodology, the available studies were focused on few specialties, such as physicians and nurses, while others, such as paramedics, have been given less attention.

### **Conclusion**

This scoping review showed that healthcare providers in Saudi Arabia, specifically during Hajj, need more education and training in disaster management to ensure they have the capabilities to respond to any disaster or emergency during Hajj. The other competencies in addition to disaster preparedness include planning and responding effectively to a disaster and conducting disaster drills and exercises.

### **References**

- Al Thobaity, A., Plummer, V., Innes, K., & Copnell, B. (2015). Perceptions of knowledge of disaster management among military and civilian nurses in Saudi Arabia. *Australasian Emergency Nursing Journal*, 18(3), 156–164.
- Al Thobaity, A., Williams, B., & Plummer, V. (2016). A new scale for disaster nursing core competencies: development and psychometric testing. *Australasian Emergency Nursing Journal*, 19(1), 11–19.
- Al-Shareef, A. S., Alsulimani, L. K., Bojan, H. M., Masri, T. M., Grimes, J. O., Molloy, M. S., & Ciotton, G. R. (2017). Evaluation of hospitals' disaster preparedness plans in the holy city of Makkah: a cross-sectional observation study. *Prehospital and disaster medicine*, 32(1), 33–45.
- Alamri, Y. A. (2010). *Emergency management in Saudi Arabia: Past, present and future*. University of Christchurch Report, New Zealand, 21.
- Alaska, Y. A., Aldawas, A. D., Algerian, N. A., Memish, Z. A., & Suner, S. (2017). The impact of crowd control measures on the occurrence of stampedes during mass gatherings: The Hajj experience. *Travel Medicine and Infectious Disease*, 15, 67–7  
doi:<https://doi.org/10.1016/j.tmaid.2016.09.002>
- Alotaibi, B. M., Yezli, S., Bin Saeed, A.-A. A., Turkestani, A., Alawam, A. H., & Bieh, K. L. (2017). Strengthening health security at the Hajj mass gatherings: Characteristics of the infectious diseases surveillance systems operational during the 2015 Hajj. *Journal of Travel Medicine*, 24(3), taw087.
- Alzahrani, F., & Kyratsis, Y. (2017). Emergency nurse disaster preparedness during mass gatherings: a cross-sectional survey of emergency nurses' perceptions in hospitals in Mecca, Saudi Arabia. *BMJ Open*, 7(4), e013563.
- Fadhlullah, S., & Ismail, W. (2016). A statistical approach in designing an RF-based human crowd density estimation system. *International Journal of Distributed Sensor Networks*, 2016. Retrieved from <http://dx.doi.org/10.1155/2016/8351017>.
- Ibrahim, F. A. A. (2014). Nurses' knowledge, attitudes, practices and familiarity regarding disaster and emergency preparedness—Saudi Arabia. *American Journal of Nursing Science*, 3(2), 18–25.
- moh.gov. (2016). Ministry MediaCenter Publications.
- National Transformation Program. (2018). Exclusive plan for national transformation programme. Retrieved from <file:///Users/aalthobaity/Downloads/NTP%20Arabic%20Public%20Document%202810.pdf>.
- Nofal, A., Alfayyad, I., Khan, A., Al Aseri, Z., & Abu-Shaheen, A. (2018). Knowledge, attitudes, and practices of emergency department staff towards disaster and emergency preparedness at tertiary healthcare hospital in central Saudi Arabia. *Saudi Medical Journal*, 39(11), 1123–1129.
- Shalhoub, A. A. B., Khan, A. A., & Alaska, Y. A. (2017). Evaluation of disaster preparedness for mass casualty incidents in private hospitals in Central Saudi Arabia. *Saudi Medical Journal*, 38(3).

# The Potentiality of Biogas from Landfilling of Solid Waste in Madinah, KSA

Faisal Osra <sup>(1)(2)</sup>

(1) Umm Al-Qura University

(2) University of Business and Technology (UBT)

## إمكانية تولد الغاز الحيوي من مرادم النفايات الصلبة بالمدينة المنورة

فيصل أسره <sup>(١)(٢)</sup>

<sup>(١)</sup> جامعة أم القرى

<sup>(٢)</sup> جامعة الأعمال والتكنولوجيا UBT - جدة

### ملخص البحث (Abstract):

يسبب التخلص من النفايات الصلبة العديد من المشاكل البيئية والاجتماعية والاقتصادية، مما يدعو الباحثين لتطوير بدائل لإدارة النفايات الصلبة والاستفادة منها. يعتبر استخراج الطاقة من النفايات إحدى الطرق الهامة للاستفادة من النفايات الصلبة بالأخص عند استخدام الطمر الصحي. وبالإشارة إلى التنمية الاقتصادية المتزايدة وزيادة الطلب العالمي على الطاقة، والذي خلق ضغطاً بالتبعية على موارد الطاقة الحالية، ومن منطلق تعزيز مفهوم التنمية المستدامة، أمكن التوصل إلى بدائل للطاقة الآمنة والمتجددة مثل الطاقة الحيوية المتولدة من مرادم النفايات البلدية الصلبة. لذلك يناقش هذا البحث مدى إمكانية الاستفادة من الغاز الحيوي المتولد من مرادم النفايات الصلبة بالمدينة المنورة وتحويله من عبء بيئي وخطر محقق إلى قيمة مضافة. هناك عدة طرق لاستخراج الطاقة من النفايات بتقنيات مختلفة ومنها عملية الهضم اللاهوائي للنفايات الصلبة في المرادم والذي يفتح الأفق للاستفادة من مرادم النفايات البلدية الصلبة كمصدر للطاقة الحيوية بجميع أنحاء العالم، حيث لا يوجد فصل وفرز كاف للنفايات القابلة لإعادة التدوير بمعظم البلدان في جميع أنحاء العالم. لذلك للحصول على تنمية بيئية مستدامة يفضل بجانب توفير أحدث تقنيات فرز النفايات للاستفادة منها جنباً إلى جنب مع أنظمة توليد الغاز الحيوي من مرادم النفايات الصلبة. ويبلغ إجمالي النفايات المتولدة من المدينة المنورة بالمملكة العربية السعودية حوالي ١,٦٩ مليون طن مشتملة على النفايات الانشائية والبلدية الصلبة والأشجار والمحطات الانتقالية والمجازر. وتصل النفايات خلال شهر رمضان إلى ١٤٠ الف طن بنسبة ٨,٣%، بينما ترتفع بشكل ملحوظ خلال موسم الحج إلى أكثر من ٣٥٠ الف طن بنسبة ٢١,٢% من إجمالي النفايات بالمدينة المنورة. ويعتبر الغاز الحيوي نتاج تحلل الطمر اللاهوائي للنفايات الصلبة، حيث تعتمد كميته وتركيبه على نوعية وتصنيف مكونات النفايات الصلبة القابلة للتحلل بالمدينة المنورة. تم حساب كمية الغاز الحيوي (الميثان) الناتجة من مرادم النفايات الصلبة بالمدينة المنورة الواقع بطريق ينبع القديم بناءً على نسبة النفايات العضوية القابلة للتحلل والتي يتم طمرها بهذا المردم سنوياً. ولتقدير كمية الغاز الحيوي وثاني أكسيد الكربون الناتجة من المردم تم استخدام برنامج LandGEM. بلغت كمية غاز الميثان المحسوبة بواسطة البرنامج أكثر من ٨٥٠ مليون م<sup>٣</sup>/سنة، وغاز ثاني أكسيد الكربون أكثر من ٦٥٠ مليون م<sup>٣</sup>/سنة.

Unsafe disposal of solid waste causes many environmental, social and economic problems, which leading researchers to investigate and develop alternatives to solid waste management and utilization. Extraction of energy from solid waste is an important way, especially when the solid waste was landfilled. With reference to increasing economic development and increasing global demand for energy, which created a pressure on existing energy resources, and in promoting the

concept of sustainable development, alternatives to safe and renewable energy such as biomass generated from municipal solid waste landfills is preferred. Therefore, this research discusses the potential of biogas production from the landfills of solid waste in Madinah, and transforming the solid waste from environmental load to added value of energy.

There are several ways to extract energy from solid waste by different techniques, including the anaerobic digestion in the landfills, which opens the prospect of benefiting from solid municipal waste landfills as a source of bioenergy throughout the world. There is no sufficient separation and sorting of recyclable solid waste in most countries around the world. For sustainable environmental development, as well as providing the latest waste sorting techniques to be used in conjunction with biogas generation systems from solid waste landfills.

The total solid waste generated from Al Madinah, KSA is about 1.69 million tons per year, which includes municipal, trees, transit stations and slaughterhouses waste. During Ramadan, solid waste reaches 140,000 tons by a rate of 8.3%, while during the Hajj season it rises to more than 350 thousand tons by a rate of 21.2% of the total waste in Medina.

Biogas is the product of the decomposition of anaerobic landfill for solid waste, depending on the quantity and composition of biodegradable components of solid waste in Madinah. The amount of biogas (methane) produced from the solid waste landfill of Madinah, located in Old Yanbu Road, was calculated based on the proportion of biodegradable solid waste that in this landfill annually. To estimate the amount of biogas and CO<sub>2</sub> produced from the landfill, LandGEM was used. The estimated amount of methane was more than 850 million m<sup>3</sup>/yea, where the Carbon Dioxide more than 650 million m<sup>3</sup>/year.

## **Introduction**

Madinah is the second holiest city in the Kingdom of Saudi Arabia (KSA), which hosts millions of Muslims every year to visit Prophet's Mosque. The number of visitors to Madinah is growing significantly during the last few decades due to a continuous expansion of the Prophet's Mosque, improved transportation services, high security reduced overall cost and time, and current expansions in the Prophet's Mosque.

In Madinah city, the total waste generated from Madinah during 2017 was about 1688118 tons, including construction, domestic, solid waste, trees, and slaughterhouses waste, on average around 700 thousand tons of MSW is generated per year, in addition to a construction waste by an average of 800 thousand tons, high volume waste by about 200 thousand tons, slaughterhouse waste by about of 16 thousand tons. During the month of Ramadan, the waste reaches 139,667 tons representing a total rate of 8.27% from the total quantity of Madinah, while during the Hajj season it reaches 357,263 tons, representing 21.16% of the total waste (Municipality of Madinah, 2018).

The KSA has recently launched a new policy of Vision 2030 with an ambition to reduce all types of waste and produce renewable energy from its indigenous sources, including the waste. The policy made a roadmap for the development of integrated solid waste management system to optimize the financial and environmental values of waste through reuse and recycling (KSA Vision 2030).

Biogas as a renewable energy source could be an alternate means of solving the problems of energy crisis, which is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage,

municipal waste, green waste, plant material, and crops. Biogas comprises primarily methane (CH<sub>4</sub>) and Carbon Dioxide (CO<sub>2</sub>) and may have small amounts of Hydrogen Sulphide (H<sub>2</sub>S).

The process of anaerobic digestion entails a community of microorganisms that first convert complex organic wastes to organic acids (such as acetic and propionic acids) and then the organic acids to biogas, containing primarily methane and carbon dioxide. Bio-produced methane is a renewable energy source that can be used in boilers, cleaned of impurities to enable insertion in natural gas lines, burned in a generator to produce electricity or simply flared if energy production

is not economical.

Landfill gas can be defined as a complex mixture of hundreds of different types of individual gases and vapors. However, the most common components are methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>). According to the USA Agency for Toxic Substances and Disease Registry (ATSDR), landfill gas typically contains 45-60% methane and 40-55% carbon dioxide. Landfill gas often also includes small amounts of ammonia, sulphides, carbon monoxide, hydrogen, and volatile organic compounds (VOCs) (Henderson R. E., 2011).

Methane (CH<sub>4</sub>) is the second largest driver of climate change behind carbon dioxide and one of the six greenhouse gases (GHGs) listed in the Kyoto Protocol, with global warming potential of 25 over 100 years (IPCC, 2007a). CH<sub>4</sub> is also a short-lived climate pollutant with an average life-time around 12 years in the atmosphere. According to the IPCC Fourth Assessment Report (IPCC, 2007b), the total CH<sub>4</sub> emissions and those from waste management accounted for 14.3% and 2.8% respectively, of the global GHG emissions in 2004. The CH<sub>4</sub> emissions from waste management shared 4% of the global total GHG emissions in 2010 (UNEP, 2012), with about half both from municipal solid waste (MSW) landfill and waste water treatment (JRC and PBL, 2012). The CH<sub>4</sub> emissions from MSW landfill rose fast from 16.50 Mt in 1970 to 29.50 Mt in 2008, with the total growth of 78.79% (JRC and PBL, 2012). About 73% of safely disposed MSW in China was landfilled in 2012 (NBSC, 2013).

Now, landfilling is the most dominant treatment of MSW disposal at present in Madinah, with the development of economy, advance of urbanization and improvement of people's living standards, both the waste generation and landfill are substantially increasing. The gaseous emissions emitted from landfills constitute one of the major environmental concerns. Gaseous compounds are produced following biochemical reactions, such as the methane and carbon dioxide generated in MSW landfills from the anaerobic degradation of the organic fraction of the waste.

The gaseous compounds emitted from landfills have various impacts on their surroundings at different scales (Fig. 1). In addition to, their impacts over a large spatial scale, gaseous emissions also act on different time scales. Compared to most other processes used in waste treatment, those occurring inside the landfill and the emissions they generate extend over a very long period of time after the waste has been disposed: from tens to hundreds of years.

Not only is the period of significant emissions long, but the compounds emitted will themselves have effects and life-spans of varying duration. Odours and dust, for example, are mainly transient phenomena. Methane constitutes both a very short term and acute explosion hazard and has a much more far-reaching and long-term effect on global warming (Fischer C., et al., 1999).

## Research aims

the potential of biogas production from the landfills of solid waste in Madinah, and transforming the solid waste from environmental load to added value of energy.

## Research methodology

### 1. Landfill Gas Generation

Gas formation and quality in landfills depends on constituents of landfilled wastes, the environmental conditions at/in the landfill and on landfill technology. LFG composition is the result of degradation processes in the landfill, as well as of evaporation of volatile substances and exchange of gaseous compounds between the landfill and the surrounding atmosphere. The composition of the gas will also in itself affect landfill processes, and thus the formation of gas.

When predicting landfill gas formation, the focus is usually put only on biogas formation as a result of the anaerobic degradation of the biodegradable fraction of the waste, neglecting the fraction resulting from other processes. A potential gas generation can be calculated from the composition of the substrate. Empirical data is used or anaerobic degradation tests are carried out. The rate and ultimate yield of LFG is highly variable from site to site. A typical yield may be in the range of 200-300 m<sup>3</sup>/ton of fresh MSW and the range of methane generation may range from below 1-40 m<sup>3</sup>/ton and year (Lawson et al. 1992).

Nowadays, there is much interest in energy production from Municipal Solid Waste. It generally comprises a mixture of organic matter (food wastes), plastics, paper, glass, metal and other inert parts. It can also include some commercial and industrial waste that is similar in nature to household waste. MSW is primarily considered a liability. It needs to be collected and processed, which comes at a certain cost. If managed improperly, it can cause severe human health problems and harm the environment (UN Habitat, 2010).

Waste to Energy (WTE) is a general term to describe an incineration process which uses MSW as raw material. WTE industry is gaining growing acceptance worldwide as an important part of the waste treatment hierarchy- reduce, reuse, recycle, recover and dispose, with WTE being considered part of "recover". However, it is only applicable when a number of overall criteria are fulfilled (UN Habitat, 2010), as following:

- Existence of a mature and well-functioning waste collection and management system for a number of years.
- A minimum and stable supply of combustible waste (at least 50,000 tons/year).
- A minimum average lower calorific value (at least 7 MJ/kg, never below 6 MJ/kg).
- A community that is willing to absorb the increased treatment cost.
- Skilled staff that can be recruited and maintained.
- Solid waste disposal at controlled and well-operated landfills.
- A stable planning environment for the community (planning horizon at least 15 years).

### 2. Landfill Gas Composition and Characteristics

Landfill gas is the product of solid waste decomposition. The quantity and the composition depend on the types of solid waste that is decomposing. A waste with a large fraction of easily biodegradable organic material will produce more gas than one consisting largely of ash and construction debris. The rate of gas production is governed by the rate at which decomposition is occurring in the wastes. When decomposition ceases, gas production also ends. Gas production

begins almost immediately after the solid waste is placed in a landfill. (Willumson 9/1990) noted that the most significant gas production usually begins 200 days after solid waste is disposed of in a landfill.

Landfill gas evolves from the breakdown of biodegradable materials in a landfill. The composition of gas varies according to the type and phase of breakdown which occurs within the site at specific time. Schumacher (1983) noted that after the refuse has been placed in the landfill, aerobic decomposition of the organic waste begins and a small amount of greenhouse gas, i.e CO<sub>2</sub> is produced. Once the Oxygen has been depleted, the anaerobic microorganisms become dominant and produce the greenhouse gases in landfill sites.

During the second stage of methane fermentation, the organic acids are consumed by a special group of methanogenic bacteria and converted into methane and carbon dioxide (EMCON, 1980). It is believed that the anaerobic process in a typical landfill occurs between 180 and 500 days after landfilling, depending on the waste composition, moisture content, temperature, pH, nutrients and refuse density (Boyle, 1977).

In general, landfill gas composition depends on the composition of the waste, but it will generally contain about 40-60% methane (CH<sub>4</sub>), 40-50% carbon dioxide (CO<sub>2</sub>), small amounts of 0.2-1% oxygen, 2-5% nitrogen, 0-1% hydrogen and other trace components such as hydrogen sulfide (0.0017-0.01%) and vinyl chloride (<0.0001%) (Senior, 1990) (Table 1).

A large landfill may produce gas for a period in excess of 50 years and can result in a total yield of landfill gas in the range 0.06 m<sup>3</sup>/kg up to 0.53 m<sup>3</sup>/kg. typically, the heating value of typical landfill gas is roughly 16.8 mega Joule/m<sup>3</sup> (450 BTU/ft<sup>3</sup>) or approximately half the lower heating value of natural gas (David, 1997).

### 3. Factors Affecting Landfill Gas Generation

There are a number of factors affecting gas generation including: refuse deposits, pH, temperature, nutrients, moisture content, and site operational factors. These will be discussed as following:

- **Refuse Deposits:** Refuse high in organic matter, such as food waste, and paper, will decompose more rapidly than inorganic materials such as demolition and construction debris (Owens and Chynoweth, 1992).
- **pH:** Optimum pH values for anaerobic digestion range from 6.34 to 7.4. The pH value in landfills may be influenced by industrial waste discharge, alkalinity, and clear water infiltration (Boyle, 1977). The average pH value in a landfill does not drop below 6.2 when methane is produced (Rare Earth Research Conference, 1978).
- **Temperature:** Temperature of the landfill will indicate which class of bacteria is functional. Mesophile bacteria grow best in the temperature range of 20 to 40 °C, while thermophiles grow best above 45 °C (Schmuacher, 1983).
- **Nutrients:** Sufficient nutrients are required for the growth of bacteria in the landfill. These primarily are carbon, hydrogen, oxygen, and phosphorus (EMCON Association, 1980).
- **Moisture Content:** Rate of methane production increases with higher moisture content. The optimum moisture content should be approximately 40 to 45% (wet weight) for the maximum gas production (Pacey, 1986). Studies have shown, in addition, that the gas production increase after a heavy rainfall as recorded high moisture content as 80% phosphorus (EMCON Association, 1980).
- **Site Operational and Characteristic Factors:** Gas production increase with the reduction in particle size and the resultant increase surface area. Pacey (1986) suggested that reduced particle size will expose a greater

surface area of refuse to the key parameters: moisture, nutrients and bacteria. In addition, gas production increase with the increment of refuse thickness. The designed refuse height of 40 meters (or more) is the standard landfill designed structure for landfill gas recovery.

#### **4. Characterization of Solid Waste in Madinah City**

The target of characterization of solid waste in Madinah will provide a primary figure out of the main components of the solid waste, especially the organic matters, that represents an important role controlling the generation of landfill gas in the landfills in Madinah, in addition to the characterization of solid waste will provide baseline data for its municipality to assess their progress toward specific sustainable waste management goals.

In Madinah City, the solid waste was received and collected from all municipalities by means of compressors and transferable containers. Large-size materials, trees, solid and liquid slaughterhouses and medical waste are also received, in addition to some commercial private companies. There is a separation unit of solid waste was initiated to sort the different types of solid waste before the landfilling process, where there is a treatment incineration unit for medical waste and a specific unit for slaughterhouses waste.

Generally, the total quantities of solid waste generated during 2017, reached to about 1688118 tons, where the construction and demolition waste representing about 48%, domestic waste representing 40%, High-volume waste representing 11%, slaughterhouses waste representing about 1%, and finally the trees representing less than 1% (Fig. 2). During Ramadan 2017, the generated total quantities of solid waste representing about 8% of the total solid waste throughout the year of 2017 (Fig. 3), the most dominant component is the domestic waste representing about 58%, construction and demolition waste representing about 28%, High-volume waste representing 12%, slaughterhouses waste representing about 1.4%, and finally the trees representing less than 1%. While in Hajj season 2017, the generated total quantities of solid waste representing about 21% of the total solid waste throughout the year of 2017 (Fig. 4), the most dominant component is the construction and demolition waste representing about 58%, domestic waste representing about 33%, High-volume waste representing 8%, slaughterhouses waste representing about 1%, and finally the trees representing less than 1%

Morsy and Al-Sebaei 2015, stated the classification of solid waste after the manual sorting, the component of the organic matters represents the largest component by a rate of 49%, where the plastics rate of 29%, paper and card board rate of 13%, metals of 6%, glass of 1%, textiles of 1%, and finally the wood with a rate of 1% (Fig. 5).

#### **5. Landfilling of Solid Waste in Madinah City**

There is a waste sorting unit, which is responsible for sorting all the recyclable materials such as, plastic, cardboard, iron, aluminum and paper, are extracted in the form of bales, which are directed to the specialized companies. There is a baling unit consists of two pistons equipped with conveyors to transport the sorted waste into the compressor chamber. The pistons operated automatically until the bales are released from the piston and connected automatically to be ready for transmission to the recycling facilities.

Worth mentioning, the landfill of Madinah city, is covered daily with sand deposits not less than 20 cm, and lined with High Density Poly Ethylene layer (HDPE), in addition to a network of sewage water to collect the generated leachate, and a gas collection system (The landfill gas connected to a main pipe to reach the gas burners for the safe disposal of gas by burning).



## Results and discussion

### 6. Estimation of Potential of Landfill Gas Production in Madinah City

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in MSW landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, CAA regulations. LandGEM uses the following first-order decomposition rate equation (1) to estimate annual emissions over a time period that you specify. The model parameters  $k$  and  $L_0$  used by this decomposition equation.

$$Q_{CH_4} = \sum_{i=1}^n \sum_{j=0.1}^1 KL_0 \left( \frac{M_i}{10} \right) e^{-kt_{ij}} \quad 1$$

where

$Q_{CH_4}$  = annual methane generation in the year of the calculation ( $m^3$ /year)

$i$  = 1-year time increment

$n$  = (year of the calculation) - (initial year of waste acceptance)

$j$  = 0.1-year time increment

$k$  = methane generation rate ( $year^{-1}$ )

$L_0$  = potential methane generation capacity ( $m^3$ /Mg)

$M_i$  = mass of waste accepted in the  $i^{th}$  year (Mg)

$t_{ij}$  = age of the  $j^{th}$  section of waste mass  $M_i$  accepted in the  $i^{th}$  year

### 7. Estimation of Methane Gas Generation Potential

The Scholl Canyon model was applied to estimate the energy potential of Madinah's landfill. Two steps were carried out to determine waste management options, that consisted of inputting:

- 1) field data to determine constants into Scholl Canyon model to determine gas generation under different waste management options for composting; and
- 2) accepted constants into model for comparison of results with field data.

To calculate landfill gas production. The different parameters were input into the model including greenhouse gas production constants from US EPA upper and lower limits for both wet and dry climates (US EPA, 2001), and Madinah's landfill site-specific parameters were applied. These compared the variation possible in landfill gas generation rates under two different waste management scenarios to investigate the impact of a composting program on gas generation.

#### ○ Step 1: Site-Specific Inputs into Scholl Canyon Model

Although it is easy to input constants into this model in this step, it is much more demanding to input site and waste specific factors. Below the methane generation potential ( $L_0$ ) was calculated by using % degradable organic compound and the decay rate constant ( $K$ ) inputs to determine these specific inputs.

#### ○ Step 2: Calculating Methane Generation Potential ( $L_0$ ) of Kakia Landfill

To determine the site-specific value of ( $L_0$ ) the following equation was applied (IPCC, 1996)

$$L_o \left( m^3 \text{ of } \frac{\text{methane}}{\text{tonne}} \text{ of waste} \right)^3 = MCF * DOC * DOC_F * \frac{16}{12} * F \quad (2)$$

Where:

$MCF$  = methane correction factor (1 = well managed landfill, it is assumed in our case 0.7).

$DOC$  = degradable organic carbon (fraction).

$DOC_F$  = fraction  $DOC$  dissimilated; and

$F$  = fraction of methane in landfill gas (measurement at landfill has indicated a value of 56%  $CH_4$  in biogas).

○ **Determining Degradable Organic Carbon for Methane Generation Model**

The site-specific degradable organic carbon ( $DOC$ ) is calculated based on IPCC (1996) formula (3), The inputs, into degradable organic carbon ( $DOC$ ), Madinah waste stream are shown in Table (2).

$$\% DOC \text{ (by weight)} = 0.4(A) + 0.17(B) + 0.15(C) + 0.3(D) \quad (3)$$

Where municipal solid waste consists of:

$A$  = % paper and textiles;

$B$  = % garden waste, park waste or other non-food organic putrescibles;

$C$  = % food waste; and

$D$  = % wood or straw.

According to equation (3),  $DOC$  content value of 13.02% was obtained based on the composition of waste, calculated from a weighted average of the carbon content of various components of the waste stream. the biodegradable fraction was calculated by using equation (3) that considers the state of decomposition. The average volatile lignin content 44.1% was employed in equation (4): this yields a figure of 0.82 dissimilated  $DOC$ .

$DOC_F$  can be determined through the lignin content of the volatile solid (VS) (Tchobanoglous et al., 1993, pp.88)

$$DOC_F = 0.83 - 0.028 LC \quad (4)$$

0.83 = empirical constant;

0.028 = empirical constant; and

$LC$  = lignin content of the VS expressed as a percent of dry weight from leachate sample.

Using equation (2) and the data profiled in Table (4), the measured methane potential of 62.68m<sup>3</sup> of methane per tonne of waste (1.336 ft<sup>3</sup>/lb) was obtained. This value is the first time to be calculated for landfill of Madinah City where the default values (170 kg methane per tonne of waste or 2.72 ft<sup>3</sup>/lb) recommended, while it is different from the US EPA value by LandGEM model.

By entering data on the LandGEM worksheet that relate to the identity and size of the landfill being modeled, Landfill name or identifier: Madinah, Landfill open year: 2006, Landfill Closure Year: 2020, Waste design capacity: 12538000 short tons, Methane Generation Rate,  $K$ : 0.050 year<sup>-1</sup>, Potential Methane Generation Capacity,  $L_0$ : 62.68m<sup>3</sup>/Mg (based on classification of solid waste in Madinah), NMOG Concentration: 4000 ppm as hexane, Methane Content: 50% by

volume, and Gases/Pollutants selected (Total Landfill Gas, Methane, Carbon Dioxide, and Non-methane organic Compounds-NMOC).

For the estimation of methane from the landfill sites, user specified inputs are used in the LandGEM model. The methane generation potential, ( $L_0$ ) has been specified as a default value of 62.68 m<sup>3</sup>/Mg, while the methane generation constant ( $k$ ) has been specified as 0.050 per year. The methane and carbon dioxide in the LFG have been considered to be 50%.

As indicated in Figs. (6 and 7), it is ca concluded the estimation of Madinah's landfill gases in Mg/year for the period of 2003 to 20143 as following:

- Sum of landfill total gases = 1573854200 m<sup>3</sup>/year,
- Sum of Methane = 881358352 m<sup>3</sup>/year,
- Sum of Carbon Dioxide gas = 692495848 m<sup>3</sup>/year, and
- Sum of NMOC = 6295416 m<sup>3</sup>/year.

### Summary and conclusion

In this article the evaluation of landfill biogas potential in Madinah City is performed in order to estimate the electricity that can be generated if the methane obtained from the Biogas is used as a fuel in a reciprocating combustion engine. The LandGEM model and the available data of the solid waste characteristics of the most important cities in Madinah City were used to quantify the potential methane generation obtained from the landfill of Madinah. Other models to predict the generation of landfill biogas as IPCC can be used; also in situ data from the landfills have to be obtained for better prediction of methane efficiency capture and production especially for the  $k$  and  $L_0$  parameters.

Madinah City has a high annual technical biogas potential. Unfortunately, this potential is currently unused. This would help Madinah City to reduce greenhouse gas emissions, increase the stability of the economy, open new work area and employment opportunities; as a result, sustainable energy production which could meet country's rapidly increasing primary energy demand driven by increasing population. The results presented in this article could provide valuable information to the solid waste management industry, policy makers and investors.

### Recommendations

1. Maximizing the benefits of the emitted energy from Landfills.
2. Constructing A bioenergy system for solid waste landfill in Madinah.

**Figures and Tables:**

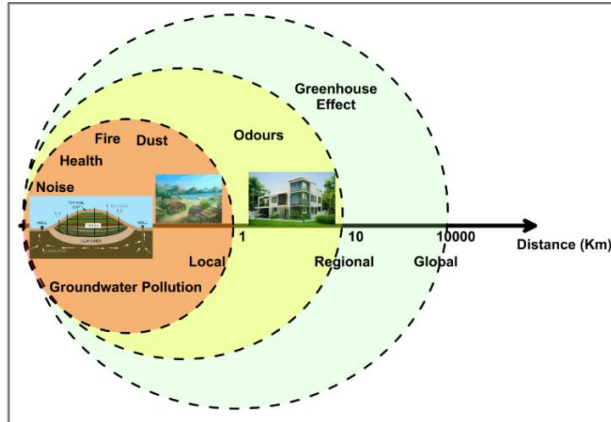


Fig. (1): The different scales of the impacts of gas from landfills (modified after Kjeldsen, 1996).

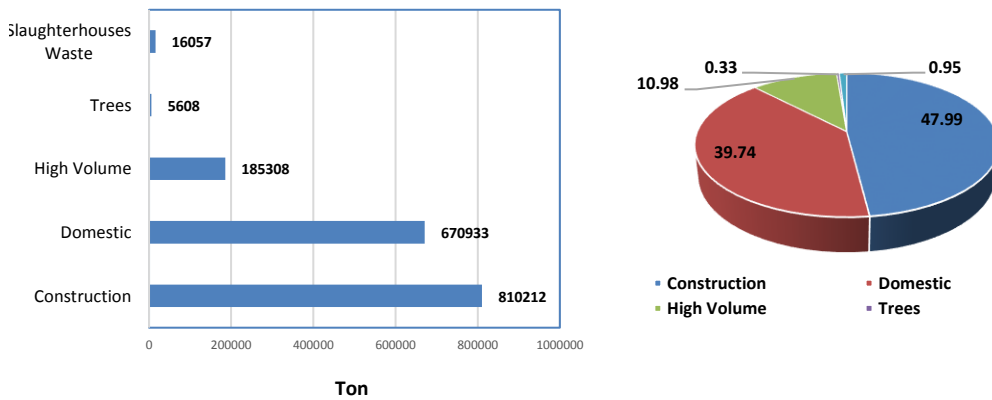


Fig. (2): Total quantities of waste generated in Madinah during 2017.

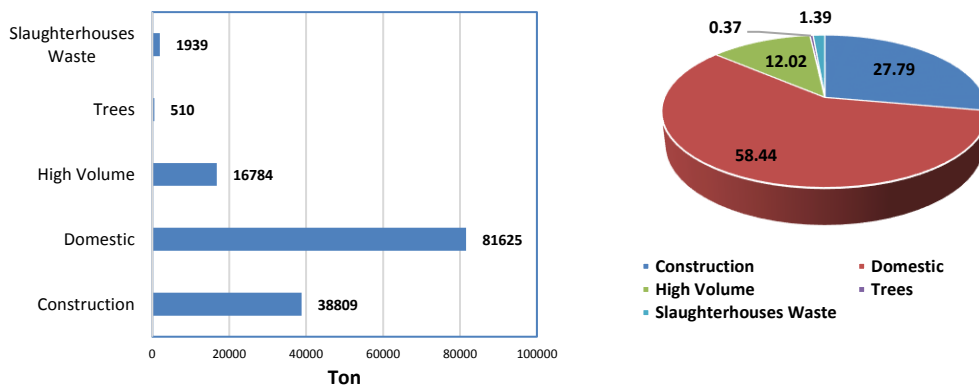


Fig. (3): Total quantities of waste generated in Madinah during Ramadan 2017.

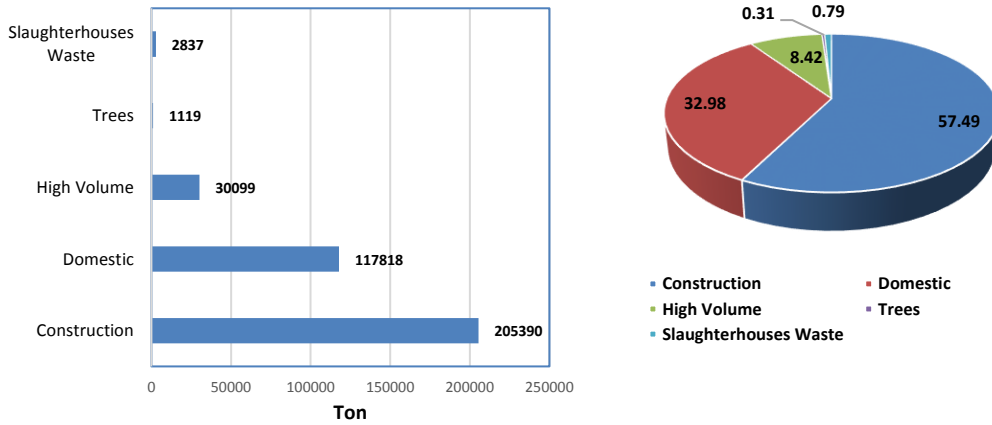


Fig. (4): Total quantities of waste generated in Madinah during Hajj 2017.

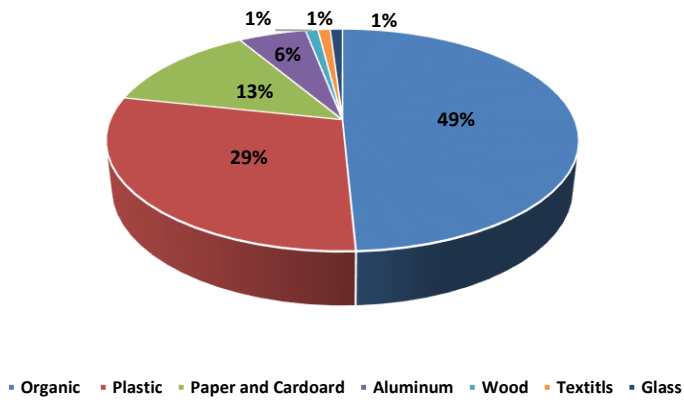


Fig. (5): Classification of solid waste in Madinah City.

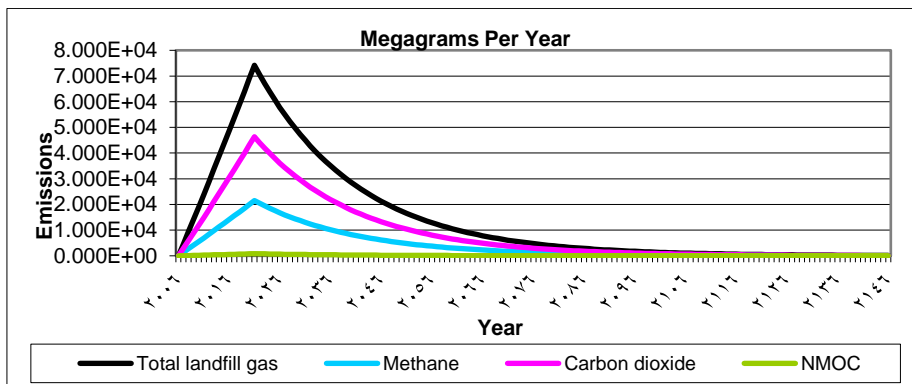


Fig. (6): Landfill gas emission estimation in Mg/year for Madinah's landfill utilizing LandGEM model for the years 2006-2020.

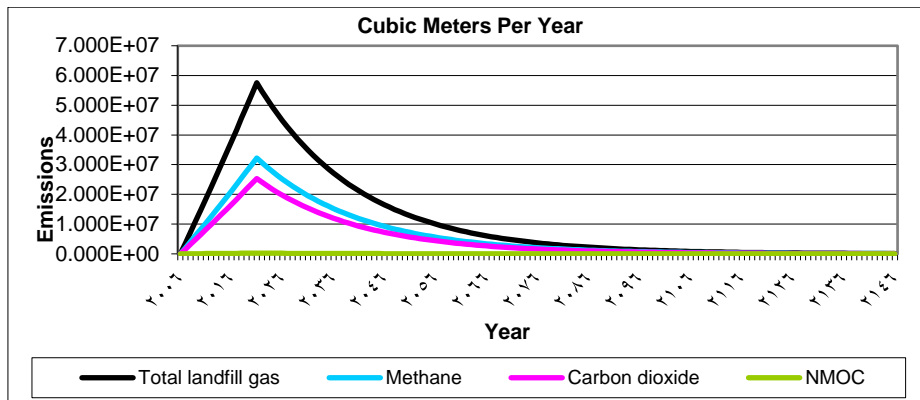


Fig. (7): Landfill gas emission estimation in m<sup>3</sup>/year for Madinah’s landfill utilizing LandGEM model for the years 2006-2020.

Table (1): Typical landfill gas composition and characteristics (Ham, 1979).

Component	Component % (dry volume basis)
Methane	47.5
Carbon Dioxide	47.0
Nitrogen	3.7
Oxygen	0.8
Paraffin Hydrocarbons	0.1
Hydrogen	0.2
Hydrogen Sulfide	0.01
Carbon Monoxide	0.1
Trace Components	0.5
Characteristic	Value
Temperature (at source)	41 °C
Specific Gravity	1.04

Table (2): Average waste streams (%) in municipal solid waste (MSW) in Madinah’s landfill.

Waste Stream	% MSW (by weight)
A: paper and textiles	13
B: Non food organic wastes	1
C: food waste	49
D: wood and straw waste	1
% <b>DOC</b> (by weight)	13.02

Table (3): The results for the determination of methane gas potential ( $L_0$ )

Category	Input Parameters				$L_0$ (m <sup>3</sup> of $\frac{\text{methane}}{\text{tonne}}$ of waste)
	<i>MCF</i>	<i>DOC</i> (%)	<i>DOC<sub>F</sub></i>	(%) <i>F</i>	
<b>Result</b>	0.8	0.1302	0.806	0.56	62.68

## References:

- Fischer C., ECONS S., Maurice C., Lagerkvist A., 1999: "Gas Emission from Landfills, An overview of issues and research needs Survey", AFR-REPORT 264 AFN, Naturvårdsverket, Swedish Environmental Protection Agency, 106 48 Stockholm, Sweden, ISSN 1102-6944, ISRN AFR-R-264-SE, Stockholm 1999
- Henderson R. E., 2011: "Portable Gas Detectors for Landfill Gases", GfG Instrumentation, Inc, AWE International | December 2010/January 2011.
- IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories. IGES, Kanagawa.
- IPCC, 2007a. Climate Change 2007: The Physical Science Basis. Cambridge University Press, New York.
- IPCC, 2007b. Climate Change 2007: Synthesis Report. Cambridge University Press, New York.
- JRC (Joint Research Centre), PBL (Netherlands Environmental Assessment Agency), 2012. Emission database for global atmospheric research (EDGAR).
- Kjeldsen, P. (1996). Landfill gas migration in: soil. In: Landfilling of Waste: Biogas, eds. T. H. Christensen, R. Cossu & R. Stegmann, E & FN Spon, London, UK, pp. 88-132.
- KSA Vision 2030: Vision 2030. Kingdom of Saudi Arabia. Official document available from <http://vision2030.gov.sa/en>.
- Lawson, P., Campbell, D. J. V, Meijer, J-E. & Lagerkvist, A. (1992). Landfill Gas Test Cell Data Exchange, IEA-report, ETSU, Harwell, U K.
- Municipality of Madinah, 2018: General Authority of Cleaning, Annual Report.
- NBSC (National Bureau of Statistics of China), 2013. China Statistical Yearbook (in Chinese). China Statistics Press, Beijing.
- UN HABITAT (2010): "WTE INDUSTRY IN LATIN AMERICA".
- UNEP, 2012. The emissions gap report 2012. United Nations Environment Programme (UNEP).
- Morsy. E., and Al-Sebaei A. 2015: The Generation Rate and Characterization of the Solid Waste Produced from the Visitor's Housing in Madinah, Saudi Arabia, during 1436 H, Umm Al-Qurra University, The Custodian of the Two Holy Mosque Institute for Hajj and Umrah Research, Annual Conference 15.

# Effect of Fasting on the Physical Effort of Pilgrims

Essam Eldin Mohammed Nour Eldin, Samir Hassan Fatani, Hiba Saeed Al-Amodi  
Faculty of Medicine, Umm Al-Qura University

## تأثير الصيام على الجهد البدني للمعتمرين

د. عصام الدين محمد نور الدين، د. سمير بن حسن فطاني، د. هبة بن سعيد العمودي  
كلية الطب - جامعة أم القرى

### ملخص البحث (Abstract):

The current research was designed to investigate the effect of dawn-to-sunset Ramadan fasting on the generation of free radicals, which will arise as a result of the muscular efforts, which produced during the performance of Umrah, in different situations. 12 students performed Umrah in Al masjid Al Haram, by all its activity in different situations and under different environmental conditions. Each student participated to perform Umrah six times. All the participants collected urine sample just before starting Umrah and after finishing. Urinary MDA and urinary creatinine determined in all samples and MDA/creatinine ratio was obtained as an index for the generation of free radicals. There is a decrease in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah in all groups of students in the non-fasting state, as well as, in fasting state for less than 6 hours whether in temperate or hot climate. On the contrary, in the fasting group for more than 12 hours there was an increase in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah whether in temperate or hot climate. The results indicate that performing Umrah in fasting state for more than 12 hours at temperate or hot weather is exhausting as indicated by the increased production of MDA. However, performing Umrah in either non-fasting state or fasting state for at least 6 hours at temperate or hot weather did not increase the production of MDA. Furthermore, it decreases significantly the production of MDA. These results has pointed out that the exercise which is performed during Umrah is not a high intensity and exhaustive excersise. The sequence of the steps of Umrah in the holly mosque as described before make this exercise is adaptive and not injurious exercise. Moreover, drinking Zamzam water may increase antioxidant capacity of the body, but fasting for a long period may decrease this capacity.

### Introduction:

Millions of Muslim people perform Umrah in Ramadan every year. Ramadan is the fasting month, and as all hugrian months it has no fixed weather seasons , as it may take place in summer , spring , winter or autumn seasons according to the year number. Therefore fasting in Ramadan may be in hot , moderate or cold weather according to the season.

In Umrah worship, according to its religious characteristics every person do certain physical effort in ritual of Umrah. Tawaf consists of circling the Kaaba seven times in an anticlockwise direction, and males are encouraged to do the first three rounds at a hurried pace, followed by the last four rounds, more closely, at a leisurely pace. A sa'i is a rapidly walking seven times back and forth between the hills of Safa and Marwah [1]. In some circumstances, The Tawaf and a sa'i are very crowded and make the Umrah very slow and very difficult. Therefore, the effort in the Umrah will be more



than in regular times. In Ramadan people perform Umrah at any time of the day, so they may be fasting or non-fasting. For many people the key question regarding performing Umrah during fasting in Ramadan is what is the effect of this effort on health. The answer to this requires a quick overview of what happens inside the body during fasting.

The changes that occur in the body in response to fasting depend on the length of continuity of fasting. Technically, the body enters into a fasting state eight hours or so after the last meal, when the gut finishes absorption of nutrients from the food.

During the fast, the storage of glucose is used up first to provide energy. Later in the fast, once the stores of glucose run out, fat becomes the next store source of energy for the body. As Ramadan fasting extends only from dawn till dusk, there is ample opportunity to replenish energy stores at pre-dawn and dusk meals. This provides a progressive gentle transition from using glucose to fat as the main source of energy, and prevents the breakdown of muscle for protein. Balanced food and fluid intake is important between fasts.[2]

Oxygen is required for all living organisms for their survival. But, at the same time, one has to remember that oxygen is base matter of free radicals development [3]. However, some of the oxygen is partially reduced to form free radicals or reactive oxygen species. Free radicals are any molecules "atoms" containing one or more unpaired electrons in an outer orbit. They come from smoking, pollution, fried foods and as a by-product of normal metabolism. Free radicals are extremely reactive. Their half-life is only a few milliseconds. When a free radical reacts with a normal compound, other free radicals are generated. This chain reaction leads to thousands of events. When free radicals overwhelm your antioxidant defenses, your cells are damaged. This damage is called oxidative stress [4].

The markers of oxidative stress are measured using variety of different assays. When a fatty acid is peroxidized it is broken down to aldehydes, which are excreted. Aldehydes such as thiobarbituric acid reacting substances (TBARS) have been widely accepted as a general marker of free radical production [5]. The most commonly measured TBARS is malondialdehyde (MDA) which is one of the most well-known products of lipid oxidation. It modifies both proteins and DNA and is the most mutagenic lipid oxidation product [6].

Malondialdehyde (MDA) has been found to be elevated under various conditions of oxidative stress, where ROS and RNS are considered to play important roles [7]. Now, the determination of plasma, urine, or other tissue MDA continues to be widely used as one of the best markers of oxidative stress.

It is widely accepted that strenuous exercise leads to an increase in reactive metabolites of oxygen capable of inducing cellular damage [8]. Increased oxygen flux and subsequent mitochondrial electron leakage has often been cited as the main source of free radical generation during exercise [8]. However, the contribution of this mechanism to the overall sum of free radicals produced during exercise has been widely debated, and it has been proposed that various mechanisms may work synergistically depending on the mode of exercise involved. Exercise intensity also plays a key role in the activation of other related and important mechanisms of free radical production such as substrate autoxidation, xanthine oxidase, intracellular calcium overload, and NADPH oxidase [9].

Lipid peroxidation is a well-defined mechanism of cellular damage in animals and plants. Lipid peroxides are unstable indicators of oxidative stress in cells that decompose to form more complex and reactive compounds such as Malondialdehyde (MDA) as natural biproducts of lipid peroxidation.

This research work was designed to investigate the effect of fasting on the generation of free radicals which will arise

due to the muscular efforts done during the performance of Umrah, in different situations.

### **Material & Methods:**

Our students and their selected collages (21 to 23 Years old) performed Umrah in Al masjid Al Haram, by all its activity under different situations and environmental conditions.

All the students performed Umrah 6 times in different cases:

- Case (1): performed Umrah non-fasting in temperate climate (24°C)
- Case (2): performed Umrah during fasting for at least 6 hours in temperate climate (24 °C)
- Case (3): performed Umrah during fasting for at least 12 hours in temperate climate (24°C) .
- Case (4): performed Umrah non-fasting in hot climate (37°C).
- Case (5): performed Umrah during fasting for at least 6 hours in hot climate (37°C).
- Case (6): performed Umrah during fasting for at least 12 hours in hot climate (37°C).

Participants in all cases collected urine sample just before starting Umrah and after finishing . Urine samples collected in containers containing drops of 0.1 % HCl as preservative and kept frozen until time of analysis.

Urinary MDA and urinary creatinine determined in all samples to obtain MDA/creatinine ratio. The result statistically analyzed, and the obtained results tabulated and discussed.

#### **MDA assay:**

Urinary MDA was measured by Kit of OxiSelect™ TBARS Assay Kit (MDA Quantitation) from Cell Biolabs, Inc. from San Diego, CA 92126

Assay principle:

The Thiobarbituric Acid Reactive Substances (TBARS) assay kit is a tool for the direct quantitative measurement of MDA in biological samples. The unknown MDA containing samples or MDA standard are first reacted with TBA at 95 C°. After a brief incubation, the samples and standard can be read either spectrophotometrically or fluorometrically. The MDA content in unknown samples is determined by comparison with predetermined MDA standard curve.

**Urinary creatinine** was determined by SPINREACT Creatinine quantitative kit.

Principle:

The assay is based on the reaction of creatinine with sodium picrate. Creatinine reacts with alkaline picrate forming red complex. The time interval chosen for measurements avoids interferences from other serum constituents. The intensity of color formed is proportional to the creatinine concentration in the sample.

#### **RESULTS:**

The analysis of our results revealed the following points:

There is a decrease in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah in all groups of students in the non-fasting condition and in the case of fasting for at least 6 hours whether in temperate or hot climate. This decrease is statistically non-significant ( $p > 0.05$ ), although it is evident in about 66% of individual cases in every group.

On the contrary , in the fasting group for more than 12 hours there was increase in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah whether in temperate or hot climate. This decrease

is statistically non-significant ( $p > 0.05$ ), although it is evident in about 50% of individual cases in both groups. These results are summarized in table 1. and illustrated in figure 1.

When we compared the results of urinary MDA/ creatinine ratio in a combined group of students performing Umrah un-fasting and fasting for at least 6 hours in temperate climate and in hot climate (48 students) we found that there is a highly significant decrease in urinary MDA/ creatinine ratio in cases after performing Umrah in comparison to that before performing Umrah ( $p < 0.006$ ).

On the other hand when we compared the results of urinary MDA/ creatinine ratio in a combined group of students performing Umrah fasting for at least 12 hours in temperate climate and in hot climate (24 students) we found that there is a highly significant increase in urinary MDA/ creatinine ratio in cases after performing Umrah in comparison to that before performing Umrah ( $p < 0.014$ ). (Table 2 & Fig 2)

Table 1 : Urinary MDA/Creatinine in all studied groups

Case	MDA/Creatinine in urine ( $\mu\text{mol MDA/Mmol creatinine}$ )			P
		Mean	SD	
1 Non fasting in temperate climate	Before	7.3	4.3	0.12
	After	5.9	3.5	
2 Fasting for at least 6 hours in temperate climate	Before	6.2	3.5	0.11
	After	4.9	2.3	
3 Fasting for at least 12 hours in temperate climate	Before	5.7	1.7	0.59
	After	6.1	2	
4 non fasting in hot climate	Before	7.2	2.8	0.66
	After	5.8	2.1	
5 Fasting for at least 6 hours in hot climate	Before	6	1.8	0.89
	After	5.9	2.2	
6 Fasting for at least 12 hours in hot climate	Before	5.2	1.5	0.88
	After	5.3	1.4	

Table 2: Comparison of Urinary MDA/Creatinine in different groups

Case	MDA/Creatinine in urine ( $\mu\text{mol MDA/Mmol creatinine}$ )			P
		Mean	SD	
Non fasting in temperate and hot climate	Before	7.3	3.5	0.014 *
	After	5.9	2.8	
Fasting for at least 6 hours in temperate and hot climate	Before	6.1	2.7	0.175
	After	5.3	2.3	
Fasting for at least 12 hours in temperate and hot climate	Before	5.5	1.6	0.594
	After	5.7	1.8	
Non-fasting and Fasting for at least 6 hours in temperate and hot climate	Before	6.7	3.2	0.006 **
	After	5.6	2.5	

non-significant ( $p > 0.05$ )

\* Significant ( $p < 0.05$ )

\*\* Significant ( $p < 0.01$ )

\*\*\* Significant ( $p < 0.001$ )

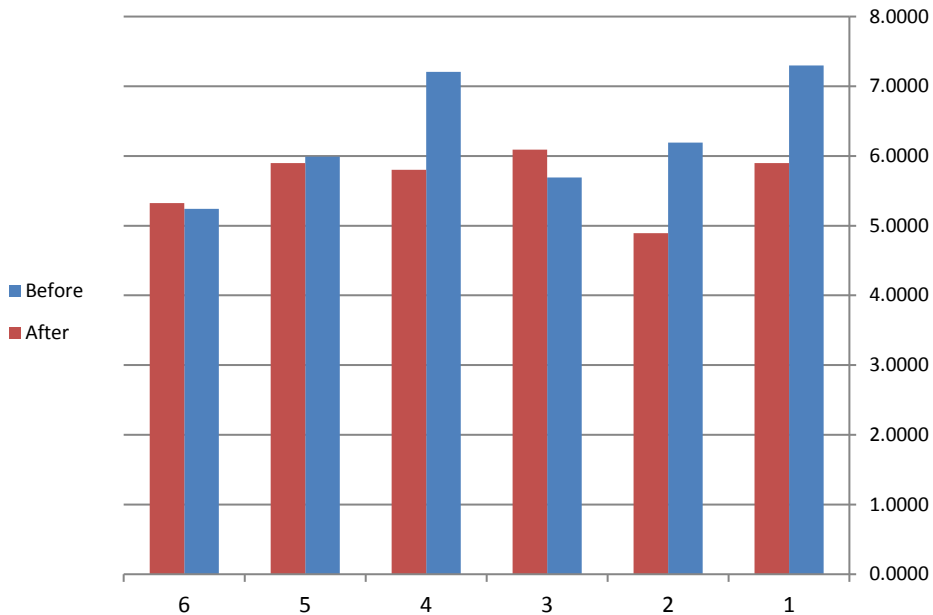


Fig. (1): Urinary MDA/creatinine before and after performance Umrah in all groups.

Performing Umrah

1: unfasting in moderate climate.

2: fasting 6 hours in moderate climate.

3: fasting 12 hours in moderate climate.

4: unfasting in hot climate.

5: fasting 6 hours in hot climate.

6: fasting 12 hours in hot climate.

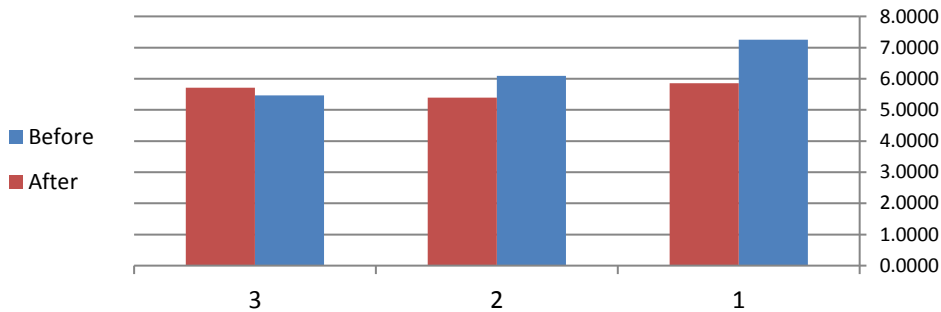


Fig. (2): Urinary MDA/creatinine before and after performance Umrah in different conditions 1. Non-fasting, 2= fasting 6 hours, 3= fasting 12 hours.

### Discussion & conclusion:

Measuring the end products of lipid peroxidation is one of the most widely accepted assays for oxidative damage. A variety of oxidation products are found in urine and thought to mirror local and systemic oxidative stress. Malondialdehyde (MDA) is an indicator of lipid peroxidation which increases in various diseases. This increase is reflected in enhanced excretion of several MDA derivatives in the urine [10]. Many studies suggest that exercise-induced oxidative stress leads to increased free radicals and lipid peroxidation with resultant subcellular damage.

Regular training and conditioning mitigate the damage associated with free radicals and lipid peroxidation by promoting increased levels of superoxide dismutase and catalase. Some studies suggest an increased need for antioxidants in those athletes engaged in intensive training regimens. Evidence is emerging that antioxidants may have subtle effects on the exercise adaptive process [11].

It appears that the steps of performing Umrah is moderately intense physical exercise which increases oxygen utilization and causes excess oxygen-derived free radical liberation. free radical liberation occurs through mitochondrial lipid peroxidation, neutrophil degranulation and up-regulation of xanthine oxidase activity, which liberates superoxide [12]. Current results revealed that there is a decrease in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah in all groups of students in the non-fasting state and in the case of fasting for at least 6 hours whether in temperate or hot climate. In the fasting group for more than 12 hours, there was an increase in urinary MDA/ creatinine ratio after performing Umrah in comparison to that before performing Umrah whether in temperate or hot climate. Comparing the results of urinary MDA/ creatinine ratio in a combined group of students performing Umrah whether in non-fasting and fasting state for at least 6 hours either in temperate and hot climates (48 students), it has been found that there is a highly significant decrease in urinary MDA/ creatinine ratio in cases after performing Umrah in comparison to that before performing Umrah ( $p < 0.006$ ). However, in the group of students performing Umrah in fasting state for at least 12 hours either in temperate and hot climates (24 students), it has been found that there is a highly significant increase in urinary MDA/ creatinine ratio in cases after performing Umrah in comparison to that before performing Umrah ( $p < 0.014$ ).

These results indicate that performing Umrah with fasting for more than 12 hours at temperate or hot weather is exhausting as indicated by the increased production of MDA in contrast to performing Umrah in non-fasting or fasting state for at least 6 hours at temperate or hot weather where the production of urinary MDA is significantly decreased.

It was expected from the previous studies that urinary malondialdehyde measured related to urinary creatinine will increase after performing Umrah in most people as pilgrims do much effort of muscle exercise during ritual Umrah [13].

Physical activity results in an increased production of free radicals and reactive oxygen species (ROS), and it is well known to induce oxidative stress in individuals subjected to intense exercise. In addition, during exercise, the process of delivering the oxygen to working muscles may actually result in oxidation of polyunsaturated fatty acids in the mitochondria. Furthermore, growing evidence implicates cytotoxic ROS as an underlying cause in exercise induced disturbances in muscle redox status that could result in muscle fatigue or injury [14].

Kelvin et al(1982) reported a two- to three-fold increase in free radical ( $R^{\cdot}$ ) concentrations of muscle and liver following exercise to exhaustion. Exhaustive exercise also resulted in a decreased mitochondrial respiratory control, loss of sarcoplasmic reticulum (SR) and endoplasmic reticulum (ER) integrity, and increased levels of lipid peroxidation products [15]. Sojdin et al (1990) found that during exercise, two of the potentially harmful free radical generating sources are semiquinone in the mitochondria and xanthine oxidase in the capillary endothelial cells. During high intensity exercise the flow of oxygen through the skeletal muscle cells is greatly increased at the same time as the rate of ATP utilization that exceeds the rate of ATP generation. The metabolic stress in the cells causes several biochemical changes to occur, resulting in a markedly enhanced rate of production of oxygen free radicals from semiquinone and xanthine oxidase[16].

The obtained results revealed unexpected result as most of the participant in the study program showed a decrease in urinary maldondialehde ratio related to urinary creatinine after performing the ritual Umrah than that was present before performing Umrah except those who were fasting for more than 12 hours.

From current results, it has been shown that the exercise which is performed during Umrah is not a high intensity and exhaustive exercise. The sequence of the steps of Umrah in the holly mosque as described before makes this exercise is adaptive and not injurious exercise. Furthermore, the emotional feeling of the pilgrims while they are performing the ritual Umrah may also share in decreasing the generation of free radicals. Drinking Zamzam water or other mineralized water may increase antioxidant capacity of the body, but fasting for a long period may decrease this capacity.

The long period of 12 hours fasting, the relative increase in temperature (afternoon), and the exhaustive efforts of muscle exercise collectively may caused the significant elevation in the urinary MDA after Umrah performance fasting for more than 12 hours.

This conclusion is supported by the results of study of Cooper et al (2002) which reviewed the role of free radicals in causing oxidative stress during exercise [17]. They found that high intensity exercise induces oxidative stress and although there is no evidence that this affects sporting performance in the short term, it may have longer term health consequences.

Venditti and Di Meo (1996) illustrated that physical training permits an animal to respond successfully to exercise loads of various types, intensities, and durations [18]. Furthermore, the trained animal can sustain the activity for a long period before the fatigue becomes limiting. The exhaustive exercise gave rise to tissue damage irrespective of the trained state.

Also our results can be explained by the study of Scott et al (2008). They reported that regular physical exercise has many health benefits including a decreased threat of all-cause mortality along with a reduced risk of cardiovascular disease, cancer, and diabetes [14]. Also Al-Shafei (2014) reported that Ramadan fasting ameliorates oxidative stress and improves glycemic control and lipid profile in diabetic patients[19], and ameliorates arterial pulse pressure and lipid profile, and alleviates oxidative stress in hypertensive patients[20].

The result of this study is preliminary one and there is a need to be supported by a study on a larger scale.

#### **RECOMMENDATION:**

There is a need to support the results of this study by performing it on larger scale. The role of physical exhaustion or deficient sleep before Umrah and its role in causing oxidative stress must be involved in this study.

#### **ACKNOWLEDGMENT**

The authors would like to acknowledge our students: Abdullah Halawani, Abdullah Al-Malki, Ahmed Assolbi, Jaber Ibrahim, Maher Alsaadi, Mohammed Ashehri and Mohammed Al-Roqi who participate in this study by performing Umrah and shared in its activity as a part of their graduate research.

#### **REFERENCES**

1. Baz AABAB: **Hajj Umrah And Ziyarah In The Light Of The Quran And Sunnah**, vol. 6: Darussalam Publishers And Distributors; 2004.
2. Vasudevan DM, Sreekumari S, Vaidyanathan K: **Textbook of biochemistry for medical students**, Eighth edition. edn. New Delhi ; Philadelphia: Jaypee Brothers Medical Publishers (P) LTD; 2016.

3. Azzi A, Davies KJ, Kelly F: **Free radical biology - terminology and critical thinking.** *FEBS Lett* 2004, **558**(1-3):3-6.
4. Palomero J, Jackson MJ: **Redox regulation in skeletal muscle during contractile activity and aging.** *J Anim Sci* 2010, **88**(4):1307-1313.
5. Ayala A, Munoz MF, Arguelles S: **Lipid peroxidation: production, metabolism, and signaling mechanisms of malondialdehyde and 4-hydroxy-2-nonenal.** *Oxid Med Cell Longev* 2014, **2014**:360438.
6. Draper HH, McGirr LG, Hadley M: **The metabolism of malondialdehyde.** *Lipids* 1986, **21**(4):305-307.
7. Jenkins RR, Friedland R, Howald H: **The relationship of oxygen uptake to superoxide dismutase and catalase activity in human skeletal muscle.** *Int J Sports Med* 1984, **5**(1):11-14.
8. Loft S, Astrup A, Buemann B, Poulsen HE: **Oxidative DNA damage correlates with oxygen consumption in humans.** *FASEB J* 1994, **8**(8):534-537.
9. Jackson MJ, Pye D, Palomero J: **The production of reactive oxygen and nitrogen species by skeletal muscle.** *J Appl Physiol (1985)* 2007, **102**(4):1664-1670.
10. Valenzuela A: **The biological significance of malondialdehyde determination in the assessment of tissue oxidative stress.** *Life Sci* 1991, **48**(4):301-309.
11. Yavari A, Javadi M, Mirmiran P, Bahadoran Z: **Exercise-induced oxidative stress and dietary antioxidants.** *Asian J Sports Med* 2015, **6**(1):e24898.
12. Waring WS, Convery A, Mishra V, Shenkin A, Webb DJ, Maxwell SR: **Uric acid reduces exercise-induced oxidative stress in healthy adults.** *Clin Sci (Lond)* 2003, **105**(4):425-430.
13. Al Shimemeri A: **Cardiovascular disease in Hajj pilgrims.** *J Saudi Heart Assoc* 2012, **24**(2):123-127.
14. Powers SK, Jackson MJ: **Exercise-induced oxidative stress: cellular mechanisms and impact on muscle force production.** *Physiol Rev* 2008, **88**(4):1243-1276.
15. Davies KJ, Quintanilha AT, Brooks GA, Packer L: **Free radicals and tissue damage produced by exercise.** *Biochem Biophys Res Commun* 1982, **107**(4):1198-1205.
16. Sjodin B, Hellsten Westing Y, Apple FS: **Biochemical mechanisms for oxygen free radical formation during exercise.** *Sports Med* 1990, **10**(4):236-254.
17. Cooper CE, Vollaard NB, Choueiri T, Wilson MT: **Exercise, free radicals and oxidative stress.** *Biochem Soc Trans* 2002, **30**(2):280-285.
18. Venditti P, Di Meo S: **Antioxidants, tissue damage, and endurance in trained and untrained young male rats.** *Arch Biochem Biophys* 1996, **331**(1):63-68.
19. Al-Shafei AI: **Ramadan fasting ameliorates oxidative stress and improves glycemic control and lipid profile in diabetic patients.** *Eur J Nutr* 2014, **53**(7):1475-1481.
20. Al-Shafei AI: **Ramadan fasting ameliorates arterial pulse pressure and lipid profile, and alleviates oxidative stress in hypertensive patients.** *Blood Press* 2014, **23**(3):160-167.

# Evaluation of antimicrobial effect of Chitosan and acetic acid during thawing of frozen chicken

Shawkt m.Fathi<sup>(1)</sup>, Osama A.Aattala<sup>(2)</sup>, Bassam H.Mashat<sup>(2)</sup>

<sup>(1)</sup> Faculty of agriculture and veterinary medicine al qassim university

<sup>(2)</sup> The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research

## تقييم الشيتوزان وحمض الخليك كمثبطات لنمو الميكروبات أثناء عملية إذابة الدواجن المجمدة

شوكت محمد فتحى<sup>(1)</sup>، اسامة على عطالله<sup>(2)</sup>، بسام حسين مشاط<sup>(2)</sup>  
<sup>(1)</sup> كلية الزراعة والطب البيطري جامعة القصيم  
<sup>(2)</sup> معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة - جامعة أم القرى

### ملخص البحث (Abstract):

تعتبر عملية إذابة الدواجن المجمدة من النقاط الحرجة في المنشآت الغذائية خاصة بان العاملين في تلك المنشآت يضعون الدجاج المجمد في احواض الماء الساخن للاسراع من عملية مما يتسبب عن ذلك فقد في القيمة الغذائية للدواجن والمساعدة على نمو الميكروبات المسببة للفساد والتسمم الغذائي . وتعتبر الاذابة بواسطة وضع اللحوم المجمدة في الثلجات عند درجة حرارة ( 5- 0 درجة مئوية) لمدة ٢٤ ساعة من اهم وافضل الطرق الصحية المتبعة ولكن للظروف الخاصة بالنسبة للمنشآت الغذائية وخاصة (مطابخ الاعاشة - مطابخ المشاعر) في مكة المكرمة والمشاعر المقدسة وعلى الرغم من ان هناك قواعد محددة لعملية الاذابة للحوم المجمدة الا انه هناك صعوبات تواجه العاملين في تنفيذ تلك الاشتراطات وذلك لعدة اسباب منها ضيق المساحات في المطابخ وعدم وجود منطقة مخصصة لعملية الاذابة، عدم توافر ثلجات او مبردات لعملية الاذابة الصحيحة والمطلوبة من الجهات ذات العلاقة (الامانات)، ضيق الوقت وخاصة في اوقات الذروة مثل مواسم الحج ورمضان (تحتاج عملية الاذابة الى حوالى ١٠-١٢ ساعة) وانه لا بد من تجهيز وجبات الغذاء والعشاء لعدد كبير من الحجاج والمعتمرين في اقصروقت ممكن ولهذا اسلوب الاذابة المتبع في الثلجات لا يفي بتحضير تلك الوجبات في المواعيد المطلوبة لذلك يمكن أن يكون استخدام المواد المثبطة لنمو الميكروبات في احواض الاذابة للمساعدة على تقليل التلوث الميكروبي وخاصة السالمونيلا والاشيرشاي كولاي. ويمكن تقسيم تلك المواد الطبيعية والكيميائية والبيولوجية. ويعتبر الشيتوزان من المواد الطبيعية والمستخلصة من الكيتين ولها تأثير مضاد للميكروبات ويمكن استخدامها لاطالة فترة صلاحية المنتجات الغذائية وتم استخدامها مع حامض الخليك وهو من المواد الكيميائية التي تستخدم بامان تام في مجال الاغذية. وقد قامت هذه الدراسة للتحقق من تأثير الشيتوزان ومقارنته مع حامض الخليك المضاف الى احواض التي تم فيها عملية الاذابة على السيطرة على ميكروبي السالمونيلا واى كولاي. وقد تم المعالجة بمحلول الشيتوزان بتركيزات مختلفة (٠,٥% - ١%) وحامض الخليك (٠,٥% - ١%) وخليط منهما (١%) لكلا منهما وتم فحص العينات للاختبارات الحسية والبكتيرية. وقد اظهرت النتائج ان الشيتوزان (٠,٥% - ١%) وحامض الخليك (٠,٥% - ١%) والخليط منهما لم يختلف معنويا عن المجموعة الضابطة بالنسبة الى الاختبارات الحسية. اما بالنسبة للسيطرة على ميكروبي السالمونيلا واى كولاي فلم يكن هناك اختلاف معنوى بين العينات الضابطة وتلك التي عولجت بالشيتوزان او حامض الخليك ٠,٥% بينما اختزلت محلول الشيتوزان وحامض الخليك ١% اعداد ميكروب السالمونيلا بمقدار ١ لوخلية\جم وكذلك كان هناك فارق معنوى بين واضح بين استخدام الخليط من الشيتوزان وحامض الخليك بتركيز ١% على العدد الكلى للبكتيريا وميكروب الاشيرشاي كولاي واختزال اعداد ميكروب السالمونيلا بمقدار ١,٢ لوخلية\جرام عن العينات الضابطة. وبالتالي توصى الدراسة باستخدام خليط من الشيتوزان وحامض الخليك بتركيز ١% وذلك باضافتهما الى المياة المستخدمة في عملية صهر الدواجن المجمدة وذلك للسيطرة على التلوث الميكروبي.

الكلمات المفتاحية: الشيتوزان - حمض الخليك - الدجاج المجمد - إذابة اللحوم - الاشيرشاي كولاي - السالمونيلا



Thawing process in chicken preparation is considered a critical step because handlers in food service establishment put frozen chicken in a Hot Water to enchantment the defrosting food material. Thawing by placing the frozen meat in the refrigerators at a temperature (0 - 5 °c) for 24 hours of the most important and best methods of health, but the special circumstances for the food and especially (kitchens – masahar kitchens) in Mecca and the holy sites and although There are specific rules for the process of melting frozen meat, but there are difficulties faced by the workers in the implementation of these requirements for several reasons and narrow areas in the kitchens and the absence of an area dedicated to the process of melting, the absence of refrigerators or coolers for the correct process required by the relevant authorities, Especially during peak times, such as the Hajj and Ramadan seasons (the process of thawing needs about 10-12 hours), and that meals and dinners should be prepared for a large number of pilgrims in the shortest time possible. Therefore, the method of thawing used in refrigerators is not sufficient to prepare these meals on the required time. The use of inhibitory microbial agents in melting ponds can help to reduce microbial contamination, especially salmonella and Eshrachia coli. The application of decontamination treatments during chicken processing specially during the thawing step could be highly useful to prevent the growth of food poisoning microorganisms causing spoilage of poultry meat. Several decontaminants have been reported to be effective in destroying pathogens; these treatments can be classified as natural and chemical decontaminants. Chitosan is a natural bioactive polysaccharide, derived from deacetylation of chitin with intrinsic antimicrobial activity and can be recognized as a natural alternative to synthesized antimicrobial for extending perishable food shelf life. Also organic acid with proven effectiveness as a decontaminant with different kinds of food, acetic acid is generally recognized as safe substance (GRAS).Therefore, the present study designed to investigate the effect of chitosan and acetic and their combination on the process of thawing of frozen chicken and decontamination of Salmonella typhimuium and E. coli. Addition of chitosan and acetic acid in water used for thawing process at a concentration of chitosan 0.5%, 1% and acetic acid 0.5%, 1% solutions beside their combination. Treated samples were examined for sensory attributes and bacterial load .Samples treated with chitosan 0.5%, 1% and combinations with acetic acid did not significantly differ from the control samples for sensory attributes. Using of acetic acid 1% reduces the bacterial load (Apc). Chitosan 0.5% and acetic 0.5% nearly had no effect on reduction of E. coli and salmonella. Combination of acetic acid 1% and chitosan 1% reduced E. coli and salmonella count.

**Key words:** Chitosan, Acetic acid, Chicken, Thawing, E.coil, Salmonella

## **Introduction**

Poultry meat shelf life is affected mainly by two factors, storage temperature and initial microbial load. Consequently, refrigeration storage is a crucial step that significantly prevents microbial growth and maximizes both product safety and shelf life karadag and puhakka (2010).Poultry meat is a highly perishable food commodity providing an almost perfect medium for microbial growth ,including both spoilage and pathogenic microorganism ,therefore the microbial contamination during the poultry processing is very crucial(Jay el al., 2005).The application of decontamination treatments during processing specially during thawing process could be highly useful because growth of food poisoning microorganisms. Several decontaminants have been reported to be effective in destroying pathogens, these treatments can be classified as physical, chemical, and biological decontaminants Capita et al.( 1999) .Thawing process is to melt the frozen food by extracting the food from the freezer and transfer it to the refrigerators at a temperature of(0 ° C to 5 °

C). Thawing process is a critical control point due to growth of microbes specially (*E. coli* and *salmonella*), It is considered to be one of the most important causes of food poisoning Mor-Mur, and Yuste (2010), especially since it has sufficient time and grow in a highly nutritive media (water and proteins), which needed to grow rapidly and secretion of toxins in those meat, which leads to damage and corruption (change in color and odor of meat) and decreased the nutritional value and sensory evaluation of poultry meat. The results of the previous research found that the survival of bacteria in food for two hours or more at the temperature of the area of danger zone (5-60°C) helps to damage and causing spoilage of those foods. Acetic acid is generally recognized as safe substance with no upper limit of daily intake for humans several of the organic acids investigated for application in poultry include acetic, formic, citric, lactic, and propionic acid. Although these acids can be effective antimicrobials, it has been reported that they could cause negative flavor and color changes Bagamboula et al. (2004). To avoid the negative quality changes associated with organic acids, the ideal approach is to combine antimicrobials. This will allow the use of lower levels of organic acids but maintain the antimicrobial efficacy of the compound. Chitosan is a natural carbohydrate polymer derived from the decetylation of chitin, a main component of exoskeletons of crustaceans. Different production methods are used to produce chitosan with different chemical properties, which potentially reflect variations in the antimicrobial activity No and Myrers (2002). With increasing consumers awareness of food treated chemicals, food industry became highly interested in applying natural compounds that could achieve a high level of food safety Rauha et al. (2000). Therefore, the present study was designed to investigate the effect of chitosan as a natural decontaminate and acetic acid as a chemical decontaminate on reduction of microbial load during thawing process.

### **Research aims**

The present study was designed to investigate the effect of chitosan as a natural decontaminate and acetic acid as a chemical decontaminate on reduction of microbial load during thawing process.

### **Research methodology**

The experiment was designed to investigate the effect of chitosan and acetic acid on microbial load during thawing of frozen chicken.

### **Preparation of samples:**

Five groups of whole chicken samples obtained from local markets (average weight of each sample 1 kilo gram)

### **Preparation of treatments:**

Chitosan: acid soluble chitosan (SIGMA ALDRICH) and used as solvent for 0.5% solution of acetic acid (v/v) in distilled water. Concentration of 0.5 and 1% chitosan were prepared (w/v).

Acetic acid: a solution of 0.5 and 1% of acetic acid in distilled water (v/v) was prepared.

Application of chitosan and acetic acid on water used thawing of frozen chicken:

Five treatments solutions were performed as follows: chitosan 0.5%, chitosan 1%, 0.5% acetic acid 1% acetic acid and combination between chitosan 1% and acetic acid 1%. Each solution was used as a dipping solution for a group from previously prepared solution frozen chicken (100ml prepared solution added to two liter of water) in addition to control where dipped in water only.

### Sensory examination:

Three raw samples were examined for its appearance, odor, consistency, and overall acceptability score according to Sumarmono and Raharrdjo(2008)using five point hedonic scale where 1 (very bad) to5 (very good) then the average was recorded as overall sensory score.

### Bacteriological examination :

Bacterial counts- :

The technique recommended by Downes, Ito and Association (2001) was applied.

Preparation of sample homogenate-:

Ten grams of the chicken samples were weighed under aseptic condition into sterile stomacher polyethylene bag containing 90ml of a sterile ringer solution (OXIOD, BO0619), stomached in stomacher for 1 minute at room temperature,Then fivefold serial dilutions were prepared using 0.1 ringer solution.

Bacteriological analysis was performed according to the standard procedures for enumeration and identification of microorganisms (ICMSF 2005) as follows-:

Aerobic plate count.

Isolation and identification of Salmonella.

Isolation and identification of E. coli.

### Statistical Analysis:

All data were analyzed using Statistical Analysis System SPSS Comparisons between treatments within each analysis were tested. Significance was determined by the F-test and least square means procedure. Main effects were considered significance at  $P < 0.05$ .

### Results and discussion

Sensory attributes (mean values  $\pm$  SD) of different treated frozen chicken samples (TABLE 1)

treatments	control	0.5% acetic acid	0.5% chitosan	1% acetic acid	1% chitosan	1% acetic and 1% chitosan
appearance	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$
odor	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$
consistency	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	4.6a $\pm 0.18$
Overall acceptability	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	5.0a $\pm 0.0$	4.8a $\pm 0.12$

### Sensory analysis:

Appearance is one of the most important sensory attributes of poultry meat as it can generally persuade a consumer's decision to purchase meat

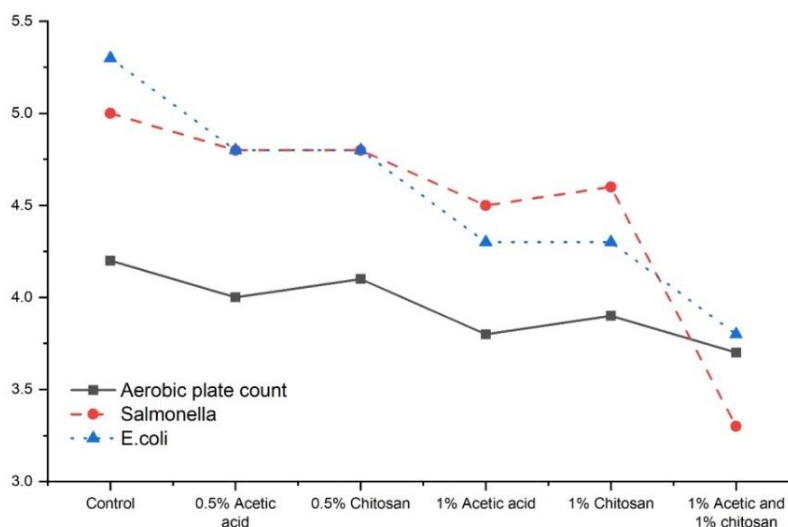
Application of acetic acid and chitosan (0.5%, 1%) has no significant effect on appearance, odor, consistency and overall acceptability compared with control samples was observed. The obtained results are in agreement with that reported by kross(2004)and Qiao(2002).Combination of acetic acid and chitosan treatment(1%)for each showed slightly slimness

(this could be attributed to the viscous nature of chitosan solution), while this combination had no effect on odor and overall acceptability. The results recorded by Ibrahim and El-khawas (2015) are in agreement of the obtained results.

Results of microbial counts of the treated frozen chicken samples (log cfu/g mean  $\pm$  SD) (TABLE 2)

treatments	Aerobic plate count	Salmonella	E.coli
control	4.2a $\pm 0.20$	5.0a $\pm 0.20$	5.3a $\pm 0.21$
0.5% acetic acid	4.0a $\pm 0.5$	4.8a $\pm 0.15$	4.8b $\pm 0.42$
0.5% chitosan	4.1a $\pm 0.25$	4.8a $\pm 0.15$	4.8b $\pm 0.36$
1% acetic acid	3.8a $\pm 0.26$	4.5b $\pm 0.20$	4.3b $\pm 0.35$
1% chitosan	3.9a $\pm 0.29$	4.6b $\pm 0.20$	4.3b $\pm 0.35$
1% acetic and 1% chitosan	3.7b $\pm 0.2$	3.3b $\pm 0.8$	3.8c $\pm 0.34$

Results of microbial counts of the treated frozen chicken samples (log cfu/g mean  $\pm$  SD) Figure (1)



The control of foodborne pathogens in primary production, at hatchery and farm levels, is the first important step in the safety of poultry meat during the whole production chain. The microbiological condition of live birds influences the microbiology of the products as live animals are the principal source of microorganisms found in poultry carcasses European Union (1998).

Table (2) and Fig. (1) represents a marked decreased in aerobic plate count (log cfu/g) was seen in all examined samples treated with (0.5%, 1%) acetic acid or chitosan compared with control. Combination of acetic acid and chitosan at a concentration 1% revealed a significant reduction in aerobic plate count than control samples, the obtained results generally agree with that obtained by Chounou et al.(2013).

Poultry meat ranked first as cause in food poisoning with incidence of 29.32%, followed by meat with incidence 15.33% (Altabari and Al-Dughaym, 2002). The food poisoning microorganisms causing outbreaks were mainly salmonellae and E. coli. These bacteria are considered indicators of microbiological quality.

Table (2) represents the initial count of *Salmonella Typhimurium* in control and treated samples with 0.5% acetic acid and 0.5% chitosan were 5, 4.8, 4.8 log (cfu/g), respectively with no significant difference between these groups, while samples treated with 1% chitosan and 1% acetic acid showed reduction in salmonella count (4.6, 4.5 log cfu/g). On the other hand, treated samples with combination of acetic acid and chitosan at 1% showed significant reduction 3.3 log cfu/g, these results agreed with Wang (1992) and Knowles and Roller (2001). Antibacterial activity of chitosan involves binding of the amino group of chitosan to the surface components of bacteria, thereby inhibiting their growth, chitosan binds to the negatively charged bacterial surface to disturb the cell membrane and cause cell death due to leakage of intracellular components (Sudarshan et al., 1992).

E. coli counts were determined on broiler chicken carcasses visibly and not visibly contaminated with fecal material during commercial slaughter practice (Jimenez et al., 2003).

Table (2) and Fig. (1) showed significant reduction in E. coli count could be observed in samples treated with chitosan 1% and 1% acetic acid than control and chitosan and acetic acid at a concentration 0.5%

Reduction of E. coli count may be attributed to acetic acid at 1% decreases the ionic concentration within the bacterial cell membrane of the exterior cell wall of the bacterial organism. This leads to an accumulation of the acid within the cell cytoplasm, acidification of the cytoplasm and inhibition of substrate transport (Praveen et al., 2007).

### **conclusion**

From the obtained results, it could be concluded that treatment with chitosan 1% and 1% acetic acid can slightly reduce bacterial load specially Aerobic plate count and E. coli, while treatment with 1% acetic acid and 1% chitosan combination between them proved significant reduction in *Salmonella* and E. coli count by 1- 1.5 log cfu/g and has no adverse effect on odor, consistency, and overall acceptability.

### **Recommendations**

The application of decontamination treatments during chicken processing specially during the thawing step could be highly useful to prevent the growth of food poisoning microorganisms causing spoilage of poultry meat. Especially during peak times, (Hajj and Ramadan seasons) the process of thawing needs about (10-12 hours), and that meals and dinners should be prepared for a large number of pilgrims in the shortest time possible. Therefore, the method of thawing used in refrigerators is not sufficient to prepare these meals on the required time. The use of inhibitory microbial agents in melting ponds can help to reduce microbial contamination, especially salmonella and *Escherichia coli*.

### **References**

- Altabari, G., and Al-Dughaym, A.M., (2002): The role of sanitary inspection of meat in relation of food poisoning. Annual Scientific Meeting For Environment Hygiene (Meat Hygiene), Riyadh, pp. 180-203.
- Bagamboula, C. F., Uyttendaele, M., and Debever, J., (2004): Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragol, linalool towards SHIGELLA and S. flexneri. Food Microbiology, 21:33-42.
- Capita R.C., Alonso-Calleje C, Garcia-Arias MT, Garcia-Fernandes MC and Moreno B (1999): Decontamination of poultry: Chemical treatments and decontamination situation within the European Union. Alimentaria, 303.

- Chounou,N.,Chouliara, E., Mexis ,S.F., Stavros,K.,Georgantelis,D.and Kontominas,M.G:(2013). Shelf life extension of ground meat stored at 4 c using chitosan and an oxygen absorber. *International Journal of Food Science and Technology*, 48, 49-95.
- Downes ,F, P.,Ito,K., Association,A.P.H.(2001):Compendium of Methods for the Microbiological Examination of Food .American Public Health Association ,DC USA .
- European Union (1998) Benefits and Limitations of Antimicrobial Treatment for poultry carcasses. Report of the Scientific Committee on Veterinary Measures relating to Public Health (SCVPH ).(
- Ibrahim, S.and El-khawas,K.M.(2015): Extending the shelf life of chilled fillet using developed active packaging material .J.EGYPT .VET. Med.Assoc.75 (4):625-629.
- ICMSF(International Commission on Microbiological Specifications of Food)(2005):Poultry products in Microorganisms in foods 6:108-173.
- Jay J., M., loessner,M.j., Golden, and David, A. (2005).Modern food Microbiology. New York: Springer Science inc .
- Jimenez, S.M., Tiburzi,M.C., Salsi, M. S., Pirovani, M.E. and Moguilevsky, M.A.(2003):The role of visible faecal material as a vehicle for generic E.coli and other enterobacteria contaminating poultry carcasses during slaughtering .J.Appl .Microbiology. 95:451-456.
- Karadag, D.and Puhakka,J.A. (2010):Effect of changing temperature on anaerobic hydrogen production and microbial community composition in an open-mixed culture bioreactor. *Int .J Hydrogen Energy*, 35:10934-10959.
- Knowles, J.and Roller, S.(2001):Efficacy of chitosan ,carvacrol, and a hydrogen peroxide based biocide against foodborne microorganisms in suspension and adhered to stainless steel . *J.Food Prot.*64 (10):1542-1548 .
- Kross,R.September 2004. Methods for reducing meat discoloration.U.S.patent 20040175476 AL.
- Mor-Mur,M., and Yuste,J,(2010): Emerging bacterial pathogens .Meat and Poultry : An Overview ,Food Bioprocess and Technology,3,24-35.
- No,H.K., PARK,N.Y., Lee,S.H.,and MEYERS, S.P.(2002):Antibacterial activity of chitosan and oligomers with different molecular weights .*Int.J.Food Microbiology.*(74)65-72.
- Parveen, S.,Taabodi M.,Schwarz J.G., Oscar T.P., Harter-Dennis J.,and White D.G.(2007): Prevalence and antimicrobial resistance of salmonella recovered from processed poultry.*J.Food Prot.*( 70):2466-2472.
- Qiao, M., Fletcher D. L., Northcutt J. K., and Smith D. P. (2002): The relationship between raw broiler breast meat color and composition .*Poult. Sci.* 81:422-427.
- Rauha, P., Remes , S., Heinonen ,M., Hopia,A.,Kahkonen,M.,Kujala,T. Pihlaja, K. Vuorela, P.(2000):Antimicrobial effect of finnish plant extracts containing flavonoids and other phenolic compounds.*Inc. Food Microbiology* .56:3-12.
- Sudarshan, N.R., Hoover,D. G., and Knorr,D.(1992):Antibacterial action of chitosan .*Food Biotechnol.*6257-6272.
- Summarmono, J., Agustins, D. and Rahardjo, H.D.(2008): Effect of decontamination using organic acids on total microbial number and qualities of poultry carcasses , *Animal Production*,4:129-139 .
- Wang,G.(1992):Inhibition and inactivation of five species of foodborne pathogens by chitosan.*J.Food Prot.*(55):916-919.

# Service Availability and Readiness Assessment of Health Facilities in Mina and Arafat during the 2017 Hajj

Ahmed Elganainy, Kingsley Bieh, Nour Abdulmalek, Sujoud Ghallab, Nomai Mukhtar  
Global Center for Mass Gatherings Medicine-MOH

## تقييم استعداد المنشآت الصحية وتوفير الخدمات أثناء موسم الحج

أحمد الجنائني، كنجزلي بيه، نور عبدالملك، سجاد غلاب، نمي مختار  
المركز العالمي لطب الحشود - وزارة الصحة

### ملخص البحث (Abstract):

المقدمة أجرى المركز العالمي لطب الحشود أول تقييم لتوفر الخدمات والاستعدادات في المرافق الصحية التابعة لوزارة الصحة في الأماكن المقدسة (منى وعرفات) خلال موسم حج ١٤٣٧ هـ والذي يهدف إلى تقييم توافر الخدمة، والجاهزية، والتحقق من جودة البيانات في المرافق الصحية في الحج لتسهيل التخطيط واتخاذ القرارات. يصف هذا التقرير نتائج التقييم الثاني والذي أجري خلال موسم حج ١٤٣٨ هـ المنهجية نفذ هذا التقييم بأسلوب الدراسة المستعرضة لتوافر الخدمة والاستعداد لتقديمها في المرافق الصحية التابعة لوزارة الصحة في منى وعرفات. استُمد استبيان الدراسة من أداة جمع بيانات قياسية/معيارية لمنظمة الصحة العالمية، والتي تم تعديلها بما يتماشى مع سياق الحج. تم جمع البيانات في أغسطس وسبتمبر ٢٠١٧ م. النتائج أظهرت النتائج أن غالبية المرافق الصحية لديها الأجهزة والمرافق الأساسية اللازمة لتقديم الخدمات الصحية الأساسية خلال الحج. بعد اعتماد وتطبيق معايير جديدة لتوزيع الممارسين الصحيين عام ١٤٣٨، ارتفعت نسبة الممارسين الصحيين الأساسيين (الأطباء والتمريض) من ٣٤٪ في عام ١٤٣٧ هـ إلى ٤٦٪ في عام ١٤٣٨ هـ إضافة إلى ذلك، كان هناك انخفاض بنسبة ٣٥٪ في متوسط عبء العمل (عدد الاستشارات اليومية / طبيب) في منى وعرفات. وزاد متوسط الوقت الذي قضاه الحاج مع الطبيب خلال الزيارات في مراكز الرعاية الصحية الأولية من ١,٣٥ دقيقة في عام ١٤٣٧ هـ إلى ٢,٣٨ دقيقة في عام ١٤٣٨ هـ الخاتمة سيمثل هذا التقييم لمرافق الرعاية الصحية في الحج قاعدة لتعزيز تقديم الخدمات والأساس للتخطيط والإدارة. إجمالاً، تم تعزيز كثافة وتوزيع الموارد الصحية وبعض مجالات الاستعداد للخدمات خلال موسم الحج ١٤٣٨ هـ هناك حاجة للبناء على هذه النتائج الإيجابية لتحسين معايير توزيع الممارسين الصحيين. ومن بين الاحتياجات الإضافية لاستدامة تعزيز النظام الصحي: برامج التدريب المناسبة، تحسين وتطوير البنية التحتية و تطوير نظم الرصد والمراقبة.

Background The Global Center for Mass Gatherings Medicine (GCMGM) conducted the first Service Availability and Readiness Assessment (SARA) of Ministry of Health (MOH) health facilities in the Holy Places (Mina and Arafat) during the 1437 Hajj. The goal of SARA is to assess service availability, readiness, and to conduct data verification in Hajj health facilities for planning and decision making. This report describes the results of 2nd SARA, which was conducted during the 1438Hajj. Methods The assessment was a cross-sectional survey of service availability and the readiness to provide services in MOH health facilities in Mina and Arafat. The survey questionnaire was derived from a standard set of the World Health Organization (WHO) SARA data collection tool, which was modified in line with the Hajj context. Data collection was conducted in August-September 2017. Results The results showed that the majority of health facilities had the required basic amenities and equipment during Hajj. With the adoption of new standards for the distribution of

Health Care Workers, the percentage of core providers (doctors and nurses) increased from 34% in 1437H to 46% in 1438H. Additionally, there was a corresponding 35% reduction in average workload (Number of daily consultations/doctor), in Mina and Arafat. The average time spent with the doctor during outpatient visits in the PHCs increased marginally from 1.35 minutes in 1437H to 2.38 minutes in 1438H. Conclusion This SARA of healthcare facilities in the Hajj serves as a platform for strengthening service delivery and foundation for planning and management. Overall, the density and distribution of health resources and some service readiness domains strengthened during the 1438 Hajj. There is need to build on these gains to improve the standards for allocation of HCWs. Appropriate training programmes, improved infrastructural development and enhanced surveillance systems are additional needs for sustainable health system strengthening

## **Introduction**

The Hajj is among the largest annual religious mass gatherings (MGs) globally. In 2017, 2,352,122 pilgrims, including 1,752,014 international pilgrims, performed the Muslim pilgrimage in Makkah Kingdom of Saudi Arabia (KSA). The main Hajj rituals are performed within 7-8 days in the city of Makkah and the Holy Places (Mina, Muzdalifah and Arafat). However, extended stays in KSA are not uncommon among international pilgrims due to flight delays and other logistics reasons.

A variety of health risks are reported among pilgrims during the MG. The significant elderly Hajj population with the accompanied high chronic diseases burden and the strenuous Hajj rites are principal risk factors for non-communicable diseases (NCDs), heat illnesses, trauma and certain infectious diseases complications among pilgrims. It is not uncommon for critically ill pilgrims needing specialised services to travel from their countries for the Hajj, either to access the free health services provided by KSA authorities or to fulfil the obligatory Islamic religious rites whenever a rare opportunity presents itself once in their life time. Notwithstanding, increased pilgrims morbidity correspondingly accelerates the demand for health services.

The Saudi Ministry of Health (MOH) provides and regulates health service delivery for pilgrims at the Hajj. [1] In 2017, the MOH deployed 29,262 health personnel and provided free health services to all pilgrims through 126 health facilities in the Hajj areas. In addition, private hospitals in Makkah provided healthcare services for pilgrims. However, without appropriate health insurance coverage for international pilgrims, out-of-pocket payment for health services in private hospitals potentially hindered access to care in these facilities. Non-MOH government hospitals, such as National Guard hospital and Security Guard hospital, which operate in the Hajj areas, also provided health services but coverage was limited to their own personnel during the Hajj. Furthermore, around 60% of countries sending pilgrims to the Hajj provide essentially primary healthcare services for their own pilgrims through clinics that are operated by their medical missions [1] Even for these countries, the demand for health services often exceeds the capacity of their medical missions, in terms of access to care and availability of specialised health services. [4] More so, the operations of foreign medical missions are limited to Makkah, since they are not licensed to operate clinics in the Holy Places.

Considering the significant investments in the Hajj health system, periodic health system performance monitoring is warranted. This may involve estimating how health system inputs, such as workforce and infrastructure, interacts with processes to produce output measures, such as accessibility of care and readiness to deliver services. [6, 7] The development of an effective monitoring and evaluation system is vital to achieving this goal. Such a system would



facilitate the detection of health system changes following the implementation of key interventions as prerequisite for measuring progress in health system strengthening. The literature on health system performance monitoring at international MGs is scanty.[8] This is partly because most international MGs, such as the Olympics and FIFA World Cup are quadrennial events that are held in different countries/cities globally and as such the health infrastructure and human resources utilised during an event is either withdrawn or incorporated into the national health system, soon after the event.

In 2 consecutive years (2016 & 2017), the Global Center for Mass Gatherings Medicine (World Health Organization Collaborating Center for Mass Gatherings), MOH Riyadh KSA conducted the service availability and readiness assessment (SARA) of MOH health facilities in Mina and Arafat to generate evidence base for annual health system review and to guide health sector decision making and planning. This paper describes the methods and findings of the 2017 Hajj SARA to highlight health system strengths and gaps and to make recommendations for their improvement.

### **Research aims**

In 2 consecutive years (2016 & 2017), the Global Center for Mass Gatherings Medicine (World Health Organization Collaborating Center for Mass Gatherings), MOH Riyadh KSA conducted the service availability and readiness assessment (SARA) of MOH health facilities in Mina and Arafat to generate evidence base for annual health system review and to guide health sector decision making and planning. This paper describes the methods and findings of the 2017 Hajj SARA to highlight health system strengths and gaps and to make recommendations for their improvement.

### **Research methodology**

#### **Study design**

The SARA was a cross-sectional survey of MOH health facilities in Mina and Arafat. The WHO core SARA instrument was modified based on the Hajj context to exclude mostly the maternal and child health component and to introduce some tracer items for management of common health risks at the Hajj, such as heat illnesses, which were not covered in the original instrument.[9] The modified tool was piloted in one primary health center (PHC) and readjusted accordingly. Field data was collected from all (8) hospitals and about half (55/101) of PHCs from August- September 2017. An assessment team consisting of trained MOH personnel visited each health facility to complete the survey. In each health facility, the team held interviews with the medical director, conducted on-site inspections and reviewed documents/guidelines to complete appropriate sections of the SARA questionnaire. Specific data, such as number of hospitals and PHCs, number of core health workers deployed for Hajj and number of outpatient visits were retrieved from the appropriate MOH databases.

The modified SARA tool consisted of three main domains: the service availability domain described the physical presence of essential components of service delivery, which was measured by the health infrastructure index (facility density and inpatient bed density), health workforce index (core health worker density) and service utilization index (outpatient consultation/doctor). The general service readiness domain described the capacity of the hospitals and PHCs to provide general health services and it was defined by the availability of tracer items for basic amenities and equipment, standard precautions for infection prevention, diagnostic capacity and essential medicines. The service-specific readiness domain described the capacity of hospitals to provide certain specific health services, which were

quantifiable with the aid of tracer items for trained staff, guidelines, selected relevant procedures and specialised diagnostic capacity.

#### Data Analysis

The data was cleaned and entered into the Statistical Package for the Social Science (SPSS) and then analysed using descriptive statistics. The availability and readiness scores and indices were initially calculated based on relevant standard definitions in the original WHO SARA instrument. Then, certain SARA variables were compared with other MOH health service statistical data to explore facility-distinct variations in availability and readiness indices. Relevant graphs and charts were produced in Microsoft Excel.

### Results and discussion

#### Result

The result of the SARA is discussed using three main themes namely Service Availability Index, General Service Readiness Index and Service Specific Readiness Index. Each of these is summarized as follows:

##### Service Availability Index

Generally, the MOH operated 109 health facilities (8 hospitals and 101 PHCs) in the Holy Places during the 2017 Hajj. Thus the facility density (number of health facilities/10,000 population) was slightly less than 1/4 (23.5%) of the expected standard facility density. Based on surface area, the facility density was 6.6 km<sup>2</sup> in Mina and 3.5 km<sup>2</sup> in Arafat. The in-patient bed density (number of in-patient beds/10,000 population) was 28.8% of the expected standard in-patient bed density. In addition, the core health workforce density (number of core health workers/10,000 population) was about half (54%) of the expected standard human resource density (Figure 2). From facility distinct data analysis, the average number of daily out-patient consultation/doctor was 291 in Mina PHCs and 317 in Arafat PHCs (Figures 3 & 4). This translates to an estimated average consultation length (based on a 12 hour shift duty schedule for MOH doctors during Hajj) of 2.47 minutes and 2.27 minutes in Mina and Arafat respectively.

Figure 2: Service availability index in the Holy Places during the 2017 Hajj

Location of facility	Pilgrims population (p)	Number of health facilities (n)	Facility density (d) =n/p X 10,000		Facility density /square kilometer	Number of core health workers (c)		Human resources density (d) =c/p X 10,000		Number of in-patient bed (i)		Inpatient bed density (d) =i/p X 10,000	
			Hajj	WHO standard		Hajj	WHO standard	Hajj	WHO standard	Hajj	WHO standard		
Mina		48			6.6								
Muzdalifah		6											
Arafat		55			3.5								
<b>Total Holy Places</b>	<b>2,300,000</b>	<b>109</b>	<b>0.47</b>	<b>2</b>		<b>2863</b>	<b>12.44</b>	<b>23</b>	<b>1676</b>	<b>7.2</b>	<b>25</b>		

Eight tracer items were assessed to estimate the availability of specialist services. All hospitals had coronary, critical care, medical and surgical units. A fewer proportion of hospitals had haemodialysis (87.5%), orthopaedic (62.5%), burns (50%) and obstetrics and gynaecology (50%).

Figure 3: Number of daily consultations/doctor in MOH PHCs in Mina during 2017 Hajj

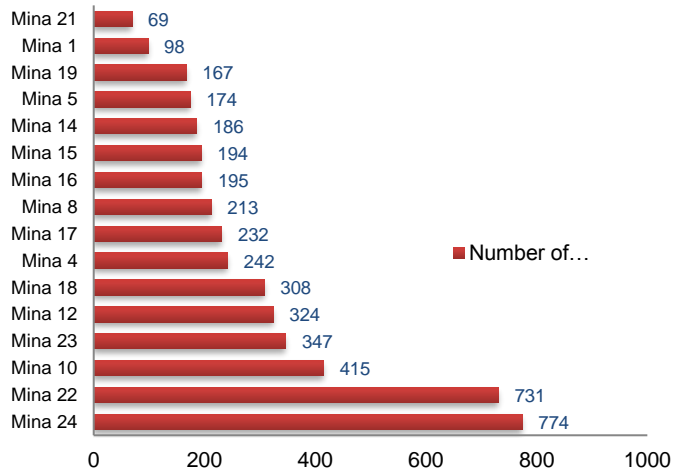
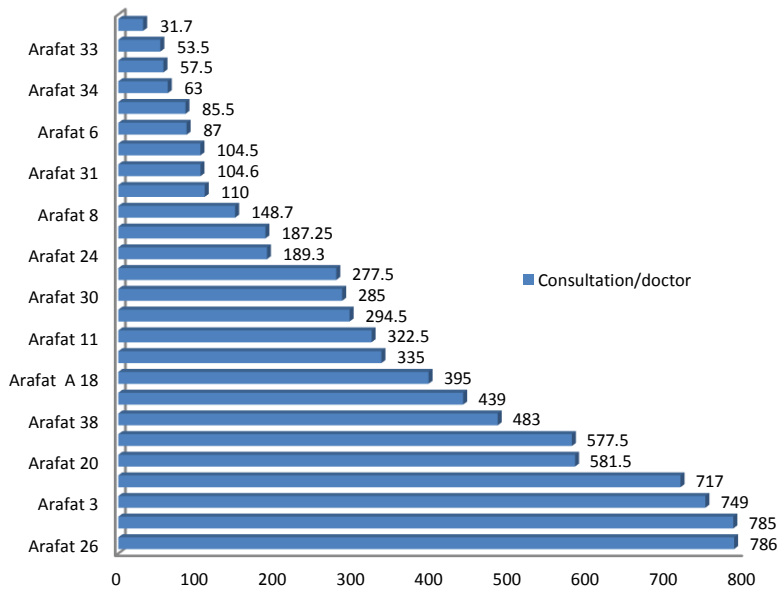


Figure 4: Number of daily consultations/doctor in MOH PHCs in Arafat during 2017 Hajj



### General Service Readiness Indices

The readiness to deliver general health services was estimated from the availability of tracer items for basic amenities, basic equipment, infection control capacity and diagnostic capacity (Figures 5, 6 & 7). Overall, 5 of 7 tracer items for basic amenities were available in all hospitals. However, only 25% of hospitals had consulting rooms with auditory and visual privacy. Fewer PHCs had access to email or internet (43.1%), a functional cellular phone (76.9%) and a functional computer (32.7%). In addition, just over half of PHCs had consulting rooms with auditory and visual privacy (56.1%) and access to ambulance/emergency services (53.1%). The tracer items for basic equipment and infection control capacity were available in all hospitals and nearly all PHCs (96.8% and 97.6% respectively). In the diagnostic capacity

domain, all hospitals had the assessed tracer items, except HIV testing capability which was available in only 25% of hospitals. In comparison, fewer proportions of PHCs had access to haemoglobin assay (50%), HIV testing (48%) and urinalysis (10%).

Figure 5: Proportion (%) of hospitals and PHCs with basic amenities during 2018 Hajj

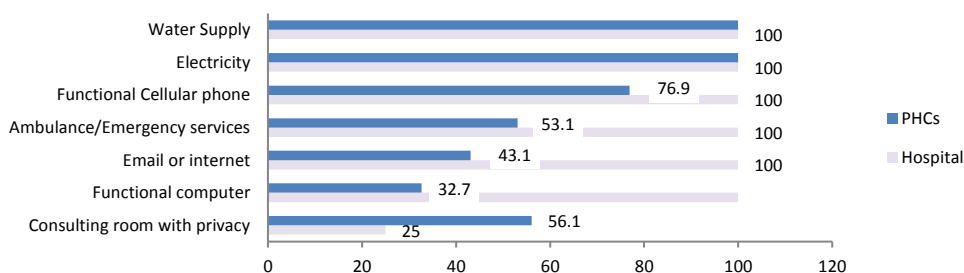


Figure 6: Proportion (%) of hospitals and PHCs with basic equipment during 2018 Hajj

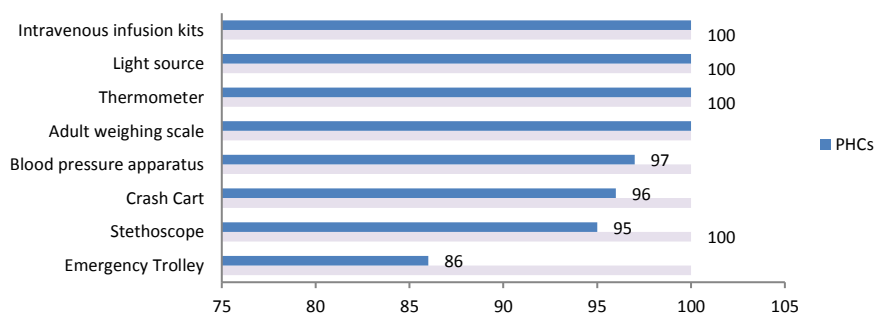
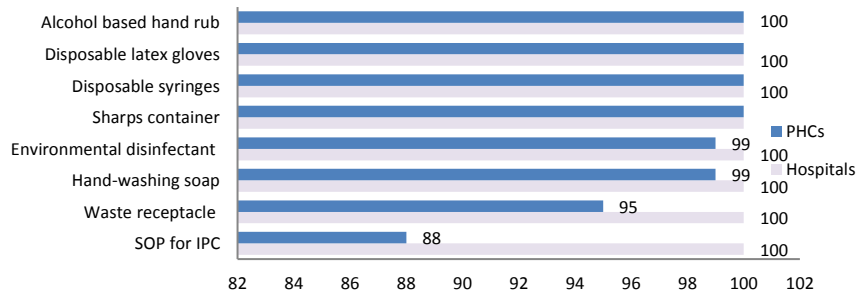


Figure 7: Proportion (%) of hospitals and PHCs with tracer items for infection control during 2018 Hajj



### Service Specific Readiness Indices

The readiness of health facilities to deliver specific services was assessed based on the capacity of hospitals to diagnose and manage eight health conditions that were identified as markers for the common health risks at the Hajj. All hospitals had the capacity to diagnose and manage TB, heat stroke, diabetes, cardiovascular diseases, food poisoning, altered consciousness and acute respiratory illnesses, such as Middle East Respiratory Syndrome (MERS) and Influenza H1N1. However, only half (4 hospitals) could diagnose and manage major trauma. On average, the majority of hospitals had conducted training within the previous 1 year (89.2%) and had guidelines (79.68%) for the diagnosis and management of the health conditions. A significant proportion (62.5%) of hospitals completed appropriate notification forms for TB and the majority could conduct sputum microscopy (100%) and sputum culture (62.5%). However, no hospital had

Xpert/MTB/RIF testing capability. The majority of hospitals had isolation services (100%), fit test and seal checks for HCWs (87.5%) and completed appropriate notification forms (75%) for acute respiratory infections. All hospitals had X-rays and ultrasound scan, but computed tomography (CT) Scan and magnetic resonance imaging (MRI) were available in 75% and 25% of hospitals respectively. The tracer item for heat stroke management procedures (cooling beds) was found in all hospitals during the assessment (Figure 8).

Figure 8: Service specific readiness in 8 MOH hospitals during the 2017 Hajj

Specific Measures	Diagnosis and management (%)	Training in diagnosis and management (%)	Availability of guidelines for diagnosis and management (%)	Procedures/Laboratory capacity availability (%)
TB	100	100	100	<ul style="list-style-type: none"> <li>• Sputum microscopy 100</li> <li>• Sputum culture 25</li> <li>• Xpert/MTB/RIF 0</li> <li>• Notification 62.5</li> </ul>
Heat stroke	100	100	100	<ul style="list-style-type: none"> <li>• Thermometer 100</li> <li>• Serum electrolytes 100</li> <li>• Cooling beds/ 100</li> </ul>
Diabetes	100	N/A	87.5	<ul style="list-style-type: none"> <li>• Fasting blood sugar 87.5</li> <li>• HbA1c 25</li> </ul>
Cardiovascular diseases (hypertension, congestive cardiac failure)	100	87.5	87.5	<ul style="list-style-type: none"> <li>• Troponin and cardiac enzymes 75</li> <li>• Lipid profile 75</li> <li>• ECG 100</li> </ul>
Acute respiratory illnesses like MERS, H1N1,SARS	100	100	87.5	<ul style="list-style-type: none"> <li>• RT-PCR 50</li> <li>• Serology 25</li> <li>• X-ray 100</li> <li>• Isolation services 100</li> <li>• Fit test, seal check 87.5</li> <li>• Notification 75</li> </ul>
Trauma	<ul style="list-style-type: none"> <li>• Major trauma =50</li> <li>• Minor trauma=100</li> </ul>	62.5	75	<ul style="list-style-type: none"> <li>• X-ray 100</li> <li>• Ultrasound Scan 100</li> <li>• CT Scan 75</li> <li>• MRI 12.5</li> </ul>
Food poisoning	100	87.5	100	<ul style="list-style-type: none"> <li>• Stool culture 87.5</li> <li>• Serology for Salmonella 62.5</li> <li>• Notification 75</li> </ul>
Altered level of consciousness	100	87.5	100	<ul style="list-style-type: none"> <li>• Glasgow coma scale 100</li> <li>• Toxicology Screening 37.5</li> <li>• Lumbar puncture 87.5</li> <li>• Medical imaging 87.5</li> </ul>

## Discussions

This survey explores the availability of health services and the readiness of MOH health facilities in Mina and Arafat to deliver these services. The majority of hospitals and PHCs had adequate capacity for general and specific service delivery, but there were significant variation in the patient-to-physician ratio across PHCs.

The assessment showed that standardised SARA indicators potentially have limited application in the Hajj context. For instance, the Hajj health facility density was about one-quarter of the recommended WHO standard health facility density. This implies that the existing number of health facilities (109) in the Holy Places would increase by four-fold to attain the recommended WHO standards. Currently, the average distance between the health facilities is about 150 metres in Mina and 280 metres in Arafat. Thus pilgrims performing their Hajj rites in slow moving crowds are more likely to find the nearest PHC and access care in Mina than in Arafat, despite evidence of a higher health facility density in Arafat (Figure 2). Based on the estimated distance between these Hajj health facilities, the immediate interventions should not necessarily favour the provision of more health facilities; it should seek to address the capacity gaps within the existing health facilities. Given that population-based SARA indicators, such as health facility density, were developed for a far-broad geographically located general population, there is need for the development of appropriate benchmarks that would guide health system monitoring during Hajj, and indeed other mass gatherings.

The patient-to-physician ratio varied significantly across PHCs in Mina and Arafat during the 2017 Hajj. In particular, the health workforce index was 54% of the WHO recommended standards. Due to concerns over the limited application of population-based standards in the Hajj contexts, the utilization of core health workers in PHCs was estimated from the daily outpatient consultations per physician. The assessment showed significant variation in the number of daily consultations per physician in Arafat (31.7-786) and Mina (69-774) PHCs. With an estimated average number of daily consultations per physician of 291 and 371 in Mina and Arafat respectively, correcting the variability in patient-to-physician ratio across PHCs may contribute to balancing the workload, without necessarily impacting on the average workload. By deduction, the estimated average consultation lengths were significantly shorter than the 10-20 minutes consultation lengths that are reported in PHCs in non-mass gatherings settings [10, 11]. The shortened consultation length estimated in this assessment may be attributed to the increased demand for health services at the Hajj. The size of the Hajj population and its significant elderly demography (a proxy for those with chronic diseases), the need for pilgrims with pre-existing health conditions to replace prescription drugs and the increased risks of communicable diseases outbreak and transmission potentially increases the demand for health services during the mass gathering. Regardless, the consequences of a shortened consultation length in outpatient clinics could be similar across settings and include decreased patient satisfaction, congested emergency rooms and non-adherence to treatment [12]. This informs the need for the development of a standard for the deployment of HCWs during Hajj to strengthen the core health workforce capacity and to balance the workload across health facilities during the MG.

The assessment showed that a proportion of the health facilities lacked consulting rooms with auditory and visual privacy. Apparently, the design of these seasonal health facilities hindered the provision of out-patient services in an environment that guaranteed privacy for patients during clinical consultations. Under such circumstances, patients may feel uncomfortable sharing relevant personal information with their doctors or care givers. This may also hinder effective health service delivery, since providers may be wary of conducting appropriate medical examinations, given

the lack of privacy in consulting rooms. Resolving these privacy concerns, although subject to extensive renovation of the infrastructures, could contribute to strengthening the quality of health services within the Hajj health system.

The majority of health facilities had basic and specialised diagnostic services at on-site or off-site locations. The availability of essential diagnostic services in seasonal (temporary) hospitals and PHCs attest to the readiness of MOH health facilities to provide quality services for pilgrims. However, there is need to strengthen certain capacity areas, especially those that address the most common health needs at the Hajj. For instance, there is need to scale-up the proportion of health facilities that manages major trauma, since historical evidence suggests that pilgrims are more vulnerable to trauma from crowd-related incidents and structural failures in these areas. Basic diagnostic services, such as urinalysis, blood sugar and HIV test kits should be provided at the point of care in PHCs to expedite the diagnostic process and case management of specific health conditions and to prevent unwarranted referral of cases to hospitals. It is often rationalized that religious mass gatherings, unlike sporting MGs do not necessarily propagate the spread of sexually transmitted diseases. However, sharing of sharp objects by some pilgrims during the “head shaving” ritual is a potential risk factor for the transmission of HIV and Hepatitis B and C during Hajj. Since it is unlikely that individuals who are infected with HIV during Hajj may test positive with available HIV test kits before the end of the Hajj (window period), provision of HIV testing and care services may be seemingly unjustified. However, pilgrims arriving from HIV/AIDS high prevalent countries, who are living with the disease, may need re-supply of their antiretroviral medications or develop complications that warrant a clinic visit during the pilgrimage. In addition to these reasons for ensuring accessible services, HCWs involved in Hajj should have unfettered access to post exposure prophylaxis for HIV and Hepatitis B, when the need arises. Furthermore, a proportion of pilgrims arrive for the Hajj from TB endemic countries with undiagnosed active TB disease [13]. Currently, Xpert MTB/RIF is the recommended first line TB diagnostic test due to its high sensitivity, quick processing time and rifampicin resistance detection capability[14]. Expedited laboratory processes are particularly needed in the Hajj context due to the wider public health benefits of limiting the spread of pathogens among pilgrims and protecting global health security. Therefore, the MOH ought to provide Xpert MTB/RIF diagnostic services in TB laboratories in the Hajj areas to speed up the TB diagnostic process to promptly detect active TB disease, identify potential multi-drug resistant TB (MDR-TB) cases, and aid the timely implementation of appropriate control measures.

This assessment was conducted in MOH seasonal health facilities in the Holy places. However, health services are also provided by country health missions, private health facilities, and MOH and non-MOH governmental hospitals in Makkah. Thus, the findings of this assessment do not necessarily provide a comprehensive overview of the existing Hajj health service availability and readiness indices. However, the temporal nature of the health facilities where the current assessment was conducted potentially compromise long-term planning and management. Hence, by prioritizing the seasonal health facilities in the initial assessments, an attempt has been made at focusing on one of the most vulnerable areas within the limit of available Hajj resources. Since health services for pilgrims are exclusively provided by the MOH in Mina and Arafat and all pilgrims move from one area to another to perform the rituals simultaneously, the choice of MOH health facilities and the total Hajj population as a proxy for assessing service availability and readiness in the Holy Places is rationalised.

## Summary and conclusion

### Conclusion

This SARA is among the foremost health system assessments for Hajj. The majority of health services were available and most MOH health facilities had the capacity to deliver basic and specialised health services. However, some essential capacity areas, such as health workforce deployment, basic amenities and diagnostic capability require strengthening. The poor applicability of original SARA indicators in the Hajj contexts provides the basis for the development or adoption of new indicators for monitoring the Hajj health systems. Future SARA should be extended to other health facilities, including health missions' clinics to provide holistic evidence and to describe how the differences and similarities that exist might impact on health service delivery at the Hajj. Additionally, there is need for the design of appropriate research studies to explore the relationship between service availability and readiness domain characteristics and the quality of health services within the Hajj health system.

### References

1. Alotaibi, B.M., et al., Strengthening health security at the Hajj mass gatherings: characteristics of the infectious diseases surveillance systems operational during the 2015 Hajj. *J Travel Med*, 2017. **24**(3).
2. Yezli, S., et al., Prevention of meningococcal disease during the Hajj and Umrah mass gatherings: past and current measures and future prospects. *International Journal of Infectious Diseases*, 2016. **47**: p. 71-78.
3. Memish, Z.A., et al., Hajj: infectious disease surveillance and control. *The Lancet*, 2014. **383**(9934): p. 2073-2082.
4. Ministry of Health, 1437 Hajj Strategic health risk assessment report. 2016.
5. Ministry of Health, Statistical yearbook 1437. 2017: Riyadh.
6. Murray, C.J. and J. Frenk, A WHO framework for health system performance assessment.
7. World Health Organization, Service availability and readiness assessment (SARA): an annual monitoring system for service delivery: implementation guide. 2015.
8. Chang, W.-H., et al., Mass gathering emergency medicine: a review of the Taiwan experience of long-distance swimming across Sun-Moon Lake. *International Journal of Gerontology*, 2010. **4**(2): p. 53-68.
9. World Health Organization, Service Availability and Readiness Assessment (SARA): an annual monitoring system for service delivery: Reference manual. 2013.
10. Deveugele, M., et al., Consultation length in general practice: cross sectional study in six European countries. *BMJ*, 2002. **325**(7362): p. 472.
11. Yarnall, K.S., et al., Primary care: is there enough time for prevention? *American journal of public health*, 2003. **93**(4): p. 635-641.
12. Dugdale, D.C., R. Epstein, and S.Z. Pantilat, Time and the patient–physician relationship. *Journal of general internal medicine*, 1999. **14**(S1): p. 34-40.
13. Yezli, S., et al., Undiagnosed Active Pulmonary Tuberculosis among Pilgrims during the 2015 Hajj Mass Gathering: A Prospective Cross-sectional Study. *The American journal of tropical medicine and hygiene*, 2017. **97**(5): p. 1304-1309.
14. World Health Organization, WHO Compendium of TB Guidelines and Associated Standards. 2017: Geneva.



# Assessment of the risks of landslides in Thawr Mountain in Makkah by measuring slope stability factors and geographic information system

Fathy Shaaban, Turki Habeebullah, Safwat Gabr, Waleed El-Saud, Essam Morsi, Abd Allah Ghoram Allah  
Institute of the Custodian of the Two Holy Mosques for Hajj and Umrah Research - Umm Al Qura University

## تقييم مخاطر الإنهيارات الصخرية بجبل ثور بمكة المكرمة بقياس عوامل استقرار المنحدرات ونظم المعلومات الجغرافية

فتحي شعبان، تركي حبيب الله، صفوت جبر، وليد أبو السعود، عصام مرسى، عبد الله غرم الله  
معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة، جامعة أم القرى

### ملخص البحث (Abstract):

عدم استقرار الميول هي المشكلة الأكثر خطورة في مناطق التلال والجبال بالمملكة العربية السعودية. مدينة مكة المكرمة هي واحدة من هذه المناطق حيث تحتوي العديد من المناطق الحضرية التي تحيط بها بالجبال. ويمكن رؤية أنواع مختلفة من عدم الاستقرار في المنحدرات في هذه المنطقة التي تشمل الانتشار الجانبي، والإسقاط، والزحف، والانهيارات الأرضية، والانزلاقات الأرضية. جبل ثور هو من الأماكن التي يقصدها الحجاج في موسم الحج والعمرة، يزوره تقريبا ما يقارب من ٢٠٠٠ زائر يوميا، ويقع جنوب مكة المكرمة على بعد ٤ كم، بين سهل وادي المفجر شرقاً وبطحاء قريش غرباً، ويشرف الجبل على حي الهجرة، ويصعد إليه الحجاج لرؤية غار الثور الذي اختبأ فيه الرسول عليه الصلاة والسلام مع أبي بكر الصديق أثناء الهجرة إلى المدينة المنورة، وجبل ثور هو جبل له قاعدة مستديرة الشكل وله قمم جبلية مدببة ترتفع من قاعدته الدائرية وعددها عشرة. يرتفع جبل ثور عن مستوى سطح البحر نحو ٧٥٤ متراً. يعد جبل ثور أحد المناطق التي تهدد الانهيارات الصخرية به على الطرق والمناطق المحيطة به. يستخدم الآلاف من الزوار والجولات السياحية طريق الجرف لزيارة غار ثور الذي يقع في الجزء العلوي من جبل ثور، بالإضافة إلى المناطق الحضرية المحيطة بالجبل والتي يزداد انتشارها على مدى السنوات الأخيرة، والتي تعاني من سقوط الصخور المتكرر في الغالب في موسم الأمطار، وزيادة شدة الانحدار للمنحدرات على طول الوجوه المختلفة للجبل يجعل هذه المناطق عرضة للمخاطر بسبب عوامل مختلفة مثل التجوية والتآكل وتأثير الإنسان. وقد تمت هذه الدراسة لتحديد مدى استقرار جرف جبل ثور، من خلال تحديد المناطق غير المستقرة، وتطبيق المحاكاة الصخرية وخاصة الاستشعار عن بعد، دراسة ميدانية ومحاكاة بالكمبيوتر ثنائية الأبعاد باستخدام برامج قياس درجة استقرار الميول والكتل الصخرية.

تم تحديد المناطق غير المستقرة المختلفة على طول طريق جبل ثور والجسور باستخدام القياسات الحقلية والاستشعار عن بعد على أساس تحليل الصور. بالإضافة إلى تحليل محاكاة الصخور أشار إلى إمكانية حدوث انهيارات صخرية في عدة مناطق على جانبي الطريق الصاعد إلى غار ثور والتي سيكون لها تأثير على السياح، أيضا بعض المناطق من الجبل المطل على المواقع الحضرية المأهولة بالسكان. تم اقتراح عدة تدابير وقائية مناسبة للحد من مخاطر الصخور المتساقطة قبل الوصول إلى المناطق الحضرية والطريق الصاعد أيضا.

الكلمات الدالة: الإنهيارات الصخرية، جبل ثور، مكة، استقرار المنحدرات.

Slopes instability is the most serious problem in the mountain and hills of Saudi Arabia. The city of Makkah is one of these areas where many of the urban areas are surrounded by mountains. Various types of instability can be seen in the slopes of this area which include lateral landslide, rotational landslide, creep and rockfalls.

Jabal Thawr is one of the places frequented by pilgrims in the Hajj season, it is visited by almost 2,000 visitors a day. It is located 4 km south of Makkah, between Wadi Mufajar east and Qurish in the west. The mountain overlooks Al-Hijra, and pilgrims climb to see the cave where the Prophet Mohamed and Abu Bakr al-Siddiq were hidden inside, during the migration to Medina. Mount Thawr is a mountain with a round base shape and has ten raised mountain peaks, it rises from sea level to about 754 meters. Mount Thawr is one of the areas where rockfalls threaten the roads and surrounding areas. Thousands of visitors and tours use the Cliff Road to visit Thawr cave, which is located at the top of Mount Thawr, in addition to the mountainous urban areas that have been increasing over recent years and which suffer frequent rockfalls in the rainy season. Increasing the slope intensity of the different faces of the mountain makes these areas susceptible to hazards due to various factors such as weathering, erosion and human impact.

This study was carried out to determine the stability of the Thawr mountain, by identifying unstable areas, applying rock simulation and remote sensing, field study and computer simulations using two dimensional measurement programs slopes and rocks stability.

Using field measurements and remote sensing based on image analysis, in addition to the analysis of rock instability, various unstable areas were identified along the mountain specially the ascending track that will have an impact on tourists, also some areas of the mountain overlooking the urban sites inhabited. Several appropriate preventive procedures have been proposed to reduce the risk of falling rocks before reaching urban areas and the rising road as well.

**Key words; Rockfalls, Makkah, Thawr mountain, slope stability.**

## **1. Introduction:**

The common phenomenon that can affect separated homes, long roads, entire villages, railways and other human facilities is the rockfalls. These structures are at risk of rocks in or near the base of steep rock slopes. Rockfalls is a fast block movement produced by rocks that separate from a slope and fall free and slope. Because of their high speeds and unpredictability, such events can cause injuries, even with small rock volumes less than 1 m<sup>3</sup> (Gigli et al., 2014; Volkwein et al., 2011). Most often, the risk of rocks can not be eliminated because of their frequency and magnitude, which differ on the temporal and spatial level. The main difference in the fall of rocks from the phenomena of other unstable slopes is the high movement of falling rocks (Frattini et al., 2008). Reducing the risk of rock resonance by the absence of high-accuracy geological data on mileage, rock removal, soil engineering and rock path. (Dorren, 2003).

The rock risk assessments reliability depends on the quantity and quality of available data (Pradhan et al., 2014). Rock hazards are usually estimated by a two-dimensional or three-dimensional emulation (Fanos and Pradhan, 2016), which assesses the paths of rocks, velocities, kinetic energy and bounce height of the falling masses. Simulated models emulate the imitation of rock movements, and calculate motion displacement based on Newton's second law while ignoring air friction (Bradhan and Venus, 2017b). Some of these models explicitly include the rolling movements of rocks (Lan et al., 2007). However, the study of rock impact assessment (rock interaction with topography during serial communication) remains a major scientific challenge in rock modeling (Matas et al., 2017).

Slope instability is the most serious hazard in mountainous and mountainous areas in Saudi Arabia. The city of Makkah is one of these areas where there are many urban areas surrounded by mountains. Various types of slope instability can be observed in this area, which include lateral propagation, projection, crawling, rotational landslides, sequential landslides and rocks (Youssef et al., 2009, 2012). Among these different types of landslides, rocks are one of the most important geological hazards in this region. Fewer studies have been conducted to investigate them along the city of Makkah. Thawr Mountain is one of the most attractive mountains in the Makkah city. It comprises a Thawr cave at the top and is a tourist site for religious pilgrimage. Attracts thousands of tourists and visitors every year from all over the Islamic world. Thawr Mountain became an urban area and urban areas expanded to reach the toes and over the gentle slope of the mountain. Most rocks occur along the mountainside because of an ongoing process of weathering which ultimately deteriorates the strength of the rock mass and opens the joints and fractures.

Rockfalls are a kind of slippery (small slide), where unsupported rock blocks are separated from the surface of the cliff and located freely under the influence of gravity. These rock blocks can be separated by different mechanisms such as natural mechanisms such as freezing and melting cycles (McCarroll et al., 1998; Matsuoka and Sakai, 1999); seismic activities (Bull et al., 1994; Viderih et al., 2001; Abebe et al., 2010) or human activities along cliffs and mountain regions by blasting, the movement of a heavy drilling machine (Dorren, 2003; Vijayakumar et al., 2011) and more importantly by slow deformation depends on the slope material time.

This study was carried out to evaluate the impact of falling rocks on urban areas and to assess the risk for travelers traveling through the Thawr ascending route to the top of the mountain. This area has recently experienced different types of rocks that have caused many problems. In the present study, two main objectives were analyzed: (1) the stability of Mount Thawr; (2) the causes of the rocks, hazards, and simulations of Mount Thawr were investigated in relation to the surrounding urban areas and the Thor Path. Extensive field investigations have been used to determine the stability of the mountains and to determine the location of critical unstable zones. The risk of rock collapse was determined by field and rock simulation. Therefore, the development of a complex mountain topography model has become a major challenge because of the complex process that can increase the calculation time. In general, 2D rock simulation is preferred.

The current research proposes a methodology aimed at determining the precise terrain of the slopes and the three-dimensional positions of the important features (eg, current protection measures, risk elements, etc.). In addition, it aims to identify the dimensions and shapes of rocks and major rock source areas. Several studies have already addressed some of these topics, using either light detection and range (LiDAR) or pictorial data (Abellán et al., 2010; Ferrero and Umili, 2011; Ferrero et al., 2011; Gigli et al., 2014). Although many studies have been conducted on rock risk assessment, information on impact sites in the literature has not been discussed. However, the impact site is the most important factor in assessing the risk of rock collapse and the design of mitigation processes. Moreover, the time component of existing studies has not been considered, although it is an essential component of early warning processes. Some researchers used a two-dimensional modeling approach to modeling rock movement (Keskin, 2013; Papathanassiou et al., 2013).

## 2. Study area and geological setting:

### 2.1. Location:

The study area is located in Makkah province (Fig. 1) in Makkah city. Thawr Mountain is located to the northeast of Al-Haram mosque, it has altitude of 757 m above the sea level, many urban areas are located near Thawr Mountain from all directions. Rainfall usually take place during the wet season from November through January, according to the metrological station located about 7 km southeast of the study area, and operated by the custodian of the two holy mosques research institute of hajj and omrah. Most of the rainfall is relatively short duration for few hours. The average annual precipitation is reported as about 75 mm/year. The peak monsoon seasons fall between July and October.

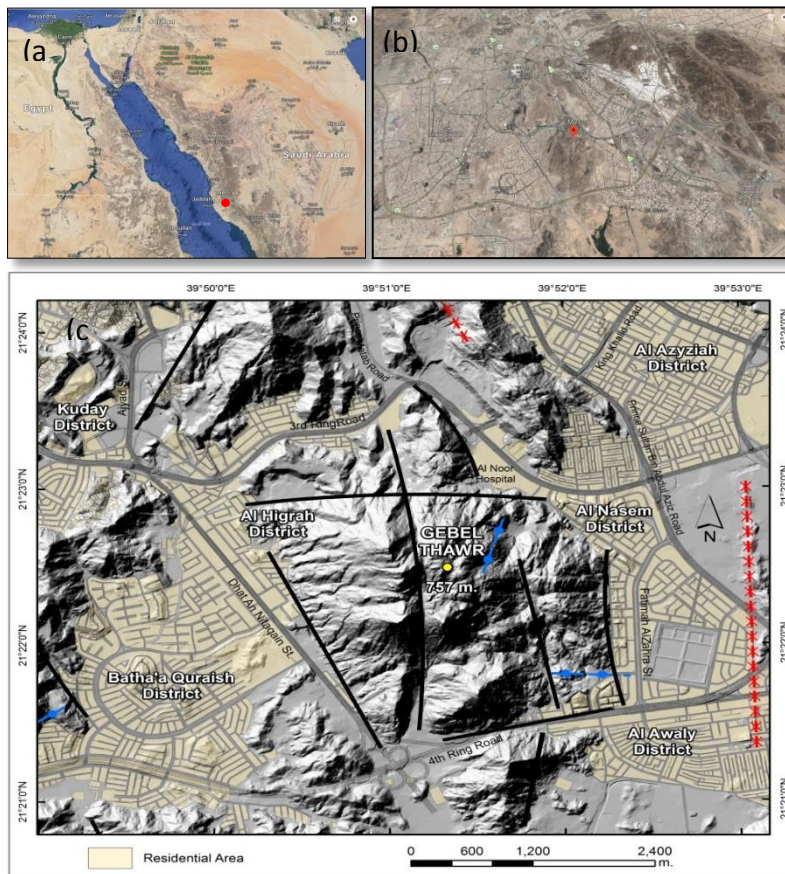


Fig.(1): (a) Location of Thawr Mountain in Saudi Arabia, (b) Thawr Mountain location in relation to Al-Haram Mosque, (c) Hillshade map prepared from the DEM showing the topography and main structural elements affecting Gabal Thawr area.

### 2.2. Geology:

Geology of Gabal Thawr is related to the Ju'ranah complex (kutg) (Moore and Al-Rehaili, 1989). It is composed of tonalite and subordinate granodiorite. It has a sharp steep intrusive rocks and composed mainly of medium to coarse-grained hornblende tonalite. The mineral composition showed that the hornblende tonalite is composed of plagioclase, quartz, and hornblende, and minor amounts of k-feldspar, biotite, epidote, chloride, sphene, apatite, and iron oxide (Makkah Quadrangle sheet 21 D)-GM-107c) (Moore and Al-Rehaili,1989). Other geologic units are present

surrounding Thawr mountain which includes alluvial fan deposits (Qu), eolian sand (Qe), alluvial, elluvial, eolian deposits (Qu), gabbro (gb), gabbro–diorite (gd), microgranite (gmb), granite (gr), complex diorite–gabbro (mdg), diorite to quartz diorite (mdq), intrusive rocks (xam), metagabbro–gabbro (xgb) and zibarah group (zm). Different types of structures are encountered in the study area. These structures include some normal faults that run perpendicular to the Red Sea. The area follows these structures in an elongation shape. Other types of structures such as linear trend lines are dissected in the study area. The trends of these linear lines are ENE–WSW (Fig. 2). Most of the exfoliation and main joint trends were measured in the field and they have same linear trends. In the Makkah quadrangle which include the study area is characterized by two main trends of structures including north–northeast, to northeast and north–northwest. The first trend is related to Precambrian phases of deformation, whereas the second main trend reflect faulting, fracturing, and shearing that associated with the Red Sea rifting. The northwesterly faults are older and they are mostly normal faults that dip steeply to the southwest. The northeasterly trending faults displace the northwesterly faults. Other fault trend which is north facing is characterized by sheared faults that displace the northeasterly faults. In addition, the youngest plutons have an elongated form, mainly foliated, sheared, and faulting (Moore and Al-Rehaili, 1989). In addition, the contact between Ju'ranah complex and other surrounding rocks are sheared.

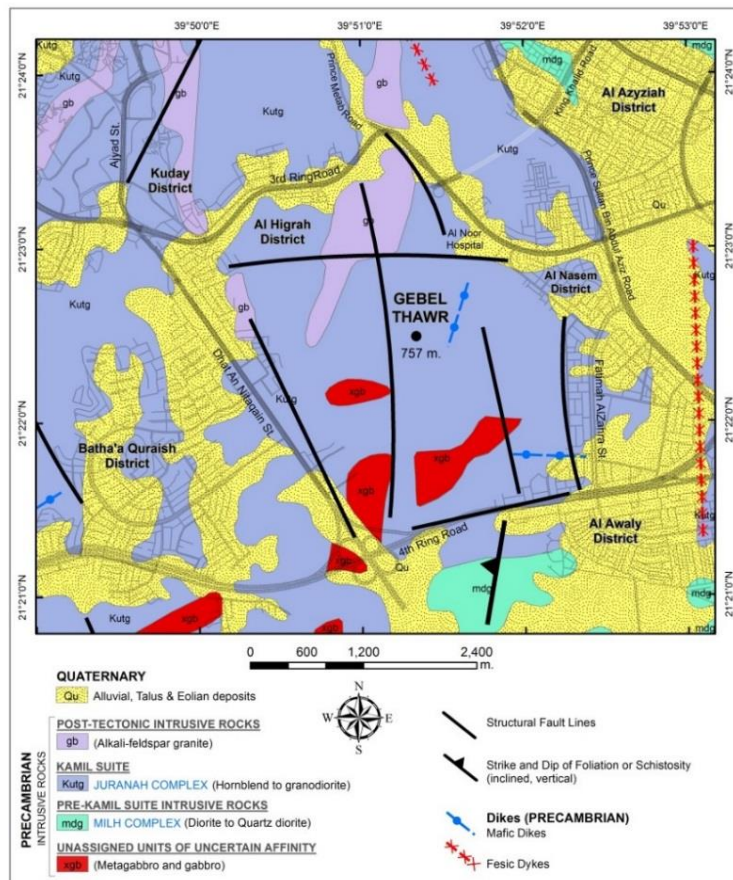


Fig.(2): Geology and structural map of Thawr Mountain and its surrounding areas.

### 2.3. Engineering geology of the Thawr Mountain;

The engineering geology characteristics of the study area were studied corresponding to field and laboratory investigations. Detailed field investigation have been done to determine the rock mass characteristics and determine the main areas that are lying down to the rockfalls. Whereas the laboratory investigation was done in order to determine the mechanical properties of the rocks (ISRM et al., 2007) (Table 1).

Table (1): Geotechnical properties of different rocks at Thawr mountain.

Property	Massive Tonalite	Grey Granite Weathered	Exfoliation Grey Granite	Cap Rocks
Deformation	No	Moderate	Moderate	High
Joints	3 joints + random	3 joints	Main one joints	Highly jointed
Average joint spacing	0.62 m	0.4 m	0.1 m	0.25 m
Weathering degree	Fresh – Slightly	Highly – Completely	Slightly – Moderately	Moderately
Persistence	10–25 m	8 m	20–30 m	10–20 m
Aperture	2–40 mm	-	20–100 mm	40–200 mm
Density (Mg/m <sup>3</sup> )	2.4	1.8	2.1	2.3
UCS MPa	200	3–10	10–35	50–100

Rock mass characteristics of Thawr Mountain is composed of tonalite and subordinate granodiorite. It has a sharp, steep, intrusive rocks, composed mainly of medium to coarse-grained hornblende tonalite. The mineral composition showed that the hornblende tonalite is composed of plagioclase, quartz, and hornblende, and minor amounts of k-feldspar, biotite, epidote, chloride, sphene, apatite, and iron oxide. The grey granite older ones are moderately to completely weathered, exfoliation characteristics appear in the grey granite weathered rocks (Fig.7). Three types of rocks were investigated in the study area including massive granite, weathered granite, exfoliated granite, and upper deformed rocks (Fig.8).

### 3. Materials and methodology:

Landslides in Makkah is a complex process since they are strictly controlled by variety of factors such as, geology, geomorphology, hydrology, the weathering processes, the recent changes in land cover and land use, etc., which have great influences at different sites in the study area. The hillslopes in the study area are originally composed of massive basement plutons to foliated metamorphic rocks. The formation of secondary structures (faults, joints, etc.) have resulted in the development of blocks and fragments of different dimensions. The detachment of these materials from the hillslopes depends on the degree of weathering, the slope angle, roundness of boulders, which is not uniform even on a single hillslope, etc. The exfoliation from granitic hillslopes is one of the main factors responsible for the development of massive rounded boulder, which may measure up to several meters in diameter. These exfoliation-boulders are the most susceptible for rockfall. Several hillslopes have very clean and smooth curved surfaces as being stripped off these boulders, which are now packed at the foot slopes. Therefore, loose boulders upslope of now steep and smooth surfaces could result in some hazard if no longer stable on these critical slopes.

The identification of potential zone for landslide hazards at Gabal Thawr requires the integration of multiple datasets including recent satellite images, DEM, geological data and detailed fieldwork. The rock-cut slopes can easily be observed using satellite images, as the spectral reflectance of the excavated rocks is markedly higher than non-excavated outcrops. Another mean of its identification is the shadow formed from the resulted artificial cliffs and the change detection using a time series of satellite images (Figure 3).



Fig.(3): Satellite images acquired in 2011 and 2018 showing the locations of rock cutting and land filling activities to the northeast of Gabal Thawr.

Using satellite images alone is not a reliable process since we cannot measure both the slope direction and amount. For this purpose, the use of Digital Elevation Models (DEMs) is a must (Figure 4) to produce both the aspect and slope maps of the area. The ArcGIS 10.6 software has been used to process the DEM of Gabal Thawr area, which has been acquired from the SRTM satellite mission (1 arc.sec).

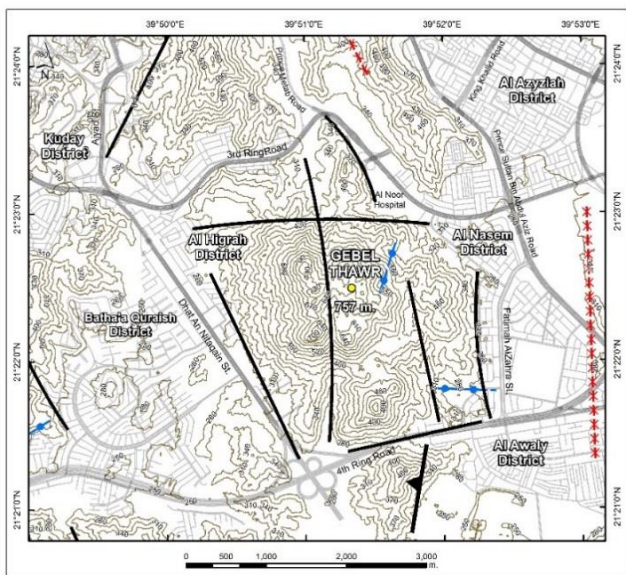


Fig.(4): Elevation contour map prepared from the DEM showing the topography and main structural elements affecting Gabal Thawr area.

The Aspect map is simply a map with 10 slope direction classes (Figure 5) ranging from flat surface to N-, NE-, E-, SE-, S-, SW-, W-, NW-, dipping surfaces. From Figure 5, we can easily see that the dominant slope trends in Gabal Thawr are N, S, E, and W. These main slope trends can easily be attributed to the N-S and E-W trending faults in the area, with the sloping surfaces represent the inclined fault blocks. It is worthy to notice that the increase of slope degrees (250- 340 ) towards the north and west banks of the mountain, this increases the likelihood of instability of the slopes and increase the chance of falling rocks, especially in the rainy seasons with the lack of friction between unstable rocks and the slope surface.

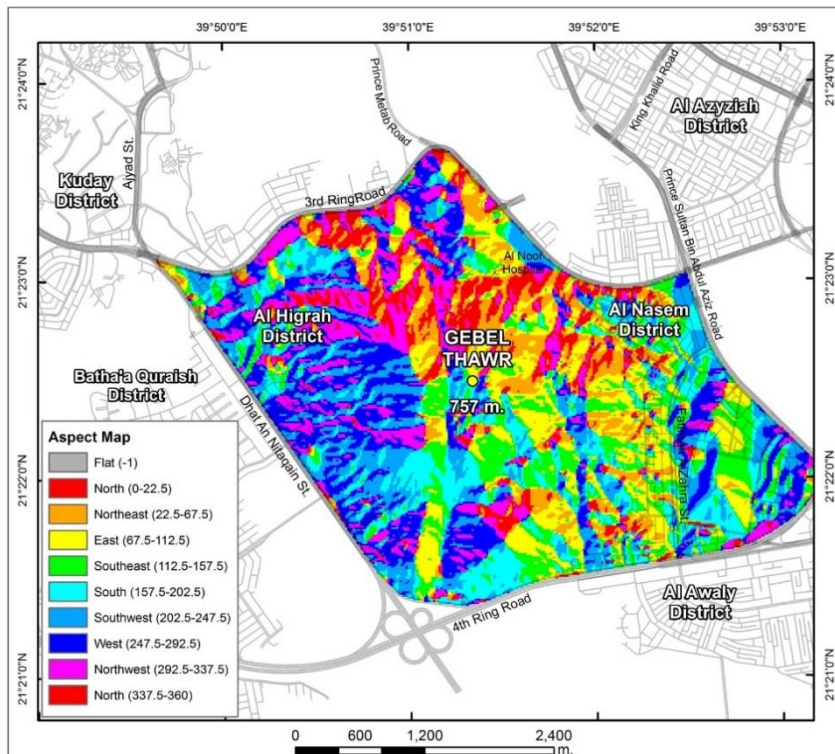


Fig.(5): Aspect map of Gabal Thawr area.

The slope map (Figure 6), on the other hand, showing the angle of which, the surface is dipping from the horizontal, where the value of 0 represents a perfectly flat horizontal surface and 90 represent a vertical surface.

It is important to say that the recent large-scale rock cutting in the area has affected the stability of the up slopes of Gabal Thawr, especially at areas dissected by incised channels and fluvial terraces now hanging on top of the artificial cuts. Therefore, it is necessary to estimate the potential runoff of given rainfall events for these particular hillslopes, in order to determine the potential landslides of detritus sediments and the embedded rock boulders.

It is so clear that the human modification of hillslopes for creating new plans suitable for urban development has affected the rock stability in certain areas. Furthermore, the dumping sites for waste rock fills are now widespread and their build in low-laying areas have also induced significant changes in the landforms of Makkah. These morphological changes may complicate the geo-environmental problems such as, blocking of drainage channels and altering runoff



flows of occasional flash floods and hence adversely affect the designated areas. Duping of loose marials on top of the mountains for ground leveling may result in the washout of the rock fragments during heavy rain events.

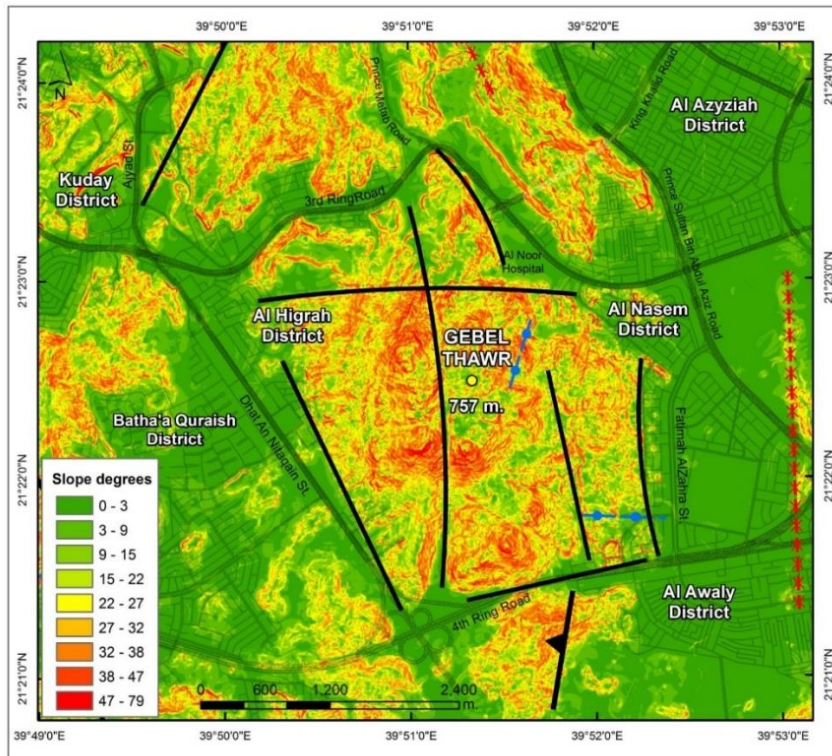


Fig.(6): A slope map of Gabal Thawr area.

#### 4. Results and discussion:

A detailed field investigation was carried out along Gabal Thawr. For this purpose, multiple field trips were performed in the study area and most unstable areas were determined along the extension of the ascending road to the Thawr cave at the topmost. It was observed that the major rockfalls problems occurred in different sides of the mountain and different unstable areas were determined along the Thawr escarpment road (track road) (Figs. 7&8). This escarpment track was used by tourists and visitors to reach the upper portion of the Thawr Mountain. However, based on the field investigation, four unsettled locations were identified and were used to apply the rockfall simulation. On the other hand, Satellite images acquired in 2011 and 2018 showing the locations of rock cutting and land filling activities to the northeast of Gabal Thawr, these human activates having a negative impact on the stability of the slopes of Mount Thawr because they generate small seismic waves during the work of machines in the rock cutting, which in turn works to increase and widen the cracks or lead to direct rock fall.

The GEO5 2018 slope stability software was used to examine the stability of some regions on the ascending road escarpment as represented in figures 9&10, the slope stability values resulting from the two cases was 0.6 and 1.12 respectively theses values are less than 1.5 which represent the safe slope stability factor.

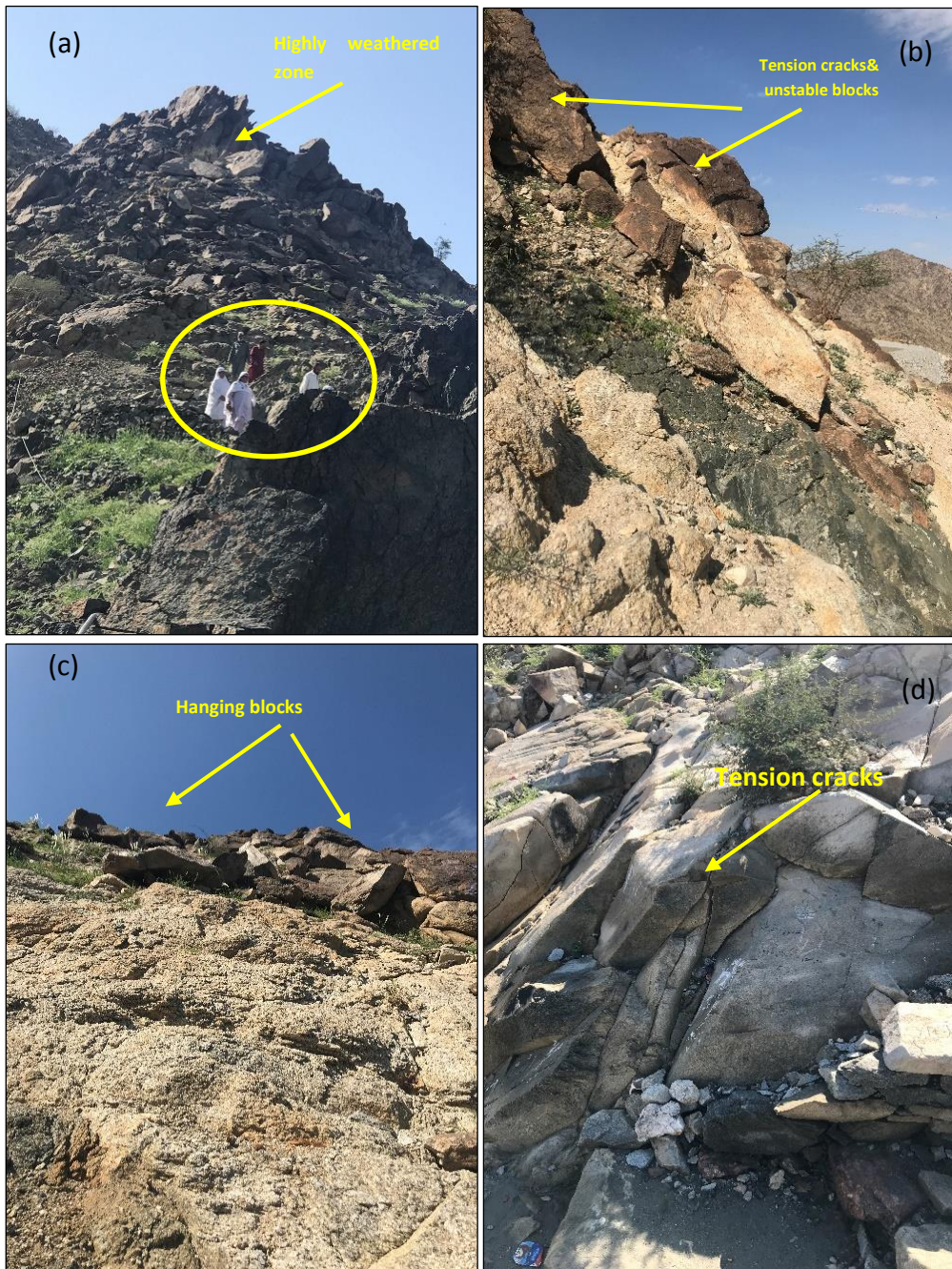


Fig (7): Field photographs show (a) highly weathered granodiorite (b) unstable blocks and tension cracks structure at the road side (c) steep fracture planes at the road side, (d) small hanging blocks.



Fig.(8): Field photographs show (a) highly weathered granodiorite (b) unstable blocks and tension cracks structure at the road side (c) steep fracture planes at the road side, (d) small hanging blocks.

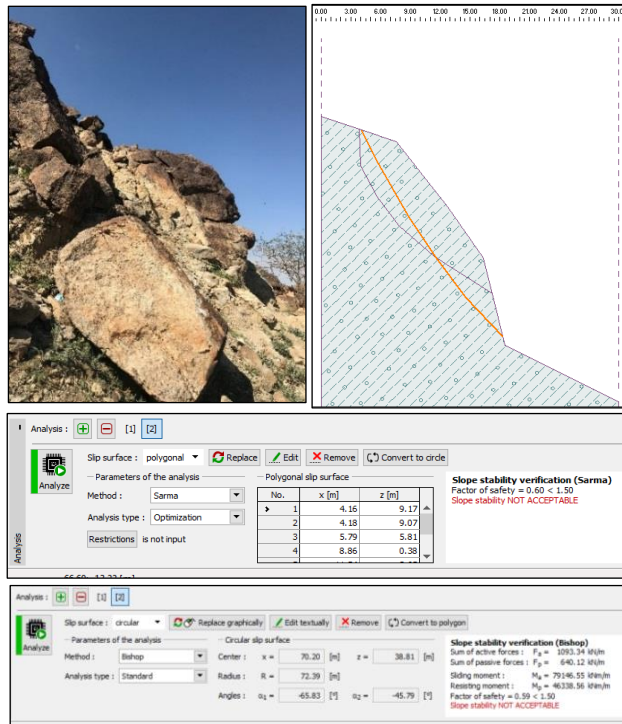


Fig.(9): An illustrative example for the study of slope stability at a part of the ascending road of Mount Thawr.

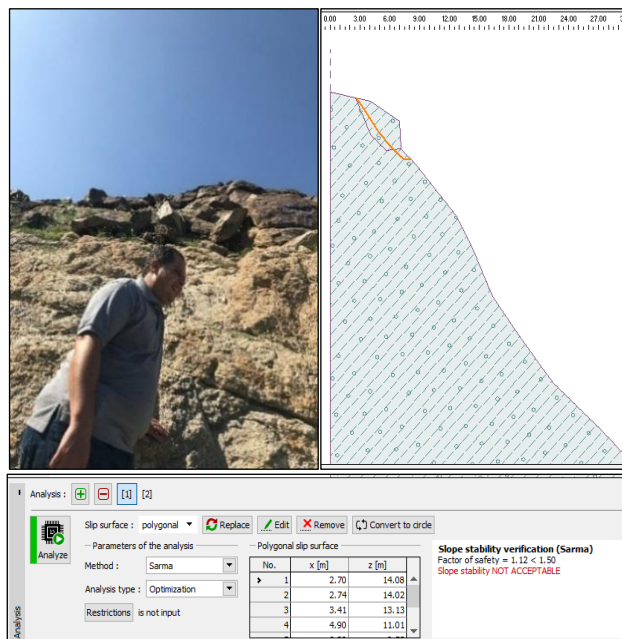


Fig.(10): An illustrative example for the study of slope stability at a part of the ascending road of Mount Thawr.

## 5. Conclusion and recommendation:

The identification of potential zone for landslide hazards at Gabal Thawr requires the integration of multiple datasets including recent satellite images, DEM, geological data and detailed fieldwork. It obtained that the increase of slope degrees (250- 340) towards the north and west banks of the mountain, this increases the likelihood of instability of the slopes and increase the chance of falling rocks, especially in the rainy seasons with the lack of friction between unstable rocks and the slope surface.

In addition to, the recent large-scale rock cutting in the area has affected the stability of the up slopes of Gabal Thawr, especially at areas dissected by incised channels and fluvial terraces now hanging on top of the artificial cuts. examine the stability of some regions on the ascending road escarpment as represented in figures 9&10, the slope stability values resulting from the two cases was 0.6 and 1.12 respectively these values are less than 1.5 which represent the safe slope stability factor.

### The researchers recommend that:

- Removal of the unstable rock masses on both sides of the ascending road at Mount Thawr which visitors use to climb up to visit the Thawr Cave,
- Fixing the sides that suffer from the accumulation of large rocks fragments on both sides of the ascending road.
- To stop the activities of rock cutting at the foot of the mountain.
- Detailed study required for the whole mountain specially the areas overlooking residential neighborhoods.
- This study should also be applied to the mountain areas surrounding the holy places.

### References:

- Abebe, B., Dramis, F., Fubelli, G., Umer, M., Asrat, M., 2010. Landslides in the Ethiopian highlands and the Ansari, M.K., Ahmad, M., Rajesh, Singh., Singh, T.N., 2012. Rockfall assessment near Saptashrungi Gad temple Nashik, Maharashtra, India. *Int. J. Disaster Risk Reduct.* 2, 77–83.
- Basson, F.R.P., 2012. Rigid body dynamics for rock fall trajectory simulation. *ARMA*, 12–267.
- Bull, W.B., King, J., Kong, F.C., Moutoux, T., Phillips, W.M., 1994. Lichen dating of coseismic landslide hazards in alpine mountains. *Geomorphology* 10 (1), 53–64. case study. *Chin. J. Rock Mech. Eng.* 3 (21), 3700–3708.
- Dorren, L.K., 2003. A review of rockfall mechanics and modelling approaches. *Prog. Phys. Geogr.* 27 (1), 69–87.
- Dorren, L.K.A., Berger, F., Putters, U.S., 2006. Real-size experiments and 3-D simulation of rockfall on forested and non-forested slopes. *Nat. Hazards Earth Syst. Sci.* 6 (1), 145–153.
- Fanos, A.M., Pradhan, B., Aziz, A.A., Jebur, M.N., Park, H.J., 2016. Assessment of ultiscenario rockfall hazard based on mechanical parameters using high-resolution airborne laser scanning data and GIS in a tropical area. *Environ. Earth Sci.* 75 (15), 1129.
- Frattini, P., Crosta, G., Carrara, A., Agliardi, F., 2008. Assessment of rockfall susceptibility by integrating statistical and physically-based approaches. *Geomorphology* 94 (3–4), 419–437.
- Gigli, G., Morelli, S., Fornera, S., Casagli, N., 2014. Terrestrial laser scanner and geomechanical surveys for the rapid evaluation of rock fall susceptibility scenarios. *Landslides* 11 (1), 1–14.
- Matas, G., Lantada, N., Corominas, J., Gili, J.A., Ruiz-Carulla, R., Prades, A., 2017. RockGIS: a GIS-based model for the analysis of fragmentation in rockfalls. *Landslides* 14 (5), 1565–1578.
- Matsuoka, N., Sakai, H., 1999. Rockfall activity from an alpine cliff during thawing periods. *Geomorphology* 28 (3), 309–328.

- McCarroll, D., Shakesby, R.A., Matthews, J.A., 1998. Spatial and temporal patterns of
- Pradhan, B., Abokharima, M.H., Jebur, M.N., Tehrany, M.S., 2014. Land subsidence susceptibility mapping at Kinta Valley (Malaysia) using the evidential belief function model in GIS. *Nat. Hazards* 73 (2), 1019–1042.
- Vijayakumar, S., Yacoub, T., Curran, J.H., 2011. On the effect of rock size and shape in rockfall analyses. In: *Proceedings of the US Rock Mechanics Symposium (ARMA) San Francisco CA, USA*.
- Volkwein, A., Schellenberg, K., Labiouse, V., Agliardi, F., Berger, F., Bourrier, F., Dorren, L.K.A., Gerber, W., Jaboyedo, M., 2011. Rockfall characterisation and structural protection - a review. *Nat. Hazards Earth Syst. Sci.* 11 (9), 2617–2651.
- Youssef, A.M., Maerz, H.N., Al-Otaibi, A.A., 2012. Stability of rock slopes along Raidah escarpment road, Asir Area, Kingdom of Saudi Arabia. *J. Geogr. Geol.* 4 (2), 23. <<http://dx.doi.org/10.5539/jgg.v4n2p48>>.
- Youssef, A.M., Maerz, N.H., Hassan, A.M., 2009. Remote sensing applications to geological problems in Egypt: case study, slope instability investigation, Sharm El-Sheikh/Ras-Nasrani Area, Southern Sinai. *Landslides* 6 (4), 353–360. <http://dx.doi.org/10.1007/s10346-009-0158-3>.
- Youssef, A.M., Pradhan, B., Tarabees, E., 2011. Integrated evaluation of urban development suitability based on remote sensing and GIS techniques: contribution from the analytic hierarchy. *Arab. J. Geosci.* 4 (3–4). <http://dx.doi.org/10.1007/s12517-009-0118-1>.
- ISRM, Ulusay, R., Hudson, J.A., 2007. *The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974–2006*. Kozan, Ankara.

# Prevalence and Determinants of Influenza-like illness among Pilgrims in Makkah, during Hajj Season 1439 H

Hassan Kasim Haridi<sup>(1)</sup>, Ibrahim Hussein Abd EL-Rahim<sup>(2)</sup>, Tariq Al-Malki<sup>(3)</sup>, Nadir Hamza Metair<sup>(4)</sup>, Arwa Al-Malki Atiah<sup>(5)</sup>

<sup>(1)</sup> General Directorate of Health Affairs, Hail Region

<sup>(2)</sup> The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University

<sup>(3)</sup> Preventive Medicine Saudi Board resident, Makkah

<sup>(4)</sup> Directorate of Health Affairs, Makkah

<sup>(5)</sup> Physician under training

## معدل انتشار متلازمة الاعراض التنفسية الشبيهة بالانفلونزا والعوامل المرتبطة بها بين الحجاج بمكة المكرمة خلال موسم الحج ١٤٣٩ هـ

حسن قاسم هريدي<sup>(١)</sup>، ابراهيم حسين عبد الرحيم<sup>(٢)</sup>، طارق عطية المالكي<sup>(٣)</sup>، نادر بن حمزة مطير<sup>(٤)</sup>، أروى عطية المالكي<sup>(٥)</sup>  
<sup>(١)</sup> المديرية العامة للشئون الصحية بمنطقة حائل  
<sup>(٢)</sup> معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة والزيارة - جامعة أم القرى  
<sup>(٣)</sup> البرنامج المشترك لطب المجتمع بمكة المكرمة  
<sup>(٤)</sup> مديرية الشئون الصحية بمكة المكرمة  
<sup>(٥)</sup> طبيبة تحت التدريب

### ملخص البحث (Abstract):

خلفية الدراسة: تعد الأمراض المعدية خلال موسم الحج قضية بالغة الأهمية بسبب الازدحام الشديد. وتمثل عدوى الجهاز التنفسي السبب الأكثر شيوعاً للتنويم بالمستشفيات. تعتبر متلازمة الأعراض المشابهة للانفلونزا تشخيصاً طبياً محتملاً لمرض الإنفلونزا أو غيرها من الأمراض التي تتشارك في مجموعة من الأعراض الشائعة.

أهداف الدراسة: التعرف على معدل انتشار متلازمة الاعراض التنفسية الشبيهة بالانفلونزا بين الحجاج بمكة المكرمة خلال موسم الحج ١٤٣٩ هـ، ومدى ارتباطها بمجموعة من عوامل الخطورة، ودور لقاح الأنفلونزا في الحماية.

منهجية الدراسة: هي دراسة مقطعية مسحية تم إجراؤها على عينة من الحجاج البالغين القادمين لمكة المكرمة موسم حج عام ١٤٣٩ هـ. نتائج الدراسة: تم إجراء ٥٩٩ مقابلة ناجحة، منها ٥٤١ للقادمين من خارج المملكة بنسبة ٩٠,٣%، كان متوسط عمر المشاركين 40.7±8.37 عاماً، وشكلت الإناث (٢٣١) ٣٨,٦٪. بلغ عدد من أفادوا بالإصابة بأعراض متلازمة الأعراض الشبيهة بالانفلونزا ١٠١ مصاباً بنسبة ١٧,٦%، وكانت نسبة الإصابة بين المطعمين بلقاح الأنفلونزا منهم حوالي ٣,٢٪ مقارنة بنسبة ٨٦% بين غير المطعمين، وتبين وجود ارتباطاً قوياً بين الإصابة وعدم تلقي لقاح الأنفلونزا (الاختطار النسبي (RR=9.04; 95% CI 6.89-11.89): وفرق اختطار (RD%=80.55; 95% CI 72.26-88.83). ووجد أن الذكور، والعمر أقل من ٣٠ عاماً، وذوي التعليم المنخفض، وكثرة أداء العمرة، والحجاج القادمين من خارج المملكة بصفة عامة، وحجاج جنوب آسيا وأفريقيا بصفة خاصة، وضعف المعرفة بمرض الإنفلونزا ولقاحه، عوامل اختطار أخرى مرتبطة بالإصابة بالأعراض الشبيهة بالإنفلونزا. وبين تحليل الانحدار اللوجستي متعدد المتغيرات وجود ارتباط مستقل بين الإصابة بمتلازمة الأعراض الشبيهة بالانفلونزا وبين الذكور من الحجاج، والأصغر سناً ممن تقل أعمارهم عن ٣٠ عاماً، والأقل تعليماً، والحجاج القادمين من خارج المملكة العربية السعودية.

الخلاصة: كانت نسبة المصابين بمتلازمة الأعراض الشبيهة بالإنفلونزا بين الحجاج غير المطعمين بلقاح الأنفلونزا عالية، وتبين أن تلقي اللقاح كان إجراءً وقائياً فعالاً خلال موسم الحج ١٤٣٩ هـ.

الكلمات الدالة: متلازمة الأعراض الشبيهة بالإنفلونزا، لقاح الأنفلونزا، الحج، عوامل الخطورة،

**Background:** Infectious diseases during the Hajj are critical issue due to the extreme congestion of people. Respiratory infections are the most common cause of hospital admissions. Influenza-like illness (ILI), also known as acute respiratory infection (ARI) and flu-like syndrome/symptoms, is a medical diagnosis of possible influenza or other illness causing a set of common symptoms.

**Objectives:** To assess prevalence and risk factors of Influenza-like illness among adult pilgrims in Makkah and the role of influenza vaccine in prevention.

**Methods:** This work was a cross-sectional survey carried out on a conventional sample of adult pilgrims during Hajj season 1439 H.

**Results:** Overall, 599 successful interviews were completed, of them 541 (90.3%) were coming from outside Saudi Arabia. The mean age (SD) of the participants was 40.7 (8.37). Females (231) constituted 38.6%. Overall, 101 (17.6%) of participants self-reported having Influenza-like illness. About 3.2% of the vaccinated and 86.0% of the unvaccinated reported having the Influenza like illness during their stay for Hajj 1439 H. A strong association between getting Influenza-like illness and not receiving influenza vaccine ((Relative risk (RR)=9.04; [95% CI: 6.89-11.89]; Risk Difference (RD%)=80.55; 95% CI: 72.26- 88.83)). Other factors associated with getting influenza-like illness were: younger age, male gender, low education, frequently done Umrah, pilgrims from outside KSA, pilgrims coming from south Asia and Africa and participants with poor knowledgeable about influenza disease and vaccine. Multivariate logistic regression analysis revealed that, male gender, younger pilgrims under 30 years, less educated (illiterates or primary school graduated), pilgrims coming from outside KSA, were independently associated with self-reporting sustaining Influenza-like illness among pilgrims.

**Conclusion:** Self-reported influenza-like illness was high among influenza unvaccinated. Influenza vaccine appears to be an effective preventive measure during 1439 Hajj season.

**Key Words:** Influenza-like illness (ILI); influenza Vaccine; Hajj; Risk Factors

## Introduction

Infectious diseases during the Hajj are critical issue due to the extreme congestion of people. Crowding in tents, sharing domestic facilities, moving and staying in buses for long period, fatigue and the extreme climatic conditions are important factors for transmitting air- and droplet-borne infections. It has been estimated that 1 in 3 pilgrims experience respiratory symptoms. [1] Respiratory tract infections (RTIs) are the most common cause of hospital admissions. [2,3] Several transmissible pathogens are responsible for respiratory infections; viral infections been reported to cause the majority [4] and by far influenza viruses are the most common. [1,5] Influenza-like illness (ILI), also known as flu-like syndrome/symptoms, is a medical diagnosis of possible influenza or other illness causing a set of common symptoms. This clinical syndrome not easily distinguished influenza from other respiratory infections. WHO defined ILI as an acute respiratory infection with: measured fever of  $\geq 38\text{ C}^\circ$ ; and cough; with onset within the last 10 days. [6,7] Preventive strategies, e.g., vaccination and respiratory hygiene, need to be enhanced, and antiviral influenza prophylaxis should be considered. The role of the influenza vaccine has been established in reducing mortality and morbidity of influenza. [8] Both inactivated and live attenuated vaccine prevented about 70% of cases of laboratory-confirmed symptomatic



influenza in healthy adults. [9] Studies showed a low rate of influenza among vaccinated pilgrims compared to an unvaccinated. [10-14]

Epidemiologic studies in Hajj seasons targeting respiratory infections are crucial for monitoring trends, evaluation of preventive measures and planning for next seasons.

### **Research aims**

The present study aimed to:

- (1) Assess prevalence of Influenza-like illness among pilgrims;
- (2) Explore risk factors of getting infection and to
- (3) Evaluate the role of influenza vaccine in prevention.

### **Research methodology**

#### **Study design and participants**

This work was a cross-sectional interview survey carried out on a conventional sample of adult pilgrims during Hajj season 1439 H. Pilgrims, during their stay in Makkah, after embarking on the religious pilgrimage during the period 1-20/12/1439 H., were asked to participate in the study. Those who agreed to participate were interviewed after explanation of the study objective and taking a verbal consent. Participants were recruited randomly from those who were available at hotel lobbies around and near Haram after prayers in the day time, with inclusion criteria of being adult man or woman from any nationality and present for Hajj.

#### **Data collection tool**

Upon inclusion, the participants were interviewed by two investigators (male and female) using a standardized questionnaire that collected information on demographics, influenza vaccination status, history of current or past attack with influenza-like illness during their stay in Makkah. Operationally, ILI was defined for participants as having been sick with fever and cough during Hajj period. Those who reported receiving the seasonal influenza vaccine before coming to Hajj by at least two weeks were considered as having valid vaccination. Statistical analysis Differences in the proportions were tested by Pearson's chi-square, or Fisher's exact tests when appropriate. All statistical tests were two-sided. Percentages and odds ratio (OR) with 95% confidence interval (CI) estimations and comparisons were carried out. Associations between variables, Relative risk (RR), Risk Difference (RD%) and its 95% CI were done. Univariate followed by multivariate logistic regression analysis were carried out to capture independent predictor factors associated with the outcome variable of interest. Statistical analysis was undertaken using Epi Info 7.1.3 (CDC, Atlanta, GA, USA). A p value of  $\leq 0.05$  was considered significant.

#### **Ethical consideration**

The study was done under collaborative umbrella of Saudi Community Board of Postgraduate studies, the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University, and Directorate of Health Affairs, Ministry of Health, Makkah. The study was performed in accordance with the Declaration of Helsinki and its amendments. All participants provided oral informed consent.

## Results and discussion

### Results

Overall, 599 successful interviews were completed, of them 541 (90.3%) were coming from outside Saudi Arabia. The mean age (SD) of the participants in our sample was 40.7 (8.37) distributed as 6.5, 36.6, 29.2 and 14.7 percentages for the age groups <30, 30-39, 40-49 and ≥50 years respectively. Females (231) constituted 38.6%. More than sixty percent (61.4%) of the participants were university educated. Participants belongs to Arab countries, southeast Asia, south Asia, Africa and western countries were 10.5, 60.8, 9.9, 3.2 and 16.5% respectively. Thirty-six percent of the participants frequently attended Umrah during their stay in Makkah. Overall, 101 (17.6%) of participants self-reported having Influenza-like illness. About eighty percent (79.3%) of the participants reported a valid influenza vaccination before coming to Hajj (Table 1). Among adult pilgrims (Table 2), the highest prevalence of ILI was reported by younger age <30 years (40.1%) compared to older age groups (28.8%, 8.7% and 6.8% for age groups 30-39 years, 40-49 years and ≥50 years respectively); male gender (21.8%) compared to female (10.5%); lower education than secondary school (82.9%) compared to highly educated pilgrims (12.8% and 5.9% for secondary school and university educated respectively); those who frequently attended Umrah more than once (30.0%) compared to others (11.5%); pilgrims coming from south Asia (90.7%) and Africa (84.2%) compared to those who were coming from southeast Asia (4.9%), western countries (6.1%) and Arab countries (32.4%); pilgrims assessed as having low knowledge score about influenza disease and vaccine (14.6%) compared to those with better score (6.5%); and among influenza unvaccinated participants (86.0%) compared to vaccinated (3.2%) (Figure 1).

A strong association between sustaining Influenza-like illness and not receiving influenza vaccine ((Relative risk (RR)=9.04; [95% CI: 6.89-11.89]; Risk Difference (RD%)=80.55; 95% CI: 72.26- 88.83)) (not shown in tables). Applying adjusted multivariate logistic regression analysis, controlling for other predictor variables and potential confounders (Table 3), younger age <40 years (OR 2.7, 95% CI=1.14-6.23); male gender (OR 4.3, 95% CI=1.46-12.66), less than secondary education schooling (OR 4.1, 95% CI=1.35-12.50); domestic pilgrims (OR 6.2, 95% CI=1.38-27.69); and influenza unvaccinated (OR 165.9, 95% CI=53.13-518.01) were found to be independently associated with the participants' self-reported influenza like illness. The coefficient of determination R<sup>2</sup> of linear correlation that measured the strength and the direction of a linear relationship between participants' self-reported influenza-like illness and other predictor variables in the model was 0.70, which means that 70% of the total variation in the self-reported influenza like illness among participants can be explained by these predictor variables in the model (not shown in tables).

### Discussion

Acute respiratory infections among pilgrims during Hajj season has a special concern, being the most prevalent infections, with higher rates of hospital admissions and mortalities. Influenza viral infections is by far is the most common and leading to a serious complication especially among vulnerable population like elderly and those with chronic medical conditions and immunocompromised. Influenza-like illness is a proxy for influenza prevalence. Among efforts of contentious monitoring of health condition of pilgrims as well as the effectiveness of the preventive measures in every Hajj season, this study aimed to assess prevalence of influenza-like illness among pilgrims, risk factors for getting infection and the role of influenza vaccine in protection.

An average attack rate 17.6% of self-reported influenza-like illness among study population in Hajj period was estimated and revealed wide variation among pilgrims. The attack rate was at lowest (4.9% and 6.1%) among southeast Asian and western countries respectively; higher than average among Arab countries pilgrims (32.4%) and the highest reported rates were among south Asian (90.7%) and African pilgrims (84.2%). This variation could be explained by disparities in socio-demographic, behavioral factors and influenza vaccine uptake. Engaging in recommended protective behaviors (hand hygiene, wearing a face mask, cough etiquette, social distancing, and contact avoidance) proved effective preventive measures at to reduce the risk of respiratory illness during Hajj. [15] The higher prevalence (84.2%) of ILI reported among African pilgrims in our study was consistent with the outcomes of similar studies like the study carried out by Annan et al. in 2013, who found that 77.6% of pilgrims returning to Ghana suffered from respiratory symptoms. [16] The comparatively lower rates (32.4%) of ILI among Arab pilgrims compared to Africans and south Asians pilgrims in the present study was comparable to others studies. Refaey et al. reported that 30% of Egyptian pilgrims returning from Hajj during 2012-2015 met the case definition for influenza-like illness (ILI). [17]

Our study revealed that the highest rates of ILI were independently associated with younger age, male gender, low education, being a domestic pilgrims and unvaccinated against influenza. This higher rate of ILI in youngest age were also reported in other community-based studies [11,18] This can be explained that youngsters are more active, so that have more contact with crowding and exposure to infections. They are additionally, relies on their natural immunity compared to older age groups who are more compliant to receive influenza vaccination and minimize their exposure to infections.

Male pilgrims in our study, reported a higher rate of ILI. Male pilgrims are more active than females and have the responsibility to care others, and they also tend to frequently perform Umrah than females. This by itself can explain the higher rates of ILI among males. Other studies indicate that in general males develop respiratory tract infections more frequently than females [19], explained by anatomic, lifestyle, behavioral between males and females. The role of sex hormones in the regulation of the immune system may also contribute to the reported sex differences in the incidence and severity of the various types of RTIs, especially in adolescents and adults. [19] Frequent performance of Umrah among pilgrims was an independent factors associated with ILI. This apparently, demands more movement in crowding allowing more chance of exposure to infections in general and RTIs in particular.

The highly educated participant pilgrims among the study participants, independently reported less ILI attacks. The highly educated persons of course, may have better knowledge, more compliant with respiratory etiquettes and practicing other recommended protective measures and tend to minimize their exposure to infections. Domestic pilgrims were independently reported more ILI compared to abroad pilgrims, which can be explained in part by exposure to a variants of imported infections not circulating in their local environment. Domestic pilgrims, like other pilgrims from middle east countries are less likely to use of face masks compared to Hajj pilgrims from other areas. [20] Use of surgical face mask proved effective in reducing ILI. In a randomized controlled trial to assess the effectiveness of facemasks use at Hajj, based on developing syndromic ILI, surgical mask proved effective in intervention group compared to control group incidence 31% versus 53%,  $p= 0.04$ ) in a randomized controlled trial carried out by Barasheed et al. [21]. Our results, strongly suggest, that influenza vaccination gives marked protection against ILI. Not being vaccinated was the greatest independent predictor of reporting an ILI among participant's pilgrims. This result is

consistent with other studies. [10-14] In a systematic review with meta-analysis carried out by Alfelali, 2015, [22] used raw and published data from eleven Hajj seasons between 2005 and 2014, involving pilgrims from multiple countries. The data from both sources were synthesized to estimate the relative risk (RR) of acquisition of ILI in vaccinated versus unvaccinated pilgrims. The prevalence of ILI decreased among Hajj pilgrims as the vaccine coverage increased over the last decade (RR 0.2,  $P < 0.01$ ), suggesting the beneficence of influenza vaccine for Hajj pilgrims. A study conducted on 32370 Iranian pilgrims to determine influenza vaccine's efficacy, the incidence of illness among influenza vaccinated was about 56% and compared to 72% among unvaccinated; the difference was significant ( $P < 0.001$ ), with OR = 0.50 and  $(1 - OD) = 0.50$ ; indicating 50% efficacy and was efficient in reducing the cases of ILI. [13]

### Study Limitations

The findings in this report are subject to some limitations. First, all results are based upon self-report, and neither illness nor vaccination status were validated with medical records; not all ILI are influenza, and respondents might not have accurately reported which vaccine(s) they received. Second, selection bias might have resulted from the unbalanced sample participants according their country and demographic criteria compared to characteristics of the actual Hajj population.

### Summary and conclusion

Self-reported influenza-like illness was high among influenza unvaccinated patients. The very low attack rate among influenza vaccinated pilgrims, indicates, first, a higher percentage of influenza virus infections among pilgrims compared to other infections causing influenza-like illness. Second, influenza vaccine strains appears to be comparable to the circulating strains among pilgrims in this season.

### Recommendations

1. To ensure compliance, the recommended influenza vaccination for pilgrims should be a mandatory requirement.
2. Health education campaigns for prevention of respiratory infections targeting pilgrims emphasizing on the importance of utilization of surgical mask and adherence to respiratory hygiene.

Table 1: Participants' background information (n=599).

Characteristic	% (n) or Mean SD
<b>Age in years</b>	
- <30	6.5 (39)
- 30-39	36.6 (219)
- 40-49	29.2 (253)
- ≥50	14.7 (88)
Mean (SD)	40.7 (8.37)
<b>Gender</b>	
- Male	61.4 (368)
- Female	38.6 (231)
<b>Level of Education</b>	
- Less than higher school	14.5 (87)
- Higher school	22.2 (133)
- University	63.2 (378)
<b>Omra/Hajj Frequency</b>	
- 1-2	64.0 (383)

- 3+	36.0 (215)
<b>Coming from</b>	
- Domestic	9.7 (58)
- Abroad	90.3 (90.3)
<b>Nationalities</b>	
- Arab	10.5 (63)
- Southeast Asia	60.8 (364)
- South Asia	9.0 (54)
- Africa	3.2 (19)
- Western	16.5 (99)
<b>Past History of Flu vaccination</b>	
- Unvaccinated	8.9 (53)
- Vaccinated	91.1 (545)
<b>Influenza vaccine validated</b>	
-Unvaccinated	20.7 (142)
-Vaccinated	79.3 (475)
<b>Attacked with Flu-Like Illness during Hajj (n=598)</b>	
-Yes	17.6 (101)
-No	82.4 (472)
<b>Knowledge score* about influenza disease and vaccine</b>	
-Up to 5 point	41.4 (223)
-6-8	58.6 (315)
Mean Score (SD)	5.7 (1.29)

\*Score with maximum 8 points.

Table 2: Factors associated with Flu-Like Illness among Pilgrims in Makkah, 1439 H. (n=599).

Characteristic	% (n) or Mean SD	Flu Like Illness		p-value
		Yes	No	
<b>Age in years</b>				
- <30	6.5 (39)	40.0 (14)	60.0 (21)	$\chi^2= 50.53, df=3$
- 30-39	36.6 (219)	28.8 (60)	71.2 (128)	
- ≥40-49	29.2 (253)	8.7 (21)	91.3 (221)	
- ≥50	14.7 (88)	6.8 (6)	93.2 (82)	
<b>Gender</b>				
- Male	61.4 (368)	21.8 (79)	78.2 (284)	$\chi^2=11.68, df=1$
- Female	38.6 (231)	10.5 (22)	89.5 (188)	
<b>Level of Education</b>				
- Less than secondary school	14.5 (87)	82.9 (63)	17.1 (13)	$\chi^2= 259.59, df=2$
- Secondary school	22.2 (133)	12.8 (16)	87.2 (109)	
- University/higher	63.2 (378)	5.9 (22)	94.1 (349)	
<b>Omra Frequency</b>				
- ≤1	64.0 (383)	11.5 (44)	88.5 (338)	$\chi^2= 29.81, df=1$
- ≥1	36.0 (215)	30.0 (57)	70.0 (133)	
<b>Coming from</b>				
				P=0.516

- Domestic	9.7 (58)	21.9 (7)	78.1 (25)	$\chi^2= 0.42, df=1$
- Abroad	90.3 (90.3)	17.4 (94)	82.6 (447)	
<b>Nationalities</b>				P<0.001
- Arab	10.5 (63)	32.4 (12)	67.6 (25)	$\chi^2= 311.85, df=4$
- Southeast Asia	60.8 (364)	4.9 (18)	95.1 (346)	
- South Asia	9.0 (54)	90.7 (49)	9.3 (5)	
- Africa	3.2 (19)	84.2 (16)	15.8 (3)	
- Western	16.5 (99)	6.1 (6)	93.9 (93)	
<b>Influenza vaccine validated</b>				P<0.001
- Unvaccinated	20.7 (142)	86.0 (86)	14.0 (14)	$\chi^2= 390.05, df=1$
- Vaccinated	79.3 (475)	3.2 (15)	96.8 (458)	
<b>Knowledge score* about influenza disease and vaccine</b>				P=0.002
- <5 point	41.4 (223)	14.6 (30)	85.4 (175)	$\chi^2=9.20, df=1$
- 6-8 points	58.6 (315)	6.5 (20)	93.5 (287)	

\*A score with maximum 8 points

Table 3: Adjusted Multivariate Logistic regression analyses for demographic and other potential factors associated flu-like illness among pilgrims during Hajj season, Makkah, 1439 H.

Term	aOR	95% CI	Coefficient	S. E.	Z-Statistic	P-Value
- Age (<40/1_40+)	2.7	1.14-6.23	0.981	0.43	2.269	0.023
- Gender (Male/Female)	4.3	1.46-12.66	1.459	0.55	2.651	0.008
- Education (< Secondary school/ Higher)	4.1	1.35-12.50	1.411	0.57	2.482	0.013
- Coming From (Domestic/Abroad)	6.2	1.38-27.69	1.822	0.77	2.383	0.017
- Influenza vaccination (No/Yes)	165.9	53.13-518.01	5.111	0.58	8.798	<0.001
CONSTANT	*		-6.394	1.05	-6.104	<0.001

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval;  
Final -2\*Log-Likelihood: 190.63; Likelihood Ratio: 342.66; Model P-Value: <0.001.

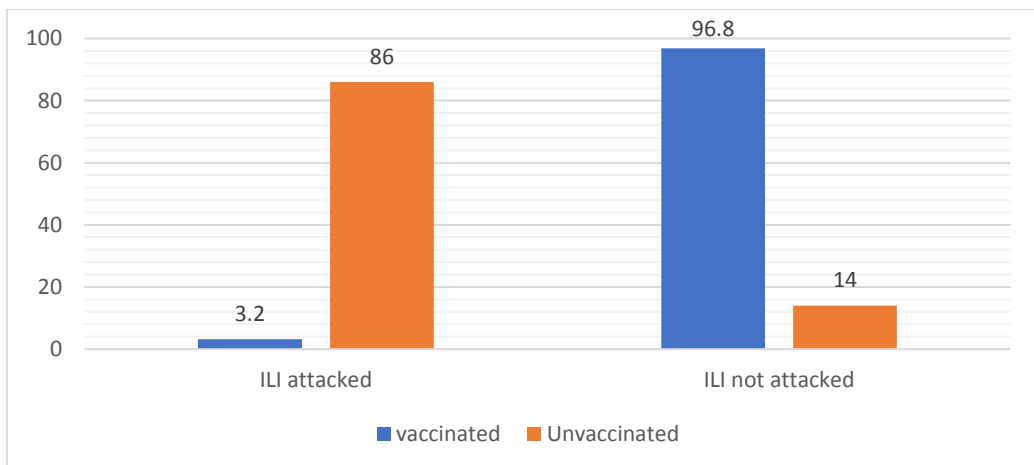


Figure 1: Attack rate of Influenza-Like Illness (ILI) among influenza vaccinated and unvaccinated Pilgrims

## References:

- [1] Balkhy HH, Memish ZA, Bafaqeer S, Almuneef MA. Influenza a common viral infection among Hajj pilgrims: Time for routine surveillance and vaccination. *J Travel Med.* 2004;11:82–6.
- [2] Alzeer A. Respiratory tract infection during Hajj. *Ann Thorac Med.* 2009 Apr-Jun; 4(2): 50–53. doi: [10.4103/1817-1737.49412]
- [3] Al-Ghamdi SM, Akbar HO, Qari YA, Fathaldin OA, Al-Rashed RS. Pattern of admission to hospitals during Muslim pilgrimage (Hajj). *Saudi Med J.* 2003, vol. 24 (pg. 1073-6)
- [4] Al-Tawfiq JA, Zumla A, Memish ZA. Respiratory tract infections during the annual Hajj: potential risks and mitigation strategies. *Curr Opin Pulm Med.* 2013, vol. 19 (pg. 192-7)
- [5] Rashid H, Shafi S, Booy R, El Bashir H, Ali K, Zambon MC, et al. Influenza and respiratory syncytial virus infections in British Hajj pilgrims. *Emerg Health Threats J.* 2008;1:e2.
- [6] WHO. Case definitions for influenza surveillance. Available at: [http://www.who.int/influenza/surveillance\\_monitoring/ili\\_sari\\_surveillance\\_case\\_definition/en/](http://www.who.int/influenza/surveillance_monitoring/ili_sari_surveillance_case_definition/en/). (Accessed 24/11/2018).
- [7] Fitzner J, Qasmieh S, Mounts A, Alexander B, Besselaar T, Briand S, et al. Revision of clinical case definitions: influenza-like illness and severe acute respiratory infection. *Bull World Health Organ* 2018;96:122–128 | doi: <http://dx.doi.org/10.2471/BLT.17.194514>.
- [8] Nichol KL, Nordin J, Mullooly J, Lask R, Fillbrandt K, Iwane M. Influenza vaccination and reduction in hospitalizations for cardiac disease and stroke among the elderly. *N Engl J Med.* 2003;348:1322–32.
- [9] Ohmit SE, Victor JC, Rotthoff JR, Teich ER, Truscon RK, Baum LL, et al. Prevention of antigenically drifted influenza by inactivated and live attenuated vaccines. *N Engl J Med.* 2006;355:2513–22.
- [10] Rashid H, Shafi S, Haworth E, El Bashir H, Memish ZA, Sudhanva M, et al. Viral respiratory infections at the Hajj: Comparison between UK and Saudi pilgrims. *Clin Microbiol Infect.* 2008;14:569–74.
- [11] Adler A, Eames K, Funk S and Edmunds W. Incidence and risk factors for influenza-like-illness in the UK: online surveillance using Flu survey. *BMC Infectious Diseases* 2014;14:232. <https://doi.org/10.1186/1471-2334-14-232> 10.
- [12] Eames KT, Brooks-Pollock D, Paolotti D, Perosa M, Gionannini C, Edmunds WJ. Rapid assessment of influenza vaccine effectiveness: analysis of an internet-based cohort. *Epidemiol Infect.* 2012, 140 (7): 1309-1315. 10.1017/S0950268811001804.
- [13] Razavy S, Dabiran S, Ziaee H Ardekani. The incidence of influenza like illness and determination of the efficacy of Flu vaccine in Iranian pilgrims during Hajj Pilgrimage. *Acta Medica Iranica* 2004, 42(6):397-401.
- [14] Alfelali M, Barasheed O, Tashani M, Irfan Azeem M, Heron L, Khandaker G, et al. Changes in the prevalence of influenza-like illness and influenza vaccine uptake among Hajj pilgrims: A 10-year retrospective analysis of data. *Vaccine.* Volume 33, Issue 22, 21 May 2015, Pages 2562-2569
- [15] Balaban V, Stauffer W, Adnan A, Afgarshe M, Abd-Alla M, Ahmed Q, et al. Protective Practices and Respiratory Illness Among US Travelers to the 2009 Hajj. *Journal of Travel Medicine*, Volume 19, Issue 3, 1 May 2012, Pages 163–168, <https://doi.org/10.1111/j.1708-8305.2012.00602.x>
- [16] Annan A, Owusu M, Marfo KS, Larbi R, Sarpong FN, Adu-Sarkodie Y, et al. High prevalence of common respiratory viruses and no evidence of Middle East respiratory syndrome coronavirus in Hajj pilgrims returning to Ghana, 2013. *Trop Med Int Health.* 2015 Jun;20(6):807-12. doi: 10.1111/tmi.12482. Epub 2015 Mar 3
- [17] Refaey S, Amin MM, Roguski K, Azziz-Baumgartner E, Uyeki TM, Labib M, Kandeel A. Cross-sectional survey and surveillance for influenza viruses and MERS-CoV among Egyptian pilgrims returning from Hajj during 2012-2015. *Influenza Other Respir Viruses.* 2017 Jan;11(1):57-60. doi: 10.1111/irv.12429. Epub 2016 Nov 11.
- [18] Biggerstaff M, Jhung M, Kamimoto L, Balluz L, Finelli L: Self-reported influenza-like illness and receipt of influenza antiviral drugs during the 2009 pandemic, United States, 2009. *Am J Public Health.* 2012, 102 (10): e21-e26. 10.2105/AJPH.2012.300651.

- [19] Falagas ME, Mourtzoukou EG, Vardakas KZ. Sex differences in the incidence and severity of respiratory tract infections. *Respir Med.* 2007 Sep;101(9):1845-63. Epub 2007 Jun 1.
- [20] Al-Shihry AM, Al-Khan AA, Mohammed AG Pre-Hajj health-related advice, Makkah, 1999. *Saudi Epidemiology Bulletin.* 1999;6:29–31
- [21] Barasheed O, Almasri N, Badahdah A, Heron L, Taylor J, McPhee K, et al. Pilot Randomised Controlled Trial to Test Effectiveness of Facemasks in Preventing Influenza-like Illness Transmission among Australian Hajj Pilgrims in 2011. *Infectious Disorders - Drug Targets.* Volume 14, Number 2, June 2014, pp. 110-116(7).
- [22] Alfelali M, Barasheed O, Tashani M, Azeem MI, El Bashir H, Memish ZA, et al. Changes in the prevalence of influenza-like illness and influenza vaccine uptake among Hajj pilgrims: A 10-year retrospective analysis of data. *Vaccine.* 2015 May 21;33(22):2562-9. doi: 10.1016/j.vaccine.2015.04.006. Epub 2015 Apr 14.



# **Third Theme**

# **Urbanization and Engineering**

# High-Efficient and Low Cost Hybrid Renewable Energy Systems Configuration for Mina Region

Husein Mohamed Basi  
Faculty of Engineering - King Abdulaziz University

## تشكيل أنظمة الطاقة المتجددة بكفاءة عالية وتكلفة منخفضة لمنطقة منى

حسين محمد باصي  
كلية الهندسة – جامعة الملك عبد العزيز

### ملخص البحث (Abstract):

تقع منى في منطقة مكة المكرمة ، المملكة العربية السعودية حيث توجد ١٠٠٠٠٠ خيمة مكيفة لتوفير الإقامة المريحة للحجاج. وقد تبين من المسح الأدبي أنه خلال موسم الحج ٢٠١٨ كان الطلب على الكهرباء في اليوم حوالي ٢٨٥ ميجاوات ، ٧٠٪ من تلك الكهرباء كانت تستخدم في تكييف والتبريد. تم تزويد هذه الطاقة بالكامل من محطات الطاقة التقليدية التي تعمل بالوقود الأحفوري (النفط والغاز الطبيعي). إن الاعتماد المستمر على الوقود الأحفوري الذي يمثل مصدر أساسي للطاقة قد يستنفد سريعاً ، وقد يسبب التلوث البيئي ، وله أثار سلبية للغاية على صحة الإنسان والاقتصاد الوطني. لذلك ، قد يكون استخدام مزيج من مصادر الطاقة المتجددة المختلفة المسماة بنظام الطاقة المتجددة المختلط ( HRES) حلاً لهذه المشكلة. في هذا الصدد ، تعرض هذه الورقة تنفيذ منهجية جديدة باستخدام برنامج ( HOMER) الشهير للتوصل إلى تصميم من للشبكة HRES. وقد تم اختيار منطقة منى في المملكة العربية السعودية لإجراء تقييم تقني-اقتصادي مفصل ، وتحليلات للأداء التشغيلي ، وتقييم الجوانب البيئية المتعلقة بالنظام المذكور لكل من الأنظمة المتصلة بالشبكة. تم النظر في أنظمة مختلفة من الخلايا الكهروضوئية ( PV) ، ومولدات الديزل ، وبطاريات التخزين في هذا العمل لمعرفة أي مجموعة تناسب المنطقة بتكلفة منخفضة وأثر بيئي أقل. كما تم إجراء تحليل الحساسية لتمثيل آثار تغيير المعايير الرئيسية ، مثل: الوقود ، PV ، أسعار البطاريات ، إعادة البيع ، شراء الطاقة والحمل المطلوب بالنسبة لأداء النظام. تظهر النتائج بأن الأفضلية تتجه نحو استخدام مصادر الطاقة المتجددة التي بدورها تعتبر أقل تكلفة. يعتبر نظام PV / Diesel / Battery الهجين الأفضل تقنياً بالمقارنة مع جميع السيناريوهات الأخرى لكل من التوصيلات الخارجية والشبكة ، بالإضافة إلى تمتعها بالأداء الاقتصادي والبيئي الجيد ، مما يؤدي إلى زيادة استدامة النظام.

الكلمات الدالة: الكهروضوئية (PV) ، مولدات الديزل ، بطاريات التخزين ، نظام الطاقة المتجددة الهجين

In this paper, the implementation of a novel approach using Hybrid Optimization of Multiple Electric Renewables (HOMER) software to come up with a flexible design of a hybrid renewable energy sources (HRES) is presented. Mina region of Makkah, Saudi Arabia has been considered to conduct detailed techno-economic assessments, analyses of operational performance, and the evaluation of environmental aspects relating to the aforementioned system for both off-grid and grid connected modes. Different combination of photovoltaic (PV), diesel generators, and storage batteries has been considered in this work to see which combination fits the city with low cost of energy and less environmental effect. A sensitivity analysis was also conducted to represent the effects of changing main parameters, such as; fuel, sell-back, power purchase and load demand on the system performance. The results show more trends towards using renewable energy

sources in energy which has the lowest net present cost (NPC) and the cost of energy (COE). Hybrid PV/Diesel/Battery system is seen to be the best technical performance compared to all other scenarios for both off-grid and on-grid connections, while also reporting good economic and environmental performance, which result in increased system sustainability.

**Keywords:** Grid connection; HOMER; Hybrid RE system.

## **1. Introduction:**

The Kingdom of Saudi Arabia is privileged with ample energy resources. Though the Kingdom has bounteous wind and solar renewable energy resources, almost all its electricity is produced from the fossil fuels by overlooking the use of renewable energy resources to generate electricity [1]. Electrical energy consumption in Saudi Arabia has increased remarkably during the last two decades. It is expected that peak loads will reach 60GW in 2023, which may cause the total investment to exceed \$90 billion [2]. Therefore, the need to develop energy conservation policies for sustainable development has become essential in Saudi Arabia.

A set of renewable energy frameworks for Saudi Arabia has been proposed in recent years to inspect the prospects of renewable sources by taking account the combined consequences of the awareness of environmental deterioration and the alleviation of fossil fuels and [3-5]. Solar energy being one of the potential renewable energy sources, is an inexhaustible, site dependent, eco-friendly, which is initiated by a number of countries with high solar radiation as an effort to lessen their reliance on fossil-based nonrenewable fuels [6]. Saudi Arabia receives the most effective kind of sunlight for existing in the heart of one of the world's most productive solar regions [7]. Applications of solar energy have been evolving since 1960 with the average annual solar radiation of 2200 kWh/m<sup>2</sup> in the Arabian Peninsula [6, 7]. Now and in the future, for Saudi Arabia exploitation of this important energy resource becomes more indispensable [8].

Mina is located in Makkah Province of Saudi Arabia where to provide accommodations to visiting pilgrims 100,000 air-conditioned tents are installed. It has annual solar radiation of 247.5W/m<sup>2</sup> and is located in western region of Saudi Arabia. In this area, there are many factors influencing the electricity demand, such as weather changes, social life activities (work, school, and prayer times), and special events (Ramadan and Hajj) [9, 10]. Replacing diesel generators (DG) with small/medium size or standalone PV/battery system is not a wise solution with the high electricity demand during both day and night time. Therefore, to reduce the electricity shortages PV and battery should be integrated with DG to form HRES. Since it is more economically viable than stand-alone diesel system [10]. However, this is not happening at the present time in Mina due to the low diesel fuel price compared to high operation cost of HRES. HRES gives various advantages, such as improved reliability and reduced pollution and emission, although the system is expensive than the stand-alone diesel system. In addition, according to 2030 vision of Saudi Arabia government, to reserve their oil and gas resources they want to diversify their power generation system from fossil fuel to renewable energy based system [10].

In this regard, by taking into account 50,000 tents located in Mina region of Makkah, Saudi Arabia a detailed framework of a flexible HRES design has been proposed in this paper which includes all associated operational performance parameters in both off-grid and on-grid connections. Furthermore, to design and analyze a flexible HRES performance, it demonstrates a comprehensive approach using HOMER software.

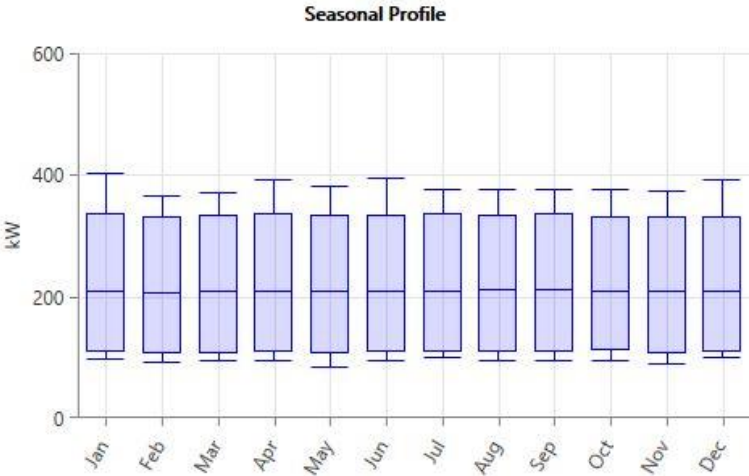
**2. Methodology:**

Successful evaluation of any renewable energy project requires appropriate criteria to be applied on the selected area to ensure that the operational behavior of different scenarios can be analyzed in an accurate manner. The following analysis frameworks are used in the current work.

**2.1 Specification of the selected site**

The work examines Mina region of Makkah Province which is located western part ((21°26’ North, 39°49’ East) of Saudi Arabia where 100,000 air-conditioned tents are built to provide accommodations for visiting pilgrims. It has been observed that the energy demand in this region is completely fulfilled by the nation grid and 70% of the total electricity has been used on air conditioning and cooling.

Figure 1 shows the monthly load profile of 50,000 tents located in Mina, Makkah, Saudi Arabia. It is observed for the selected tents the peak load in Mina is 410 kW with energy consumption of 35,462 kWh/day.



**Fig. 1.** The daily load profile of Mina

**2.2 Solar resource and temperature**

In this framework, HOMER software uses the monthly average global horizontal solar radiation and ambient temperature as input parameters.

- The solar radiation and clearance index data for the Mina region of Makkah, Saudi Arabia (21°26’ North, 39°49’ East) are presented in Figure 2. These data are obtained from the NASA website. The, maximum solar radiation (7.17 kWh/m<sup>2</sup>/day) is recorded in May, and the minimum solar radiation (4.15 kWh/m<sup>2</sup>/day) is recorded in December.

- The monthly average ambient temperature for the chosen area is illustrated in Figure 3. The summer season shows the highest ambient temperature, at 38.15 °C in July, and the lowest ambient temperature, at 30.05 °C in January.

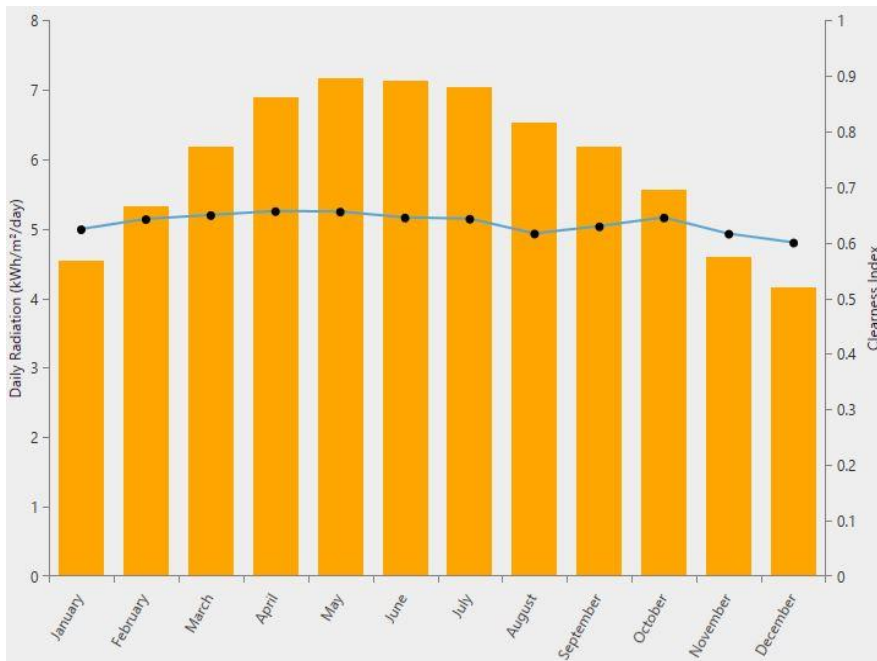


Fig. 2. Monthly average solar global radiation and clearance index of Mina

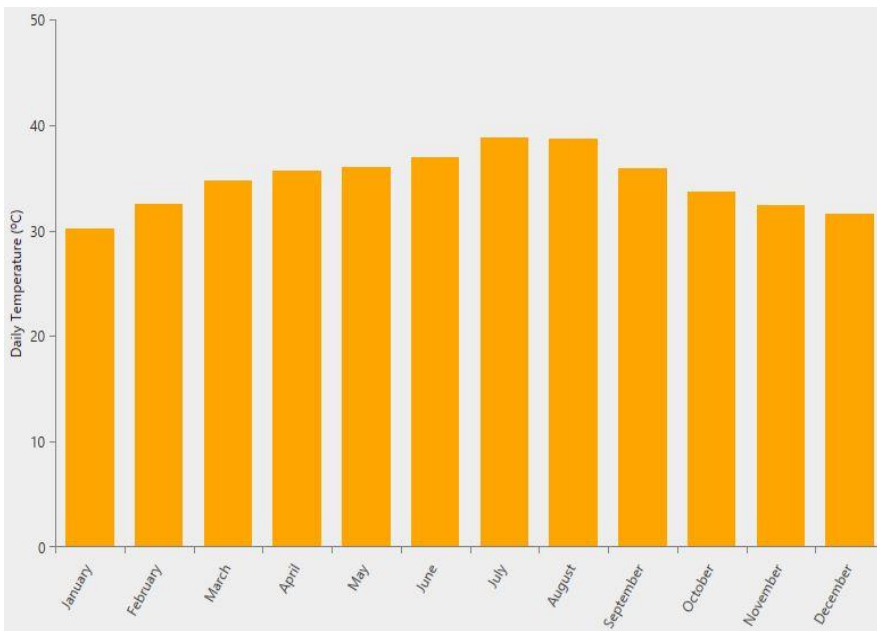


Fig. 3. Monthly average temperature of Mina

### 2.3 System components

In this research, the proposed HRES consists of four components, i.e., the PV system, diesel generator, converter, and batteries. The techno-economic input parameters for all components in the HRER are explained in detail in Table 1; note that the technical parameters and costs of the components were obtained from different references [11, 12]. A schematic diagram of the proposed HRES is illustrated in Figure 4.

**Table 1.** Input parameters and costs of different components

Description	Specification
<b>PV system</b>	
Tracking system	Fixed
Rated capacity	400 kW
Nominal operating cell temperature	-0.5% / °C
Temperature Coefficient	47 °C
Efficiency at standard test condition	13%
Derating factor	80
Capital cost	\$ 2500/kW
Operating and maintenance cost	\$ 3/kW/year
Cost of replacement	\$ 2000/kW
Lifetime	20 years
<b>Diesel generator</b>	
Cost of capital	\$ 400/kW
Cost of operating and maintenance	\$ 0.05/kW/hr
Cost of replacement	\$ 400/kW
Lifetime	15000 hr
<b>Batteries</b>	
Model	Lead Acid
Nominal capacity	1900 Ah (7.6 kWh)
Nominal voltage	2 V
Capital cost	\$ 1200
Operating and maintenance cost	\$ 30 /year
Replacement cost	\$ 1200
Lifetime	12 years
<b>Converter</b>	
Efficiency	90% for inverter, 85% for rectifier
Cost of capital	\$ 400/kW
Cost of operating and maintenance	\$ 20/year
Cost of replacement	\$ 375/kW
Lifetime	10 years

## 2.4 Economic model

The optimum combination of the HRES components are obtained on the basis of the NPC, which is the sum of all costs and revenues that take place throughout the lifetime of a project. To calculate the total NPC of a system, the following equation is used [13-15]:

$$NPC = \frac{C_{ann,tot}}{CRF(i, T_p)} \quad (1)$$

where  $C_{ann,tot}$  is the total annualized cost (\$/year),  $i$  is the annual real interest rate (%),  $T_p$  is the project lifetime (year), and  $CRF$  is the capital recovery factor [16].

COE is the average cost per kWh of producing electricity, given by [16]:

$$COE = \frac{C_{tot}}{E_{served}} \quad (2)$$

where  $E_{served}$  is the total electrical load served (kWh/year).

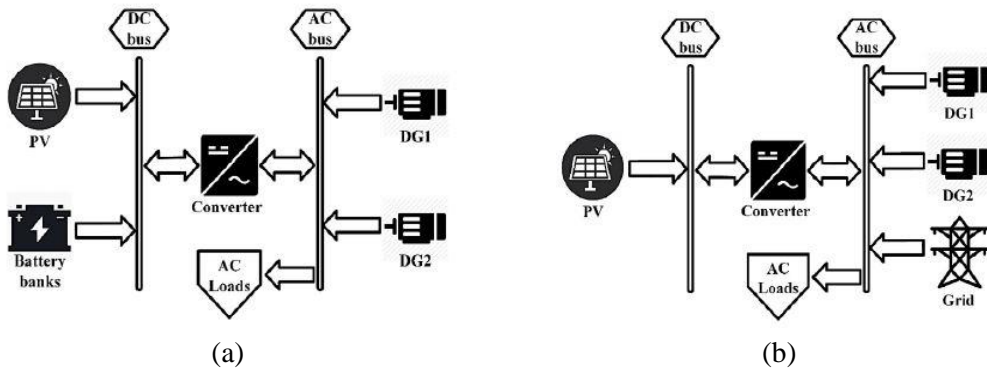


Fig. 4. Schematic diagram of HRES (a) Off-grid, and (b) On-grid

## 2.5 Control strategy

The two main control methods of the hybrid PV/diesel/battery system are the Load Following (LF) and Cycle Charging (CC) dispatch strategies. In this study, LF strategy has been used to design and analyze the data collected. Because LF uses diesel generators to supply loads only when renewable energy sources are unavailable. The LF strategy is more trend to generate lower amount of CO<sub>2</sub> emissions. LF seems to be the optimal strategy, as it helps reducing the excess energy and total NPC [17].

## 3. Results and Discussions

With each containing different technical and economic configurations, several scenarios were carried out in this paper. Initially to find the optimum solution, the system is tested over the off-grid connection. Then, the investigation of the technical, economic, and environmental performance of the proposed system has been taken place. Also, the impact of changing fuel prices and load demand on the optimal design has been

analyzed for off-grid connection during the sensitivity analysis. Similarly during on-grid connection, the optimum design of proposed HRES is also investigated, which includes the effects of grid inclusion on the system's component combination and operational performance. Furthermore, by changing important variables at the on-grid connection, the optimum design is examined during sensitivity analysis. The simulation has been carried out in HOMER platform. The simulation results show different combinations of the optimal scenarios including different COE, and NPC values.

### 3.1 Off-grid HRES

In this stage, no grid connection has been considered. A standalone system including DG, batteries, converters, and PV are proposed without any technical disruption to meet the load demand is depicted in Figure 4 (a). In this scenario, to generate adequate power, the system is designed to depend on PV generated power, where DGs are used as a backup when the PV and/or battery are unable to meet load requirements.

As the best configuration in terms of COE and NPC, the specific step sizes are summarized in table 2, which have been selected by HOMER. Two DGs with capacities of 100 kW and 60kW are included in the optimum system where the best options for converter, PV, and batteries are found 150 kW, 250 kWp, and 330 kWh respectively. The total NPC of the system is found \$2452919.0 for the optimum HRES, while the COE is 0.238 \$/kWh. In addition, the total salvage and operating costs of optimum HRES has been calculated by HOMER are \$101889.0 and \$18109.0, respectively. In table 3, the total produced harmful gas emissions are shown, where CO<sub>2</sub> forms the majority of the produced harmful emissions which is 270789.0 kg/Yr. While, emission of carbon monoxide, unburned hydrocarbons, particular matters are found null.

**Table 2.** Part of the various arrays of component's arrangements

System	PV (kWp)	DG1 (kW)	DG2 (kW)	Battery (kWh)	Converter (kW)	COE (\$/kWh)	NPC (\$)
System 1	250	100	60	330	150	0.238	2.45 M
System 2	300	100	50	330	150	0.239	2.50 M
System 3	300	140	30	330	150	0.239	2.50 M
System 4	350	110	40	330	150	0.241	2.57 M
System 5	350	100	50	330	150	0.241	2.57 M
System 6	400	100	30	330	200	0.244	2.65 M

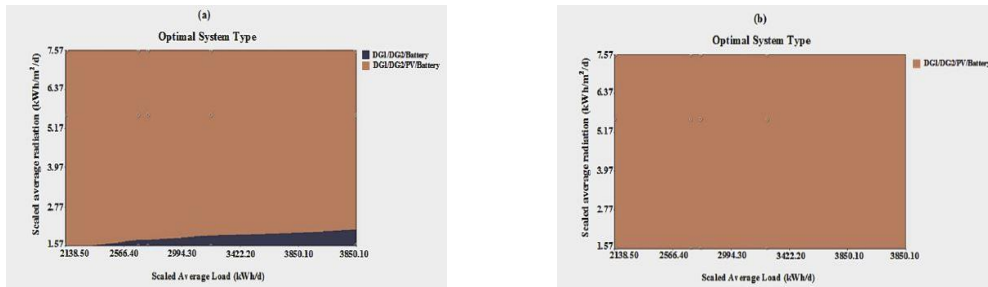
**Table 3.** Generated harmful gas emissions by HRES

Emissions	Kg/Yr
Carbone dioxide	270789.0
Carbone monoxide	0
Unburned hydrocarbons	0
Particular matters	0
Sulfur dioxide	1174.50
Nitrogen oxide	574.24



### 3.1.1 Sensitivity analysis

To examine the system behavior, sensitivity analysis is performed by varying DG fuel price. The result of the sensitivity analysis by changing the diesel price from the current price (0.7 \$/L) is shown in Figure 5 (a), to more than (1.15 \$/L) in Figure 5 (b), along with increasing the average load demand (+2.5% per year) with respect to monthly average solar radiation. The results exhibit that the optimum HRES is flexibly performs during increasing load growth, average solar radiation and diesel price variations.



**Fig. 5.** Sensitivity analysis of off-grid HRES for average loads v/s average solar radiation at (a) 0.7 \$/L and (b) 1.15 \$/L.

### 3.2 On-grid HRES

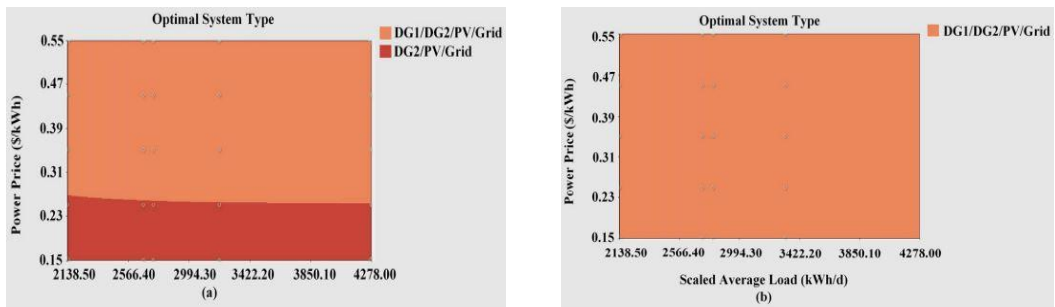
The optimal design assigned to a grid connection is discussed in this section. Therefore, to include this addition without making any change to the system configuration, the system should be flexible as shown in Figure 4 (b). Power purchases and sell-back prices are the two key parameters which have direct influence on grid-connected HRES. It is assumed that due to the non-availability of data from the selected site, the power purchase price has been considered higher than the nearest location with a grid connection due to the far distance of the proposed site. For this study, the sell-back price has been chosen higher than the power purchase prices as well as the off-grid system's COE. Alike off-grid HRES for grid connected HRES also the best optimum configuration has been consisted of PV, DG1, DG2, converter and grid which is shown in table 4. The total NPC and COE for the optimum design has been observed \$ 172367.0 and 0.167 \$/kWh respectively.

**Table 4.** Part of the various arrays of component's arrangements

System	PV (kWp)	DG1 (kW)	DG2 (kW)	Converter (kW)	COE (\$/kWh)	NPC (\$)
System 1	250	100	60	150	0.167	1.72 M
System 2	300	100	50	150	0.169	1.78 M
System 3	300	140	30	150	0.170	1.78 M
System 4	350	110	40	150	0.174	1.86 M
System 5	350	100	50	150	0.174	1.86 M
System 6	400	100	30	200	0.180	1.95 M

### 3.2.1 Sensitivity analysis

Comprising all changes to the on-grid system's operation, this section performs an extensive sensitivity analysis. The power purchase, load demand, fuel prices, and sell-back are included in the applied changes. The effects of changing the load demand against power purchase and sell-back prices are shown by Figure 6. It is seen that the system tends to depend more on the DG2/PV/Grid choice if the value of the sell-back price is lower than the COE of the off-grid system (0.238 \$/kWh) and power purchase price, while the load keeps increasing. However, in addition to the power purchase, increasing the sell-back price to exceed the COE of the off-grid system will cause the system tends to depend more on the optimum design (DG1/DG2/PV/Grid) configuration.



**Fig. 6.** Sensitivity analysis of on-grid HRES for power price v/s average loads at different sell-back prices in (\$/kWh) (a) 0.15 and (b) 0.45 and above

### 3.2.2 Environmental impact

In this work, the study of environmental impact of each system is also carried out. Table 5 shows the result of CO<sub>2</sub> emissions for different sellback prices and power purchase. The dependency on the grid to meet the load demand can be decreased by higher power purchase prices and increasing the usage of the hybrid system which includes DGs and renewable energy components. Due to the usage of DGs during renewable energy sources unavailability, larger amount of the CO<sub>2</sub> emissions has been found in the optimum design of HRES.

**Table 5.** CO<sub>2</sub> Emissions vs different power purchase and sell-back prices

Sellback Price (\$/kWh)	Power Purchase (\$/kWh)	CO <sub>2</sub> Emissions (kg/Yr)
0.15	0.45	294630
0.25	0.40	347000
0.30	0.35	475000
0.35	0.30	512000
0.40	0.25	530000
0.45	0.15	550000

#### 4. Conclusions

To meet the load demand of Mina region of Makkah, Saudi Arabia, the optimum hybrid renewable energy system was designed in this paper. HOMER software has been used to perform several scenarios for off-grid and on grid connections. The optimal system was found including, two DGs of 100 kW and 60 kW, PV modules of 300 kWp, battery banks of 330 kWh, and a 150 kW converter for both the cases. The sensitivity analysis proved that the COE normally falls within a range of (0.167-0.244 \$/kWh), while the NPC of (172367.0-225374.0 \$) for both off and on grid systems. The system emits a range of (270289.0-481652.0 kg/Yr) of CO<sub>2</sub> emissions, in both off and on grids systems. Based on the work it can be said that the obtained optimal HRES shows effective performance by satisfying corresponding economic and environmental concerns compared to other hybrid system configurations for both off and on grid connection modes.

#### References:

- [1] Y. Alyousef and P. Stevens, "The cost of domestic energy prices to Saudi Arabia," *Energy Policy*, vol. 39, no. 11, pp. 6900–6905, 2011.
- [2] S. A. Al-Ajlan, A. M. Al-Ibrahim, M. Abdulkhaleq, and F. Alghamdi, "Developing sustainable energy policies for electrical energy conservation in Saudi Arabia," *Energy Policy*, vol. 34, no. 13, pp. 1556–1565, 2006.
- [3] Y. Al-Saleh, "Renewable energy scenarios for major oil-producing nations: the case of Saudi Arabia," *Futures*, vol. 41, no. 9, pp. 650–662, 2009.
- [4] O. Alnatheer, "Environmental benefits of energy efficiency and renewable energy in Saudi Arabia's electric sector," *Energy Policy*, vol. 34, no. 1, pp. 2–10, 2006.
- [5] S. M. Rahman and A. N. Khondaker, "Mitigation measures to reduce greenhouse gas emissions and enhance carbon capture and storage in Saudi Arabia," *Renewable and Sustainable Energy Reviews*, vol. 16, no. 5, pp. 2446–2460, 2012.
- [6] S.M. Shaahid and I. El-Amin, "Techno-economic evaluation of off-grid hybrid photovoltaic-diesel-battery power systems for rural electrification in Saudi Arabia-A way forward for sustainable development," *Renewable and Sustainable Energy Reviews*, vol. 13, no. 3, pp. 625–633, 2009.
- [7] J. Dargin, "Saudi Arabia, UAE promote energy from sun and wind," *Oil & Gas Journal*, vol. 107, no. 12, pp. 18–22, 2009.
- [8] S. H. Alawaji, "Evaluation of solar energy research and its applications in Saudi Arabia-20 years of experience," *Renewable & sustainable energy reviews*, vol. 5, no. 1, pp. 59–77, 2001.
- [9] A. J. Al-Shareef and M. F. Abbod, "The application of committee machine model in power load forecasting for the western region of Saudi Arabia," *Engineering Sciences Journal*, vol. 22, no. 1, pp. 19–38, 2011.
- [10] J. Dekker, M. Nthontho, S. Chowdhury, and S. P. Chowdhury, "Economic analysis of PV/diesel hybrid power systems in different climatic zones of South Africa," *International Journal of Electrical Power & Energy Systems*, vol. 40, no. 1, pp. 104–112, 2012.
- [11] Ramli, M. A., Hiendro, A., & Boucekara, H. R. E. H., "Performance analysis of hybrid PV/diesel energy system in western region of Saudi Arabia," *International Journal of Photoenergy*, 2014.
- [12] L. M. Halabi and S. Mekhilef, "Flexible hybrid renewable energy system design for a typical remote village located in tropical climate," *Journal of Cleaner Production*, vol. 177, pp. 908-924, 2018.
- [13] L. M. Halabi, S. Mekhilef, L. Olatomiwa, and J. Hazelton, "Performance analysis of hybrid PV/diesel/battery system using HOMER: A case study Sabah, Malaysia," *Energy Conversion and Management*, vol. 144, pp. 322-339, 2017.
- [14] Halabi, L. M., Mekhilef, S., Seyedmahmoudian, M., & Horan, B. (2017). Energy management for a grid connected hybrid renewable energy system. *Universities Power Engineering Conference (AUPEC), 2017 Australasian*, (pp. 1-5). Melbourne, Australia.

- [15] M. Hossain, S. Mekhilef, and L. Olatomiwa, "Performance evaluation of a stand-alone PV-wind-diesel-battery hybrid system feasible for a large resort center in South China Sea, Malaysia," *Sustainable Cities and Society*, vol. 28, pp. 358-366, 2017.
- [16] L. Olatomiwa, R. Blanchard, S. Mekhilef and D. Akinyele, "Hybrid renewable energy supply for rural healthcare facilities: An approach to quality healthcare delivery," *Sustainable Energy Technologies and Assessments*, vol. 30, pp. 121-138, 2018.
- [17] L. Olatomiwa, S. Mekhilef, and O. S. Ohunakin, "Hybrid renewable power supply for rural health clinics (RHC) in six geo-political zones of Nigeria," *Sustainable Energy Technologies and Assessments*, vol. 13, pp. 1- 12, 2016.

# Trenchless Technology: The Right Method for Sustainable Construction & Maintenance of Urgent Infrastructure Projects within Crowded Vicinities

Moustafa Kassab<sup>(1)(2)</sup>, Omar Alruwaythi<sup>(1)</sup>

<sup>(1)</sup> Civil Engineering Department, Faculty of Engineering, Taibah University Al-Madina Al-Munawara, Saudi Arabia

<sup>(2)</sup> Systems Design Engineering, University of Waterloo, Canada

## تقنية عدم حفر الخنادق: الطريقة الأمثل للبناء المستدام وصيانة مشاريع البنية التحتية العاجلة في المناطق المزدحمة

مصطفى محمد كساب<sup>(1)(2)</sup>، عمر الرويثي<sup>(1)</sup>

<sup>(1)</sup> جامعة طيبة- كلية الهندسة- قسم الهندسة المدنية

<sup>(2)</sup> كلية الهندسة – جامعة واترلوا – كندا

### ملخص البحث (Abstract):

في مشاريع البنية التحتية العاجلة في المناطق والشوارع المزدحمة بالمشاة و العربات، فإن إيجاد طرق أسرع وأكثر أماناً لاستكمال مشاريع البناء والصيانة مع مراعاة الحد الأدنى من التأثير على المشاة وحركة المرور والبيئة هو محور اساسي لمعظم مديري المشاريع وصناع القرار. تعد تقنية عدم حفر الخنادق المكشوفة "Trenchless Technology" والتي تم تطويرها مؤخراً واحدة من أكثر التقنيات الحديثة أهمية وعملية. حيث تسمح لنا بالتشييد والصيانة الطارئة لخطوط أنابيب المياه والصرف الصحي والطاقة والاتصالات من خلال استخدام تقنية الحفر تحت سطح الأرض ومن دون الحاجة الى استخدام طرق الحفر التقليدية للخنادق المكشوفة للسطح والمسببة لاغلاق الشوارع وازعاج المارة والمركبات والتي تستغرق وقتاً طويلاً ، مثل: عبور الشوارع المزدحمة ، ممرات المشاة ، والسكك الحديدية لتركيب وصيانة المرافق ؛ على وجه الخصوص في الأوقات المزدحمة للحج والعمرة والزيارة، حيث يصبح التقليل من (ازعاج المارة وحركة المرور وتلوث البيئة نتيجة الحفر للمكشوف) هي من أهم أولويات صانعي القرار في الجهات المسؤولة. ان تقنية الحفر الغير مكشوف أساساً هي طرق مبتكرة حديثة في بناء أنفاق تحت سطح الأرض او الشارع بهدف تركيب وصيانة خطوط خدمات البنية التحتية مثل المياه ومياه الصرف الصحي، وأنابيب الغاز، والكابلات الكهربائية، والاتصالات السلكية واللاسلكية من دون أن يلاحظ او تتأثر حركة مرور المارة والمركبات على السطح. وعلى الرغم من ازدياد الاعتماد المفيد والاستخدامات الناجحة لهذه التقنية في كثير من بلديات الدول المتقدمة التي تبنت هذه التقنية في التشييد والصيانة لشبكات البنية التحتية، وخاصة في شوارع المدن المزدحمة، والمواقع الهامة، لكن لاتزال هذه التقنية المستخدمة في الإنشاءات والصيانة العاجلة او الطارئة نادرة الأستخدام في الدول العربية. هذه الورقة تقدم عرضاً عاماً لهذه التقنية الناشئة لمشاريع البنية التحتية الحيوية من (بناء ، وصيانة ، وإعادة التأهيل)، كما تتعرض لانواع وأساليب استخدامها، كما تعرض مزاياها وبعض تحديات استعمالها مع أمثلة لاستخدامات ناجحة في البلاد المتقدمة. ان ميزة واهمية هذه التقنية في التشييد والصيانة العاجلة والطارئة تلاحظ بوضوح في مواقع المرور المزدحمة بالمارة والمركبات من خلال القضاء على الازعاجات العامة والاحتقان المروري وتسهيل حياة العامة، كما يسرع من وقت اكمال المشروع والصيانة الطارئة ويقلل من تكاليفها، هذا بالإضافة الى الفوائد الاقتصادية والبيئية الأخرى في مناطق الحشود والمدن المزدحمة.

For urgent infrastructure projects in the crowded areas and busy streets, finding faster and safer methods to complete the construction and maintenance projects with minimum impact on public, traffic, and environment is the focus for most project managers and decision makers. Recently evolved "Trenchless Technology" is one of the most interesting and practical technologies that let us install and perform urgent repair to pipelines, sewer, water mains, power and

telecom through steerable trenchless method where conventional excavation of open-cut techniques are not feasible, disturbing, and time consuming, such as: crossing the busy streets, pedestrian walkways, and railways for utility installation and maintenance; particularly, in at the crowded times of Haj, Omra, and visits seasons where minimizing public, traffic, and environment impacts are the top priorities of the decision-makers. Trenchless technology (TT) is basically a tunneling construction methods below the surface to install and maintenance infrastructure service-lines like water/wastewater, gas pipes, electric, or telecommunication cables, without anyone noticing on the surface. Despite the successful uses and its beneficial acceptance by more Municipalities in western and developed countries who adopt this method of construction and maintenance, especially in the crowded cites, and critical sites. Yet, this technology for urgent construction and maintenance are hardly ever used in the Arab countries. This paper presents an overview of this emerging Trenchless technology for critical Infrastructure Projects (Construction, Maintenance, and Rehabilitation), its methods-types, advantages and limitation with examples of successful case-studies in north America and Europe. The advantage of this method are Cleary noticeable in the crowded locations and busy streets by eliminating public disturbance and traffic congestion, reducing construction and maintenance cost, reducing project completion time, with overall benefits to the economy and environment in the crowded vicinities.

## Introduction

In today's modern society, the continuous availability of the basic infrastructure services are essential part of daily life. No communities could be considered inhabitant without the availability of fresh water and wastewater networks, power and telecommunication. The necessity to provide these services and keep it in updated functioning condition is so crucial to the municipality in such away it make creating an emergency department and highly skilled emergency crew to repair urgent and damaged utility on the 24 hrs. basis are available. This task becomes big burdens and heavy task when it comes to service and maintain old and damaged infrastructure facilities in the crowded and critical locations of big cities and communities affected by events such as Haj, Omra, and other seasonal times in Makkah, Medina, and the surroundings. For Infrastructure construction, rehabilitation, and maintenance, local municipalities and Infrastructure Contractors in these dense- pedestrian and traffic are faced with challenging tasks of installing and maintaining underground infrastructure utilities in the crowded vicinities. This includes installation, inspection, repair, and replacement of underground service facilities such as water and waste water pipelines, power, and telecommunication networks.



Figure 1: Traditional Open cut excavation: Disturbance for pedestrian, traffic, and environment [8]

Traditionally, construction and maintenance of underground utilities involve open trenching method methods. Such operations methods are proven expensive, particularly in congested urban areas of crowded cities and critical locations. Contractors have to close roads, divert traffic and create chaos and frustration for vehicles, commuters, and business in the operation vicinity, in addition, they must cautiously dig and operate carefully around other existing critical utilities to achieve the required depth and proper location, which in turn slows down the whole operation and delay the projects. Additional costs in open trenching construction are incurred by the process of restoring the existing original surfaces including pavements, sidewalks, and other disturbed facilities, as well as, landscaping. Open cut trenching operations often result in high user and social costs due to the disruption to vehicles and pedestrian traffic, as well as its adverse impact on nearby businesses [1,2,3,8], let alone the danger of possible collapse of trenches walls on the working personnel, and close by pedestrians. Furthermore, the increases in the population of crowded cities, and urgent need to rehabilitate, replace aging infrastructure utilities systems, as well as, repairing damaged utilities, together with the increased emphasis on user and social costs, have pushed municipalities and contractors to seek alternative methods for repairing and replacing underground utilities [4]. Accordingly, in many western countries, under-pressured municipalities found the solution for this problem by utilizing the Trenchless technology in construction. Trenchless technology (TT) is an emerging area of construction involving innovative methods, materials, and equipment used for the installation of new, and the rehabilitation, or replacement and maintenance of existing underground infrastructure with minimal or no need for open cut excavation (Figure 2) [3].

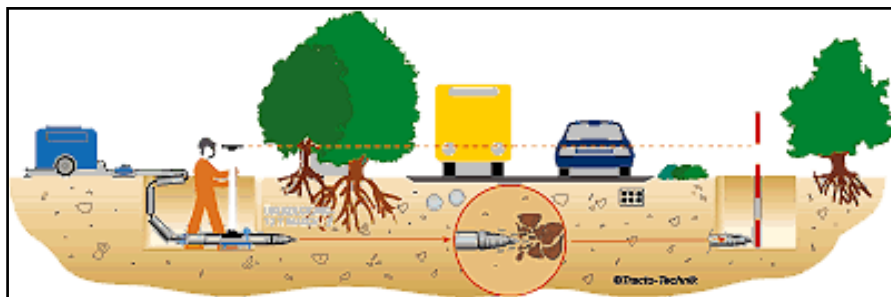


Figure 2: Sustainable Trenchless technology: No disturbance for traffic, and environment [8]

Despite the fact that trenchless construction methods have not been used in the Arab countries, as often as they have been used in the developed western world [5], it is obvious that the development, selection, and utilization of trenchless technology in the infrastructure projects have expanded rapidly over the past 15 years worldwide. The reason for this exceptional growth is the desire to install, rehabilitate and maintain underground infrastructure services - like water or gas pipes, electric or telecommunication cables, and other networks utilities systems- in the crowded and critical locations fast and with minimum impact on society and the environment. In the literature review, publications show the many benefits of trenchless technology are apparent when compared to the conventional open-cut process [1,3,4,6,7]. In the Arab Countries very little efforts have been done to recognize and encourage the importance of using trenchless technology in the crowded Arab cities as an effective and economic alternative to existing traditional methods of utility cuts with less disruptions to traffic, commerce, and community [1, 3, 6, 9, 14]. This paper, presents an overview for the concepts of Trenchless technology as the right method that could be utilized by municipalities for underground

infrastructure construction and maintenance, especially in the vicinity of critical locations and crowded areas, next it presents the most common methods that are used and successfully proof its practicality and efficiency in the western world, and finally, advantages and disadvantages of the trenchless technology will be presented as well.

### Trenchless technology

Trenchless construction technology can be defined as “a family of methods, materials, and equipment capable of being used for the installation of new or replacement or rehabilitation of existing underground infrastructure with minimal disruption to surface traffic, business, and other activities” [1, 6,7]. Based on location, type of infrastructure utility, soil type, and the project urgent needs, different trenchless construction-techniques are available such as Horizontal directional drilling, pipe jacking, micro tunneling, auger boring, and pipe bursting. Other trenchless rehabilitation techniques include lining of pipe, pipe scanning and evaluation, and robotic spot repair. Even though, the extensive use of trenchless construction in the installation, repair, and replacement of underground infrastructure utilities are relatively recent-development; yet, the idea and uses of trenchless techniques dates back to the 1860s, by Northern Pacific Railroad Company pioneer the use of pipe jacking techniques. Then by the 1930s, reinforced concrete pipes had been installed using this technique. Thereafter, other methods of trenchless construction began to emerge and utilized including: boring (1940), impact moling (1962), horizontal directional drilling (1971), microtunneling (1973), and pipe bursting (1980). [3, 6,7,10]. Subsequently, many developed countries have successfully started to adopt various trenchless technologies in one form or another as shown in Tabale 1.

Table. 1: Historical implementation of the trench technology time line developments [16]

Technology	Year Introduced	Country Invented
Pipe Jacking	1860	United States
Auger Boring	1940	United States
Impact Mole	1962	Germany
Horizontal Directional Drilling	1971	United States
Cured in Place Pipe (CIPP)	1971	United Kingdom
Microtunneling	1973	Japan
Pipe Bursting	1981	United Kingdom
Pipe Ramming	1980's	United States
Guided Moles	1990's	Germany
Pilot Tube Microtunneling	1995	Germany
Axis Vacuum Guided Boring System	2008	Australia/United States

### Trenchless Technology Methods

There are various methods of trenchless technologies that may be utilized (Figure 3) depend on the utility type, location, the ground-soil condition, the pipe-size that needs to installed, the depth it needs to be installed to, and the overall cost of the method and urgent need of the project. The most popular methods have been outlined in Figure 3 (Michigan Department of Transportation 2006) [10, 11, 12].



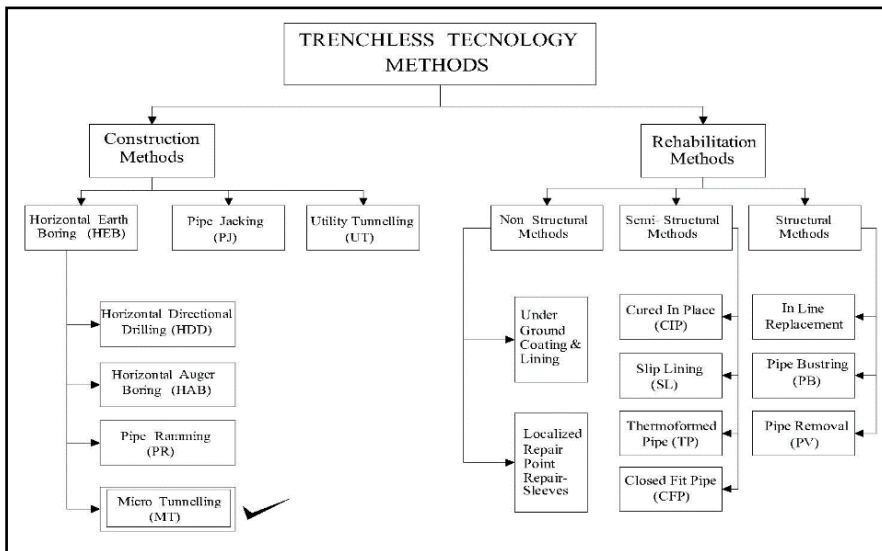


Figure 3: Popular Trenchless technology (TT) Methods

**Horizontal auger boring:** A technique for forming a bore from a drive pit to a reception pit, by means of a rotating cutting head. Spoil is removed back to the drive shaft by helically wound auger flights rotating in a steel casing. The equipment may have limited steering capability.

**Pipe jacking:** A system of directly installing pipes behind a shield machine by hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground. Usually personnel are required inside the pipe to perform the excavation or spoil removal process. The excavation can be performed manually or mechanically (Figure 4).

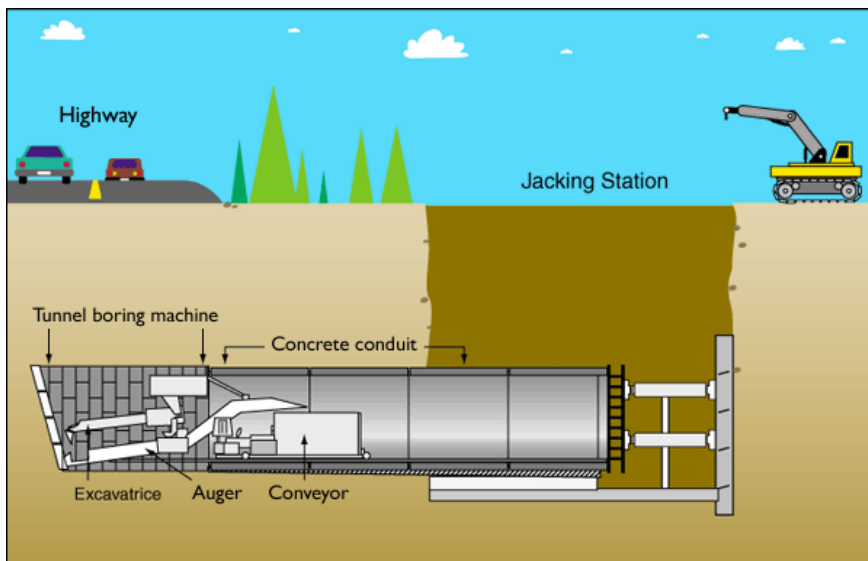


Figure 4: Pipe Jacking

**Pipe bursting:** A technique for breaking existing pipe by brittle fracture, using force from within, applied mechanically. Pipe remains are forced into the surrounding soil. At the same time a new pipe, of the same or larger diameter, is drawn behind the bursting tool (Figure 5).

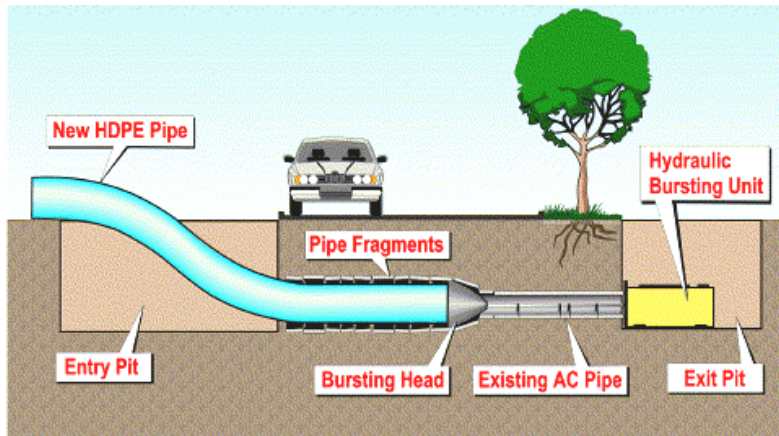


Figure 5: Pipe Bursting

**Horizontal directional drilling:** A steerable system for the installation of pipes, conduits, and cables in a shallow arc using a surface launched drilling rig. Traditionally HDD is applied to large scale crossings such as rivers in which a fluid filled pilot bore is drilled without rotating the drill string, and this is then enlarged by a wash over pipe and back reamer to the size required for the product pipe (Figure 6).

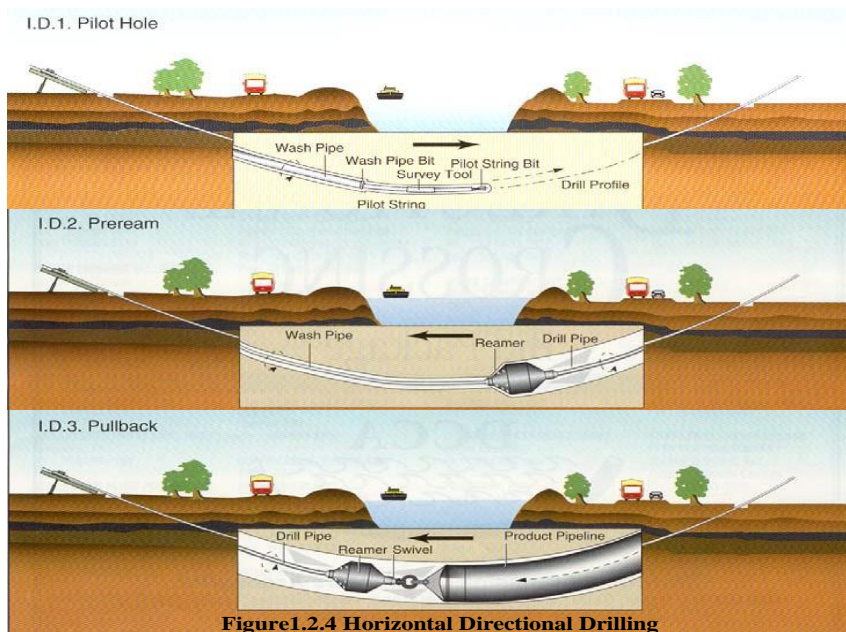


Figure 6: Horizontal Directional Drilling (Opening of the guide hole, expanding the hole and pulling the Pipe) [10]

**Pipe ramming:** A technique for installing steel casing from a drive shaft to a reception shaft utilizing the dynamic energy from a percussion hammer attached to the end of the pipe. A continuous casing support is provided and over-excavation or water is not required. This is a 2- stage process (Figure 7).

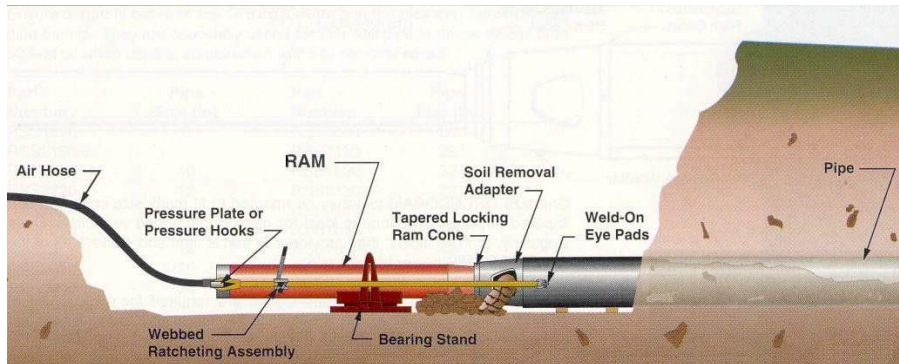


Figure 7: Pipe Ramming

**Microtunneling:** TT construction method for installing pipelines with the following features (Figure 8):

- Remote Controlled – The Micro Tunnel Boring Machine (MTBM) is operated from a control panel, normally located on the surface. It simultaneously installs pipe as spoil being excavated and removed.
- Guided – The guidance system usually refers to a laser beam projected onto a target in the MTBM, capable of installing gravity sewers or other types of pipeline to the required tolerance for line and grade.
- Jacking Pipe – The process of constructing a pipeline by consecutively pushing the MTBM through the ground using a jacking system.
- Face Support – Continuous pressure is provided to the face of the excavation to balance groundwater and earth pressure.

### Trenchless Technology vs. Open-Cut Trench Methods

Researches and piratical experiences show many advantages for the innovative-methods of Trench-technology that overcome the traditional method of open-trench in many important aspects such as [10, 11, 12, 14, 15]:

- Less disturbing: Open-cut method disturbs local properties, agricultural land, or disturbing local highways. But by using Trenchless technology, one will come out from these problems.
- Less time: Open-cut method is time consuming method. In this method time is required for the excavation and refilling of trenches. In addition to the time is taken in site restoration, spoils storage and traffic control.
- Enhanced safety: in Open-cut method, steep excavation Landslides can be occurred. Where the mud is likely to subside due to steep walls or water aggravation, protection needs to be taken with specialist equipment. While with Trenchless technology safety are provided to the workers as there are no steep trenches involved in this work.
- Save time and cost related to survey and design: Open-cut method consist of preliminary survey, detailed survey consists of the depth of the cut, the ground conditions where the trenches will run, and also how much dewatering will need to take place, and ensuring continuous and alert safe conditions to workers. But in Trenchless technique time and cost related to these tasks will be saved.

- Encountering fewer unknowns in the ground: in Open cut method, approximately 70% of the cost required for excavating and replacing the ground during the process due to the possible unknowns that come in the excavation, and or the digging cost of excavation will further increases. By use of Trenchless technology reduced this problem.
- Minimize chance of disturbing existing utilities: at the time of open cut most important problem come in front of is disruption to above surface activities, as well as at the time of digging has to avoid existing utilities. Trenchless technology comes with the ability to install new pipelines and rehabilitate and maintain existing pipelines with limited disturbance to pedestrian, traffic and business activities; reduce damage to above existing paved surfaces.
- Less Problems to the public such as noise and air pollution – The indirect social costs of Open cut projects consist of unhealthy conditions, and noise pollution. These problems can be overcome with trenchless technology without the need for road closures, noise pollution.
- CO2 Emission: Researches shows that Trenchless technology is more friendly to the environment in many ways. For example, a conducted research study for identical projects shows that using open cut exaction will safe 80% of carbon emission to the atmosphere [6,14, ariatren 2003]. In addition, less dust and no trees or green landscape areas will be disturb or removed. As shown in Figure 8
- Choosing the right excavation method, trenchless technology could save up to ½ total cost of the similar operation [16]

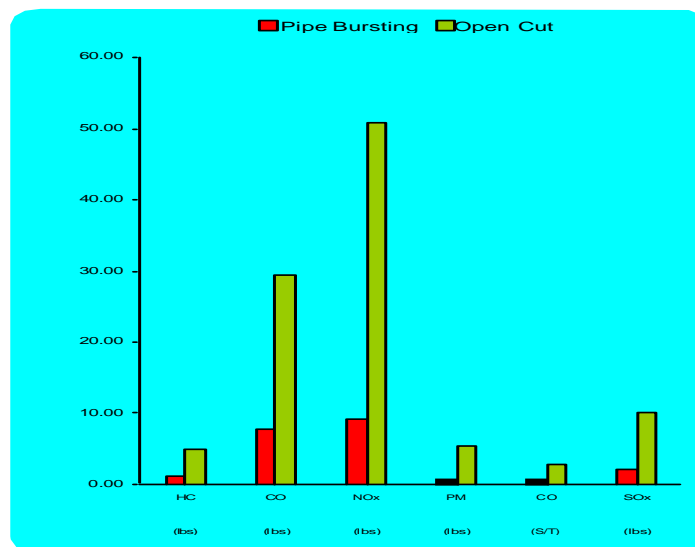


Figure 8: Sample Comparison for average reduction in gas emission between open cut and TT

### Examples of Successful case studies

Trench technology for infrastructure projects (Construction, Maintenance, and Rehabilitation) in the crowded cities and critical sites are still rarely used in the Arab countries despite its successful usage and wide acceptance in western and developed countries who adopt this method of construction and maintenance, especially in the crowded cities, and critical sites. Every year, hundreds of trench less technology projects were successfully completed. Trenchless

technology magazine and website list regularly stories and projects completed using this technology around the world particularly in North America and Europe. For example [17] [Kezdi](#) listed 50 projects which readers can access them through that reference.

#### ***Dubai Water Canal project, UAE***

UAE was among the early few pioneers that utilized the Trenchless technology among the Arab countries. In its project, Dubai Water Canal project which includes the construction of a 3-km long waterway in the vicinity of its highly crowded central business district. Al Naboodah Construction Group (ANCG) was hired to divert utilities on a section of the project. The company accomplished that task by utilizing two trenchless technologies methods of Horizontal directional drilling (HDD) for power and telecommunication cables and irrigation lines; and the method of Microtunneling for water mains. For the HDD work, ANCG completed 24 bores, totaling approximately 7,315 m, “The project was a tight corridor with multiple crossings next to busy roads,” says general manager for ANCG. The project has 24 crossings averaging 305 m in four busy locations. Their work was vital for the timeline of the overall project because installations at two of the locations had to occur before bridges, which were important to relieve traffic congestion issues, could be built. “Bridges were planned on top of the HDD route. Those locations were completed as soon as possible”. In addition Reclaimers were used on all the HDD projects to reduce cost and environmental impact,” [18].

#### ***Crossing under the River of Texas’s Rio- Grande using HDD, USA***

In Webb County, Texas, near Laredo, nine-member directional drilling crews with PUMPCO Inc. have successfully crossed under the river of Rio Grande. The project involved boring and pulling back 2,200 ft of 36-in. pipe approximately 80 ft under the river’s bed using Trenchless technology of Horizontal Directional Drilling (HDD). It was the last leg of the 17-mile long Pipeline that has to cross the river. “Using the proper method and equipments of trenchless technology, the construction process was as easily and quickly as it could” said by the project manager. On average, the crew drilled around 500 ft a day and took them around four and a half days to complete without disturbance to the river and the environment, and the project completed on time and budget [19].

#### ***Frankfurt Airport, Germany***

With nearly 65 Million passengers using its services each year, Frankfurt Airport, in Germany, can’t just shut down for maintenance. However, after 40 years of heavy usage, the airport’s vast system of sanitation infrastructure was in danger of falling into a critical state. The system exacerbated normal wear and tear, leading to cracks, pipe offsets, corrosion and multiple un-flushable deposits. With the clock ticking down, the airport authority led a charge to repair or replace the wastewater network at Frankfurt Terminal 1 and contracted Germany’s ANT GmbH to manage the project. ANT sought support from [Trelleborg Pipe Seals](#), a provider of pipe renovation systems with coverage across Europe and the United States. With a vast spiderweb of pipes lying directly beneath the terminal’s buildings, this would be no simple project for either firm. Using a combination of several trenches less technology methods, the project team had managed to successfully repair almost two and a half miles of pipes without a single trench being dug. By working at night and using compact, portable equipment, the team was able to minimize disruption to the day-to-day running of Frankfurt Airport. Crucially, the solutions that are now in place are expected to last at least 50 years, helping Frankfurt’s 1970s old sanitation system to last well into the second half of the 21st century [20].

### ***Installing Sustainable Stormwater System at Krakow Airport, Poland***

In this airport, the nearby stream into which the rainwater had previously been discharged could no longer handle the growing amounts. It was therefore decided to extend the storm water sewer system by new pressure lines which should lead the water over a distance of 3 km into the Rudawa River (Table 2). 5.85 km of drainage pipes will be installed with many stretches underneath roads and Aircrafts' taxi-ways using trenchless technology of Microtunneling. The works at the airport started in November 2017 and are expected to be completed ahead of schedule at the beginning of 2019. The installation of this new drainage network will lay the foundation for future expansions of the airport, among others a new runway and aircraft hangars. This will allow for the number of flight operations to increase and further strengthen Krakow airport's international importance [21].

Table 2: Sustainable Storm water System at Krakow Airport, Poland

Country/City	Poland / Kraków
Year of installation	2017-2019
Application	Stormwater drainage
Installation	Open trench, microtunneling, pipe-in-pipe
Technologies	<u>Hobas</u> and <u>Flowtite</u>
Total length of pipe	~ 6 km
Pipe specifications <u>Flowtite</u>	5.85 km pressure pipes DN 1000, PN 6, SN 10000 - SN 20000
Pipe specifications <u>Hobas</u>	250 m jacking pipes OD 1280, PN 1, SN 32000 - SN 40000
Investor	International Kraków Airport
Contractor	<u>Rzeszów Engineering S.A.</u> / <u>Abikorp Sp. z o.o.</u>

As can be observed, and from the literature and the many successful stories around the world, The advantages of Trenchless technology in newly installed, maintenance, and rehabilitation of underground infrastructure services are clearly noticeable in the crowded locations, busy streets, and critical locations. It eliminates public disturbance and traffic congestion, reduces construction and maintenance cost, reduces project completion time, with overall benefits to the sustainable economy and environment in the crowded vicinities.

#### **Recommendations:**

Despite its many advantages, yet the decision to use the trench less technology should have careful pre-planning and thoughtful investigation for the type of project, location, soil type and cost. Michigan Department of Transportation [10] recommendation for engineers and decision-makers should recognize that there are conditions where trenchless applications are not appropriate, such as fast emergencies, where immediate excavation of the pavement is necessary, and advanced pre-planning simply cannot be done. In other cases, conditions such as the nature of the soils and rocks below the surface, or the presence and/or uncertain location of existing utilities rule out the use of trenchless technology. Table 1 shows examples of some trenchless technology methods that suite the construction and utility type

in case of new installation. In addition, Engineers and decision-makers should cooperate with city and municipalities for more specific information and guidelines for trench less technology at the pre-plan stages for other rehabilitation and maintenance projects.

Table 3: Recommended Appropriate Techniques for Trenchless New Installation [10].

TECHNIQUE	Water	Sanitary and Storm Sewers	G	Electricity	Telecommunications
Horizontal Auger Boring	√		√	√	√
Pipe Ramming	√	√	√	√	√
Pipe Jacking		√			
Directional Drilling	√	√	√	√	√
Microtunneling		√			
Pipe Bursting	√	√	√		

### Conclusions

In today modern society, having proper underground infrastructure utilities such as, service lines of water wastewater or gas pipes, electric or telecommunication cables, becomes an essential part of the our daily life and inhabitant communities, installing new utilities and maintaining the existing old, or damaged sections are becoming costly and disturbing for the society (traffic and pedestrian delays, business disruption) and environment (safe trees, landscape, less gases emission, and less pollution to water and soils). This problem is especially magnified and tedious in crowded cities, and critical locations. Trenchless technology is a new technology successfully utilized in many developed countries. Yet, it is not commonly adopted by the majority of the crowded cites in the Arab countries. With the increasing popularity of the Trenchless technologies, many innovative methods have been developed to suit different types of utilities, soil conditions and locations. Many benefits could be gain by introducing these sustainable technology solutions in the region such as lowering construction cost, less traffic and pedestrian congestion and headache, and many others advantages that demonstrate the merits of adopting trenchless technologies for sustainable development of underground infrastructure systems.

### References

- [1] McKim, R., (1997). Bidding strategies for conventional and trenchless technologies considering social costs. *Canadian Journal of Civil Engineering* 24 (5), 819–827.
- [2] Arends, G., Bielecki, R., Castle, J., Drabek, S., Haack, A., Nedbal, F., Nordmark, A., Sterling, R., (2004). Risk budget management in progressing underground works. *Tunneling and Underground Space Technology* .19 (1), 29–33.
- [3] E.K. Zaneldin. (2006).Trenchless construction: An emerging technology in United Arab Emirates. *Tunneling and underground space technology*. 22(2007) 96-105.
- [4] Russell, D.E., Davies, A.T., (1997). New tools for water main asset management. *No-Dig Engineering* 4 (4), 2–6.
- [5] Schreyer, J., (1998). GSTT investigation: guidelines for selecting construction methods for earth-laid lines. *Tunnelling and Underground Space Technology* 13 (2), 129–130.

- [6] Ariaratnam, S.T., Lueke, J.S., Allouche, E.N., (1999). Utilization of trenchless construction methods by Canadian municipalities. *Journal of Construction Engineering and Management* 125 (2), 76–86.
- [7] [http://www.hms-it.co.uk/trenchless\\_technology.htm](http://www.hms-it.co.uk/trenchless_technology.htm)
- [8] Bauhan, T., Fowler, D., Haas, C., (1997). Performance testing of trenchless wastewater line spot repairs. *Journal of Infrastructure Systems* 3 (1), 40–48.
- [9] Committee on Construction Equipment Techniques, (1991). Trenchless excavation construction methods: classification and evaluation. *Journal of Construction Engineering and Management* 117 (3), 521–536.
- [10] Michigan Department of Transportation Trenchless Guidelines. *Michigan*, USA. 3701(11/06). USA
- [11] Mohammad Najafi, Brett Gunnink, (2005), " Preparation of Construction Specifications, Contract Documents, Field Testing, Educational Materials, and Course Offerings for Trenchless Construction", *Missouri Department of Transportation Organizational Results Division*, Pg.No.4-13.
- [12] Onkar K. Chothe 1 , V.S. Kadam.(2016) Comparative Study of traditional method and innovative method for Trenchless Technology: A Review. *International Research Journal of Engineering and Technology*. V: 03 Issue: 05
- [13] Sherif M. Hafez1, Remon F. Aziz1, A., Attia. (2015) Exploring Critical Factors Affecting upon Micro-tunnelling Equipment Productivity. *International Journal of Education and Research*. Vol. 3 No. 8
- [14] Ariaratnam, S.T. (1999). Sustainable development through innovative underground infrastructure construction practices. *Arizona State University*, Tempe, AZ USA. <http://dl.lib.mrt.ac.lk/handle/123/9383>
- [15] <http://www.istt.com/why-trenchless-no-dig>.
- [16] Samuel T. Ariaratnam. (2003). "Sustainable Development through Innovative Underground Infrastructure Construction Practices' *Arizona state University*, USA.
- [17] <https://trenchlesstechnology.com/the-top-10-in-trenchless-engineering-for-2018-projects/> (Accessed 20-1-2019)
- [18] <https://trenchlesstechnology.com/hdd-dubais-next-big-project/> (Accessed 20-1-2019)
- [19] <https://trenchlesstechnology.com/crossing-under-rio-grande-impulsora-pipeline/> (Accessed 20-1-2019)
- [20] <https://trenchlesstechnology.com/when-trenchless-kept-frankfurt-flying/> (Accessed 20-1-2019)
- [21] <https://trenchlesstechnology.com/flowtite-hobas-pipes-create-sustainable-stormwater-system-at-krakow-airport/>



# A new proposed substance to resist ignition and fire for use in Hajj and Umrah seasons

Mohamed K. Hassan<sup>(1)</sup>, Mohammed Y. Abdallah<sup>(1)</sup>, Talal S. Mandourah<sup>(1)</sup>, Ahmed F. Mohamed<sup>(1)</sup>, Ibrahim Bushnaq<sup>(2)</sup>, S. Azim<sup>(1)</sup>

<sup>(1)</sup> Mechanical Engineering Department, College of Engineering and Islamic Architecture, Umm Al-Qura University

<sup>(2)</sup> Volume Group Limited

## مادة جديدة مقترحة تقاوم الاشتعال والحرائق لاستخدامها في مواسم الحج والعمرة

أ.د. محمد قرنى حسن<sup>(1)</sup>، د. طلال مندوره<sup>(1)</sup>، د. محمد يحيى عبد اللاه<sup>(1)</sup>، د. أحمد فتحى محمد<sup>(1)</sup>

م. إبراهيم بوشناق<sup>(2)</sup>، م. سفيان أعظم<sup>(1)</sup>

<sup>(1)</sup> قسم الهندسة الميكانيكية، كلية الهندسة والعمارة الإسلامية، جامعة أم القرى

<sup>(2)</sup> فوليوم جروب ليميتد

### ملخص البحث (Abstract):

يتوافد الملايين من الحجاج والمعتمرين على مكة المكرمة والمدينة من مختلف الجنسيات والثقافات في مواسم الحج والعمرة. وهناك خدمات يحتاجها الحجاج والمعتمر من وسائل نقل واعاشه واسكان وتنقل بين المشاعر المقدسة اثناء موسم الحج مما يؤدي الى زيادة فرص التعرض لمخاطر الحريق. وبالرغم من كون الخيام المتواجدة في المشاعر المقدسة مضادة للحريق الا ان وجود كميات هائلة من المواد القابلة للاشتعال خارج الاماكن المقدسة مثل الفرش في الفنادق ووسائل النقل وغيرها من مصادر الحريق مما يزيد من احتمالية حدوث حرائق. لذلك تهدف هذه الدراسة الى تقديم مادة سائله تقاوم الاشتعال بفعالية كبيرة كما ان هذه المادة آمنة على الانسان والبيئة وليس لها أي انبعاثات بالإضافة الى تكلفتها القليلة. علاوة على انه يمكن استخدام هذه المادة في كل الاماكن التي يتردد عليها الحجاج والزوار للاماكن المقدسة

Millions of pilgrims flock to Makkaha and Medina from different nationalities and cultures during the Hajj and Umrah seasons. There are services needed by Hajj and Umrah visitors from the means of transportation, accommodation, moving between sacred feelings and the end of the pilgrimage season, which leads to increased opportunities for exposure to fire risks. Although the tents in the holy sites are fireproof, the presence of huge quantities of flammable materials outside the holy places, such as mattresses in hotels, transportation and other sources of fire, increases the likelihood of fires.

Therefore, this study aims to provide a substance that is resistant to ignition very effectively, is safe for humans and the environment and has no emissions, in addition to the low cost. Moreover, this substance can be used in all places frequented by pilgrims and visitors to holy places.

### Introduction

Fire safety is always a big concern wherever a huge number of people gather like in Hajj and Umrah season in Kingdom of Saudi Arabia; KSA. Governments spend a lot of money to prevent fire incidents including training, precautionary measures and using flame retardant and/or fire retardant materials and equipment. The flame retardants are the additives which delay ignition and fire retardants, on the other hand, are the additives which slow down combustion/flame propagation. Flame retardants are added substances, which when added to manufactured materials

like plastics or textiles, during or after manufacture, restrain or suppress the burning process. In the presence of an ignition source, they meddle with combustion at different phases of the burning process, e.g. during heating, ignition or fire spread. The primary function of these additives is to suppress the spread of fires or slow down the flashover time so that people can escape from the premises. Flame retardant chemical additives have been used for several decades to reduce the flammability of resins and polymers found in commercial products such as furniture, mattresses, electronics (e.g., televisions, cell phones), and even children's products such as car seats, strollers, and baby clothing [1-4]. These chemicals are designed to increase the time available to escape from fires by delaying the combustion of the treated materials. However, these flameretardants have been shown to leach or otherwise escape from these products over time and accumulate in both indoor and outdoor environments, raising concerns about human exposure and potential health effects [5-7]. Prior to 2004, polybrominated diphenyl ethers (PBDEs) were one of the most commonflameretardant mixtures used in furniture and electronic products. PBDEs were sold commercially as three different formulations referred to as PentaBDE, OctaBDE, and DecaBDE, each having different applications. However, due to their persistence, bioaccumulation, and potential health effects, PentaBDE and OctaBDE were banned or voluntarily phased out from use beginning in 2002 in many regions of the world, and will soon be added to the list of banned chemicals included in the Stockholm Convention on Persistent Organic Pollutants [8]. PentaBDE was historically used in the highest volumes in North America (primarily U.S. and Canada) to treat polyurethane foam in furniture [9]. The higher use of PentaBDE in North America led to elevated levels of the PentaBDE congeners in the U.S. population relative to European and Asian populations, likely due to a higher exposure from house dust [10-17]. Several studies have recently found associations between human body burdens of PBDEs (primarily PentaBDE) and health effects such as thyroid hormone and androgen abnormalities, cryptorchidism, and low birth weights [18-21]. The phase-out of PentaBDE has led to the development of alternate flame retardant formulations and the increased use of existing flame retardant chemicals to meet flammability standards for polyurethane foam [22]. We recently identified the brominated components of a PentaBDE replacement mixture suspected of high volume use in polyurethane foam [23]; however, for many flame retardants, basic information such as chemical identity and their consumer product applications is typically not available. Lack of information significantly restricts environmental and human health assessments for these chemicals, which is of considerable concern, particularly since the PentaBDE replacement chemicals recently identified were also detected in U.S. house dust [23]. Occurrence in house dust suggests that human exposure to theseflameretardants will also occur, and raises concerns regarding the potential for exposure to other PBDE replacements that have yet to be identified. Though several studies have reported the environmental fate and effects of PBDEs, very little information on the occurrence, fate, and toxicity of their replacement chemicals exists.

### **Research aims**

The aim of this research is to develop a low cost highly flame retardant additive that can be used in liquid or powder form to suppress fire.

The characteristics of the proposed product are as follows:

#### **Cost Efficient**

The aim of the research is to provide an economical solution for energy efficiency and fire protection.

### **Eco-friendly**

The developed product can be used to prevent forest wildfires and does not impact our habitat system.

### **Highly insulate**

The proposed product has an effective isolation property. It can prevent heat transfer between surfaces.

### **Water based/Anti-allergic**

The product does not contain harmful ingredients towards the human health. It is water-based and anti-allergic.

### **Non-toxic Smoke/Less Smoke Pollution**

The smoke formation from materials coated or sprayed with the proposed material is significantly less under fire exposure.

### **Validity Period**

Products and materials sprayed or applied with the additive material are infinitely protected so long as the end item is coated.

### **Free from discoloration and fabric alterations**

After several tests it has been proved that the proposed material does not affect the original characteristics and conditions of fabric materials.

## **Research methodology**

### **Flame Retardants Definition.**

Flame retardants are added substances, which when added to manufactured materials like plastics or textiles, during or after manufacture, restrain or suppress the burning process. In the presence of an ignition source, they meddle with combustion at different phases of the burning process, e.g. during heating, ignition or fire spread. The primary function of these additives is to suppress the spread of fires or slow down the flashover time so that people can escape from the premises[24].

### **Classes of Flame Retardants.**

Flame Retardants, both Reactive and Additive types, can be classified into the following classes [25]:

- Mineral compounds
- Organohalogen compounds
- Organophosphorus compounds

### **Mineral compounds**

These compounds mainly consist of aluminum hydroxide (ATH), huntite, magnesium hydroxide (MDH), and hydromagnesite,[26][27][28][29], red phosphorus, and boron compounds, mostly borates.

### **Organohalogen compounds**

Organochlorines (chlorendic acid derivatives and chlorinated paraffins), organobromines (decaBDE), decabromodiphenyl ethane, polymeric brominated compounds (brominated polystyrenes, brominated epoxy oligomers (BEOs), brominated carbonate oligomers (BCOs), tetrabromobisphenol A (TBBPA), tetrabromophthalic anyhydride and

hexabromocyclododecane (HBCD) compounds fall in this class[30]. These compounds form the largest group of flame retardants used in printed circuit board (PCB) materials [31].

### Organophosphorus compounds

Organophosphates (triphenyl phosphate), resorcinol bis(diphenylphosphate) (RDP), aluminium diethyl phosphinate, bisphenol A diphenyl phosphate (BADP), and tricresyl phosphate (TCP) and dimethyl methylphosphonate (DMMP) compounds are another class of flame retardants [32].

Proposed substance (BET200) works under a gas phase that interrupt chemical reactions that take place in the flame.

BET200 has three main forms. Depending on the materials, BET 200 can be either used as liquid, powder or jelly forms.

## Results and discussion

### Mechanisms of Flame Retardancy

Flame retardation mechanisms usually take place either physically or by chemical actions[31].

There are three modes for the physical flame retardant mechanisms. These are:

- Cooling
- Formation of Protective Layer
- Dilution

Under the cooling mode, an endothermic process is activated by added substances cooling the substrate to a temperature underneath that required for continuing the burning process. After cooling, a solid or gaseous protective layer shields the combustible layer from the gaseous phase. The heat exchange is obstructed by excluding the oxygen required for the combustion process. In dilution mode, to restrain the lower ignition limit of the gas mixture, fillers are incorporated that evolve inert gases on decomposition diluting the fuel in the solid and gaseous phase[33-36].

Chemical action flame retardant mechanisms can be subdivided into two modes:

- Reaction in the solid phase
- Reaction in the gas phase

In the solid phase, the flame retardant causes a layer of carbon to form on the polymer surface by dehydration of the flame retardant that forms a carbonaceous layer by cross linking. This layer acts as an insulation layer, preventing further decomposition of the material. Whereas, in the gas phase the free radical mechanism of the combustion process is interrupted. The exothermic processes are thus stopped, the system cools down and the supply of flammable gases is suppressed[37].The mechanism used by brominated flame retardants (BFRs) is shown in Fi. g. 1.0 At the first stage, bromine breaks down to form a bromine radical. After this HBr forms by the reaction of hydrocarbon with bromine radical. The high-energy H and OH radicals then removed by the reaction of HBr. The high-energy radicals are replaced with low-energy bromine radicals. The HBr consumed is then regenerated by reaction with the hydrocarbon.

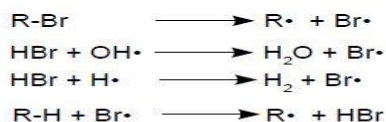


Figure 1 Brominated flame retardants (BFRs) Mechanism [37]

In the category of non-halogenated flame retardants, the phosphorus containing compound is converted to phosphoric acid by thermal decomposition. The phosphoric acid then dehydrates the oxygen containing polymer and causes charring as shown in the Fig.1.2.

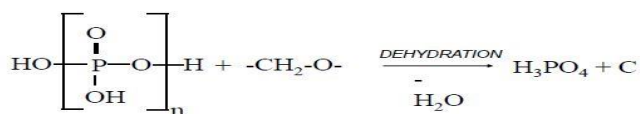


Figure 2 Non-halogenated flame retardants Mechanism[37]

Depending on the above mechanism and chemical reactions, a proposed substance called BET200 is prepared. Table 1 contains the physical and chemical properties of BET200. The benefit of spraying BET200 on wood and polystyrene foams are illustrated in Fig 3 and Fig. 4. Fig. 3 shows that there is no decrease in wood thickness after ignition for 300 seconds whereas

Thickness of wood piece without BET200 starts to decrease after only 5 seconds. This means that BET200 slows the ignition of wood piece for 300 seconds. Similarly, when spraying BET200 on polystyrene foam, the reduction in its thickness is delayed to 2500 seconds. These results clearly reveal the benefits of using BET200 as a fire retardancy substance.

### Summary and conclusion

A new proposed substance called BET200 is prepared and tested to get its chemical and physical properties. BET200 has been shown a significant positive effect on retarding fire when spraying on wood and polystyrene foams. BET200 is safe as it is non-toxic smoke/less smoke pollution and is not harmful as it is eco-friendly..

### Recommendations

3. From the above results, BET200 is recommended as a fire retardancy substance which might be used in holy sites during Hajj and Umrah seasons.

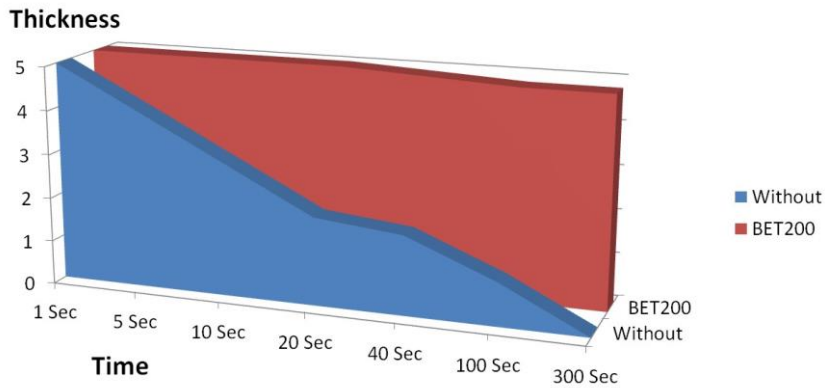
### Figures and Tables

Table 1 Chemical and physical properties of BET200

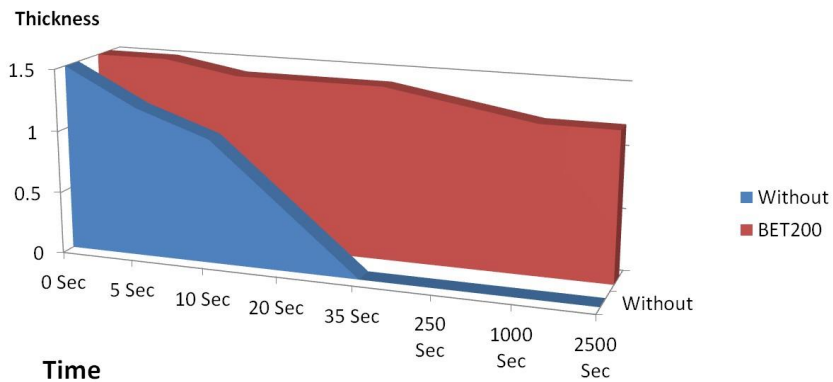
Property	Description
Appearance	Liquid
Boiling Point	98 C
Freezing Point	-2 C
pH	3 – 5
Deflagrate	None
Flammability	None
Flash Point	None
Scent	None
Colour	Turbid
Solvents	Water
Density	1.2 kg/m <sup>3</sup>
Viscosity	1.0

**Table 2 Results of spraying BET200 on foam door and polyester**

BET 200	Heat C° Direct Torch Flame	Sustain Time	Material Thickness after Process
Fire Retardant Fiber / Foam Door 5 cm Thickness	1200 C°	38 Second	1.8 cm
Fire Retardant Fiber / Foam Door 5 cm Thickness (with BET 200)	1200 C°	5 Minutes	4.8 cm
Polyester 1.5 mm Thickness	800 C°	35 Second	0 mm
Polyester 1.5 mm Thickness (with BET 200)	800 C°	35 Minutes	1.2mm



**Fig 3 Effect of spraying BET200 on ignition time of wood.**



**Fig 4. Fig 3 Effect of spraying BET200 on ignition time of polyester (Foam)**

## Referamces:

- [1] Hale, R. C.; La Guardia, M. J.; Harvey, E.; Mainor, T. M. Potential role of fire retardant-treated polyurethane foam as a source of brominated diphenyl ethers to the US environment. *Chemosphere* 2002, 46(5), 729–735.
- [2] Blum, A.; Ames, B. N. Flame-Retardant Additives as Possible Cancer Hazards. *Science* 1977, 195(4273), 17–23.
- [3] Blum, A.; Gold, M. D.; Ames, B. N.; Kenyon, C.; Jones, F. R.; Hett, E. A.; Dougherty, R. C.; Horning, E. C.; Dzidic, I.; Carroll, D. I.; Stillwell, R. N.; Thenot, J. P. Children Absorb Tris-Bp Flame- Retardant from Sleepwear - Urine Contains Mutagenic Metabolite, 2,3-Dibromopropanol. *Science* 1978, 201(4360), 1020–1023.
- [4] Alae, M.; Arias, P.; Sjodin, A.; Bergman, A. An overview of commercially used brominated flame retardants, their applications, their use patterns in different countries/regions and possible modes of release. *Environ. Int.* 2003, 29(6), 683–689.
- [5] Allen, J. G.; McClean, M. D.; Stapleton, H. M.; Webster, T. F. Linking PBDEs in house dust to consumer products using X-ray fluorescence. *Environ. Sci. Technol.* 2008, 42(11), 4222–4228
- [6] Birnbaum, L. S.; Staskal, D. F. Brominated flame retardants: Cause for concern. *Environ. Health Perspect.* 2004, 112(1), 9–17.
- [7] Webster, T. F.; Harrad, S.; Millette, J. R.; Holbrook, R. D.; Davis, J. M.; Stapleton, H. M.; Allen, J. G.; McClean, M.; Ibarra, C.; Abdallah, M. A. E.; Covaci, A. Identifying Transfer Mechanisms and Sources of Decabromodiphenyl Ether (BDE 209) in Indoor Environments Using Environmental Forensic Microscopy. *Environ. Sci. Technol.* 2009, 43(9), 3067–3072.
- [8] Stockholm Convention on Persistent Organic Pollutants. <http://chm.pops.int/>; accessed 2009.
- [9] Hale, R. C.; Alae, M.; Manchester-Neesvig, J. B.; Stapleton, H. M.; Ikonou, M. G. Polybrominated diphenyl ether flame retardants in the North American environment. *Environ. Int.* 2003, 29(6), 771–779.
- [10] Sjodin, A.; Papke, O.; McGahee, E.; Focant, J. F.; Jones, R. S.; Pless-Mulloli, T.; Toms, L. M. L.; Herrmann, T.; Muller, J.; Needham, L. L.; Patterson, D. G. Concentration of polybrominated diphenyl ethers (PBDEs) in household dust from various countries. *Chemosphere* 2008, 73(1), S131–S136.
- [11] Stapleton, H. M.; Dodder, N. G.; Offenber, J. H.; Schantz, M. M.; Wise, S. A. Polybrominated diphenyl ethers in house dust and clothes dryer lint. *Environ. Sci. Technol.* 2005, 39(4), 925–931.
- [12] Wu, N.; Herrmann, T.; Paepke, O.; Tickner, J.; Hale, R.; Harvey, E.; La Guardia, M.; McClean, M. D.; Webster, T. F. Human exposure to PBDEs: Associations of PBDE body burdens with food consumption and house dust concentrations. *Environ. Sci. Technol.* 2007, 41(5), 1584–1589.
- [13] Jones-Otazo, H. A.; Clarke, J. P.; Diamond, M. L.; Archbold, J. A.; Ferguson, G.; Harner, T.; Richardson, G. M.; Ryan, J. J.; Wilford, B. Is house dust the missing exposure pathway for PBDEs? An analysis of the urban fate and human exposure to PBDEs. *Environ. Sci. Technol.* 2005, 39(14), 5121–5130.
- [14] Allen, J. G.; McClean, M.; Stapleton, H. M.; Webster, T. F. Critical Factors in Assessing Exposure to PBDEs via House Dust. *Environ. Int.* 2008, 34, 1085–1091.
- [15] Hites, R. A. Polybrominated diphenyl ethers in the environment and in people: A meta-analysis of concentrations. *Environ. Sci. Technol.* 2004, 38(4), 945–956.
- [16] Sjodin, A.; Patterson, D. G.; Bergman, A. A review on human exposure to brominated flame retardants - particularly polybrominated diphenyl ethers. *Environ. Int.* 2003, 29(6), 829–839.
- [17] Harrad, S.; Ibarra, C.; Diamond, M.; Melymuk, L.; Robson, M.; Douwes, J.; Roosens, L.; Dirtu, A. C.; Covaci, A. Polybrominated diphenyl ethers in domestic indoor dust from Canada, New Zealand, United Kingdom and United States. *Environ. Int.* 2008, 34(2), 232–238.
- [18] Chao, H. R.; Wang, S. L.; Lee, W. J.; Wang, Y. F.; Papke, O. Levels of polybrominated diphenyl ethers (PBDEs) in breast milk from central Taiwan and their relation to infant birth outcome and maternal menstruation effects. *Environ. Int.* 2007, 33(2), 239–245.

- [19] Turyk, M. E.; Persky, V. W.; Imm, P.; Knobeloch, L.; Chatterton, R.; Anderson, H. A. Hormone Disruption by PBDEs in Adult Male Sport Fish Consumers. *Environ. Health Perspect.* **2008**, *116*(12), 1635–1641.
- [20] Meeker, J. D.; Johnson, P. I.; Camann, D.; Hauser, R. Polybrominated diphenyl ether (PBDE) concentrations in house dust are related to hormone levels in men. *Sci. Total Environ.* **2009**, *407*(10), 3425–3429.
- [21] Main, K. M.; Kiviranta, H.; H.E., V.; E., S.; Tuomisto, J. T.; Tuomisto, J.; Vartiainen, T.; Skakkebaek, N. E.; Toppari, J. Flame Retardants in Placenta and Breast Milk and Cryptorchidism in Newborn Boys. *Environ. Health Perspect.* **2007**, *115*(10), 1519–1526.
- [22] Babich, M. A. CPSC Staff Preliminary Risk Assessment of Flame Retardant (FR) Chemicals in Upholstered Furniture Foam; USCPSC: Bethesda, MD, 2006; www.cpsc.gov/library/foia/foia07/brief/ufurn2.pdf.
- [23] Stapleton, H. M.; Allen, J. G.; Kelly, S. M.; Konstantinov, A.; Klosterhaus, S.; Watkins, D.; McClean, M. D.; Webster, T. F. Alternate and new brominated flame retardants detected in US house dust. *Environ. Sci. Technol.* **2008**, *42*(18), 6910–6916.
- [24] U.S. Environmental Protection Agency (2005). Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam (Report). EPA 742-R-05-002A. Retrieved 4 April 2013.
- [25] Hollingbery, LA; Hull TR (2010). "The Thermal Decomposition of Huntite and Hydromagnesite". *Thermochimica Acta.* 509 (1–2): 1–1. doi:10.1016/j.tca.2010.06.012.
- [26] Hollingbery, LA; Hull TR (2010). "The Fire Retardant Behaviour of Huntite and Hydromagnesite - A Review". *Polymer Degradation and Stability.* 95 (12): 2213–2225. doi:10.1016/j.polymdegradstab.2010.08.019.
- [27] Hollingbery, LA; Hull TR (2012). "The Fire Retardant Effects of Huntite in Natural Mixtures with Hydromagnesite". *Polymer Degradation and Stability.* 97 (4): 504–512. doi:10.1016/j.polymdegradstab.2012.01.024.
- [28] Hollingbery, LA; Hull TR (2012). "The Thermal Decomposition of Natural Mixtures of Huntite and Hydromagnesite". *Thermochimica Acta.* 528: 45–52. doi:10.1016/j.tca.2011.11.002.
- [29] Hull, TR; Witkowski A; Hollingbery LA (2011). "Fire Retardant Action of Mineral Fillers". *Polymer Degradation and Stability.* 96 (8): 1462–1469. doi:10.1016/j.polymdegradstab.2011.05.006.
- [30] van der Veen, I; de Boer, J (2012). "Phosphorus flame retardants: Properties, production, environmental occurrence, toxicity and analysis". *Chemosphere.* 88 (10): 1119–1153. Bibcode:2012Chmsp..88.1119V.
- [31] Dr. Oliver Töpfer, Nabaltec. "Boehmite as Halogen Free Flame Retardant Filler Utilized in Cost Effective Production of Highly Reliable Base Laminates", EIPC Summer Conference Milan, September 2012.
- [32] Weil, ED; Levchik, SV (2015). *Flame Retardants for Plastics and Textiles: Practical Applications.* Munich: Carl Hanser Verlag. p. 97. ISBN 1569905789.
- [33] International Electrotechnical Commission IEC 61249-2-21.
- [34] Risks and Benefits in the Use of Flame Retardants in Consumer Products, G C Stevens & A H Mann, University of Surrey: DTI Reference URN 98/1026.
- [35] Babrauskas, V.; Harris, R.; Gann, R.; Levin, B.; Lee, B.; Peacock, R.; Paabo, M.; Twilley, W.; Yoklavich, M.; Clark, H. (1988). NBS Special Publication 749: Fire hazard comparison of fire-retarded and non-fire-retarded products (Report). National Bureau of Standards, Center for Fire Research, Fire Measurement and Research Division. pp. 1–86.
- [36] Schuhmann, J.; Hartzell, G. (1989). "Flaming combustion characteristics of upholstered furniture". *Journal of Fire Sciences.* 7 (6): 386–402. doi:10.1177/073490418900700602.
- [37] Araki, A., Saito, I., Kanazawa, A., Morimoto, K., Nakayama, K., Shibata, E., . . . Kishi, R. (2014). Phosphorus flame retardants in indoor dust and their relation to asthma and allergies of inhabitants. *Indoor Air*, 24(1), 3-15. doi:10.1111/ina.12054.



**Fourth Theme**  
**Technology and its applications**

# Towards Smart Camps in Mina Holy Place: Exploiting IoT Technologies

Mohamed Seddeik Yasein<sup>(1),(2)</sup>, Essam Ali Khan<sup>(1)</sup>, Mohamed Shambour<sup>(1)</sup>

<sup>(1)</sup> The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Makkah, KSA

<sup>(2)</sup> Electrical Engineering Department, Faculty of Engineering, Port-Said University, Port Said, Egypt

## تطبيق مفهوم المخيم الذكي بمشعر منى باستخدام تكنولوجيا إنترنت الأشياء

محمد صديق ياسين<sup>(1)</sup>، عصام علي خان<sup>(1)</sup>، محمد خالد شمبور<sup>(1)</sup>

<sup>(1)</sup> معهد خادم الحرمين الشريفين لأبحاث الحج والعمرة، جامعة أم القرى، مكة المكرمة، المملكة العربية السعودية

<sup>(2)</sup> قسم الهندسة الكهربائية، كلية الهندسة، جامعة بورسعيد، مصر

### ملخص البحث (Abstract):

حظي مفهوم المباني الذكية باهتمام متزايد خلال العقد الماضي، حيث تم تطوير العديد من التقنيات الذكية خلال تلك الحقبة. كما أخذت العديد من المنظمات البحثية مسؤولية وضع تعريف للمبنى الذكي، أو في دراستنا "المخيم الذكي". قد يركز أحد التعريفات على منظور الأداء (الإدارة الفعالة للموارد، راحة المستخدم، القدرة على التكيف بسرعة مع الاحتياجات المتغيرة للمستخدمين، وتقليل التكاليف). وهناك منظور آخر يراعي وجهة النظر التكنولوجية (أتمتة المبنى، الاتصالات، السلامة، الراحة، الخ). وبشكل عام، يجب أن ينظر إلى المخيم الذكي من وجهة نظر متعددة المنظور، بما في ذلك الجمع الصحيح بين الهندسة المعمارية وتكنولوجيا المعلومات والأتمتة والبيئة والطاقة والخدمات وإدارة المرافق، بالإضافة إلى الاهتمام بالراحة والرفاهية، والتكيف المناسب مع الاحتياجات الثقافية.

يصف مصطلح "إنترنت الأشياء" نظامًا يرتبط فيه العالم الرقمي بالعالم المادي الذي يشكل شبكة عالمية. تستخدم تكنولوجيا إنترنت الأشياء أجهزة الاستشعار وتقنية نقل البيانات المدمجة في الأجهزة والمعدات (على سبيل المثال في حالة المخيم الذكي: الأبواب، وحدات الهوية، وحدات التدفئة/التبريد، وحدات الإضاءة، أنظمة المياه، أنظمة الطاقة الكهربائية، أنظمة الاتصالات، وما إلى ذلك). يتيح ذلك تنسيق الكائنات والتحكم فيها عبر شبكة بيانات (إنترنت) بهدف توفير قيمة مضافة للمستخدم (ساكن المخيم). تعرض هذه الدراسة مفهوم المخيم الذكي باستخدام تكنولوجيا إنترنت الأشياء. ويناقش كيفية التحكم في وظائف وحالة المخيم بشكل تلقائي وذكي باستخدام أجهزة الاستشعار المتصلة باستخدام تكنولوجيا إنترنت الأشياء لمراقبة حالة المخيم (مثل درجة الحرارة، الرطوبة، مستشعرات الغازات والأدخنة، مستشعرات الضوء، وما إلى ذلك). توفر تلك المستشعرات البيانات الضرورية المطلوبة للتحكم في مستوى الراحة بالمخيم تلقائيًا وتحسين استخدامية الموارد المتاحة (مثل الطاقة والماء)، بالإضافة إلى تأمين المخيم والحفاظ على أمان المقيمين فيه.

Smart buildings have received increasing interest over the last decade, as various smart technologies have been developed. Various research organizations took the responsibility to define smart building, or in our case smart camp. One definition might focus on the performance perspective (efficient management of resources, user comfort, capability to adapt quickly to changing needs of users, and minimization of costs). Another perspective considers the technological point of view (building automation, communication automation, safety, and convenience). In general, smart camp should be seen from a multi-perspective view point, involving the right combination of architecture, information

technology, automation, environment and energy, services and facility management, in addition to comfort maximizing and proper adaption to cultural needs.

IoT (Internet of Things) exploits sensors, actuators, and data communication technology embedded into physical objects. (e.g., in the case of a smart camp, heating/cooling modules, lighting modules ventilation modules, etc.) to enable objects to be coordinated and controlled across a data network (internet) with the goal of creating value to the user.

This study presents the concept of smart camp using IoT. It discusses how to automatically and smartly control various functions and conditions of the camp by using IoT connected sensors for monitoring the camp status (e.g., temperature, humidity, smoke, light, etc.). These sensors provide necessary data that is required to automatically adjust the comfort level of the camp and optimize the available resources (energy and water) usage, in addition to keeping the camp-site safe and secure.

## 1. Introduction

Millions of Muslims visit Makkah and Madinah to perform Hajj, Umrah, and Ziyarah every year. Several development projects that include renovation and construction of infrastructure, roads, housing, and public transportation are carried out in the two holy cities [1].

Various research organizations took the responsibility to define smart building, or in our case smart camp. One definition might focus on the performance perspective (efficient management of resources, user comfort, capability to adapt quickly to changing needs of users, and minimization of costs). Another perspective considers the technological point of view (building automation, communication automation, safety, and convenience). In general, smart camps should be studied from a multi-perspective view point, including the right combination of architecture, information technology, in addition to comfort maximizing and proper adaption to cultural needs [2].

IoT exploits sensors, actuators, and data communication technology embedded into physical objects (e.g. in the case of smart camps: doors, ventilation modules, heating/cooling modules, lighting modules, water systems, electrical power systems, communication systems, etc.). This enables objects to be coordinated and controlled across a data network (internet) with the goal of creating value to the user [2].

As the electronic processors and sensors that enable IoT have become smaller and less costly, it has become easier to equip devices with computing and communication capabilities that dramatically enhance their usefulness and efficiency. A device that is IoT-enabled is often referred to as a “smart” device, as its connection to networks (or the Internet) offers additional capabilities and functionality. The additional capabilities and functions may include tracking (monitoring), analyzing, and correlating data generated by smart devices. With IoT, these devices can communicate on a larger scale and process information that has never been captured before and, in some cases, respond automatically to improve processes and services [3].

Recent advances in IoT technologies have accelerated their adoption. Advances in such technologies include:

*Small inexpensive electronics:* The cost and size of electronics, for example smartphones, are decreasing, making it easier for the electronics to be embedded into objects, enabling them as IoT devices [3].

*Increasing connectivity:* The expansion of networks and decreasing costs allow for easier connectivity. Networking allows for IoT devices to be easily accessible and connected almost anywhere. The adoption of

smartphones has also accelerated connectivity, as smartphones can connect to multiple types of networks, such as Wi-Fi, cellular, and bluetooth [3].

*Cloud computing:* Since IoT devices can produce a large amount of data, it requires large amounts of computing power to analyze the captured data. Cloud computing is one way to obtain this computing power [3].

*Data analytics:* Advances in data analytics have allowed for the efficient analysis of the rapidly increasing amounts of data created by IoT devices. For example, an algorithm can use data of traffic and road conditions to provide alerts and suggestions of alternative routes [3]. This allows extracting valuable information from the data collected by IoT devices.

However, among the most important challenges that IoT-based technologies will face is poor networking infrastructure, privacy and security problems, short battery life, and lack of standards.

The objective of this paper is to present the concept of smart camp using IoT. It discusses how to automatically and smartly control various functions and conditions of Mina camps and optimize the available resources (energy and water) usage, in addition to keeping the camp-site safe and secure. The paper is organized as follows. Section 2 discusses the background of IoT-based technology along with its uses and system architecture. In Section 3, the proposed IoT-based solutions for Mina Camps are presented. Section 4 discusses an implementation of a case study, along with experimental results. Finally, Section 5 concludes with final remarks.

## **2. Background**

### **2.1 Related Research**

IoT devices are connected to a network so that they work together to provide a specific service. This can be useful in many applications and services like smart buildings, where some sensors collect data, while other devices use it for taking actions [4].

IoT can be applied to create extremely large-scale solutions like smart cities consisting of thousands of sensors and devices [4].

Smart buildings are more private IoT networks at a smaller scale. They are gaining popularity because sensors, microcontrollers, and microcomputers are available at low costs.

Smart buildings can be defined as buildings equipped with automation systems that consist of various sensors and devices used for improving the comfort for residents. Smart buildings are often connected with mobile applications, thus taking the advantage of modern smartphones and tablets. In this way, monitoring data can be easily accessed from any place with an Internet connection [4].

In [5], an architectural model was proposed in which various sensors are connected to a hardware board that wirelessly transmits data to a central node. The received data is sent to a web server and a database server that are deployed locally or in the cloud. The architect of IoT solutions can choose different platforms for end-users. The most common ones are smartphones and tablets; however, these are not the only options. Smart TVs can also be used as devices for displaying the sensor originating information in real time [4].

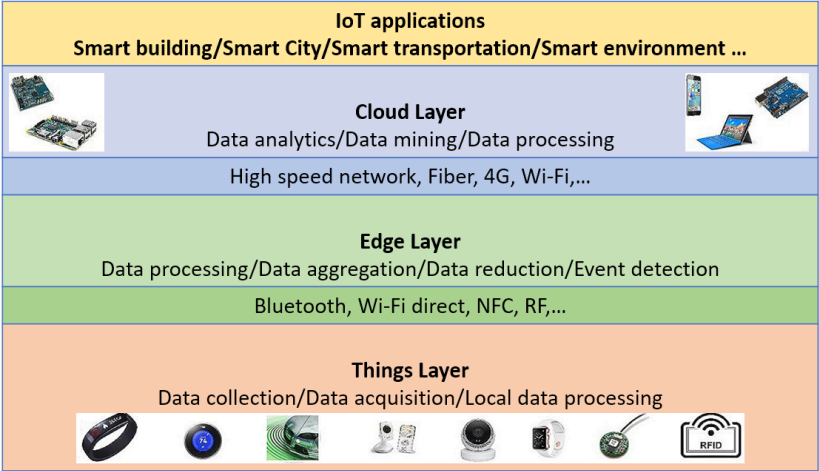
### **2.2 System Architecture of IoT**

IoT is a system that interconnects a set of IoT devices, where a large volume of data can be collected and transferred. Based on the analysis of the collected data, IoT targets building a smart world. A three-layer architecture of IoT systems

is shown in Fig. 1. The three layers are cloud layer, edge layer, and things layer. On top of these layers, IoT applications are run. In each layer, data can be collected, processed, and analyzed. A two-way communication is usually supported among layers [6].

The things layer contains a large number of things including sensors and devices. The cloud and the things are connected, but they usually have no direct communication channels. Therefore, cloud is not an optimal choice to support IoT applications that have features such as high real-time requirements or high mobility.

The edge layer is proposed to make a good contact between the resource-constrained things layer and the resource-rich cloud layer [6].



**2.3 General Uses and Benefits of IoT Technologies**

IoT devices are used across multiple sectors and can be used in almost any circumstance in which human activities or machine functions can be enhanced by data collection or automation [3].

IoT have three main users; consumers, service providers, and the public sector. Consumers can use IoT devices to collect personal information for monitoring and automation uses. On the other hand, service providers can use IoT to optimize processes and cost savings [7,8,9]. Public sector entities can use IoT to address concerns such as environment conditions [3]. Different IoT-based uses are discussed as follows:

*Smart buildings:* IoT-based technologies can be used in buildings for efficient use of resources and energy allocation, in addition to other usages. By analyzing occupancy patterns, smart thermostats can conserve energy by turning the heating and cooling on or off. Also, sensors can detect when an area is unoccupied and automatically adjust the heating, cooling, and lights to reduce energy use. IoT devices are also used for security, by using security cameras that can automatically detect possible intrusions and alert authorities [3].

*Supply chain:* IoT devices can allow suppliers (for example, food suppliers) to detect distribution bottlenecks and improve supply management by reducing labor costs. IoT devices can also enable suppliers to determine amounts of available products, giving them information they need to improve their restocking program [3].

*Health care:* IoT devices, in health care sectors, can use data to improve patient quality of life and safety by enabling patients to monitor their health. Using IoT for transmitting health information to a medical facility can be particularly

beneficial to individuals in congested or rural areas. Health care providers can detect a patient’s location, as well as receive alerts if the patient has a critical condition.

*Environment:* IoT devices can monitor the environmental condition for assessing air quality. Sensors can be distributed around an area to collect information about air quality to provide real-time data. The results can be used to inform people who experience health effects due to poor air quality. IoT devices have also helped in monitoring the environment for potential natural disasters.

*Smart communities:* IoT devices can be used to improve livability, management, and services delivered to residents. For example, IoT technologies can provide real time data about the status of the waste management systems, where sensors are used to determine if waste bins are full and, hence, waste collection crews only collect full containers.

### 3. Proposed Integrated IoT-based Solutions for Mina Camps

IoT exploits sensors, actuators, and data communication technology embedded into physical objects (e.g., in the case of a smart camp, heating/cooling modules, lighting modules, ventilation modules, etc.) to enable objects to be coordinated and controlled across a data network (internet) with the goal of creating value to the users (the camp residents).

This study focuses on the concept of smart camps using IoT and how to, automatically and smartly, control various functions and conditions of the camp by using IoT connected sensors for monitoring the camp status (e.g., temperature, humidity, smoke, light, etc.). These sensors provide necessary data that is required to automatically adjust the comfort level of the camp and optimize the available resources (energy and water) usage, in addition to keeping the camp-site safe and secure.

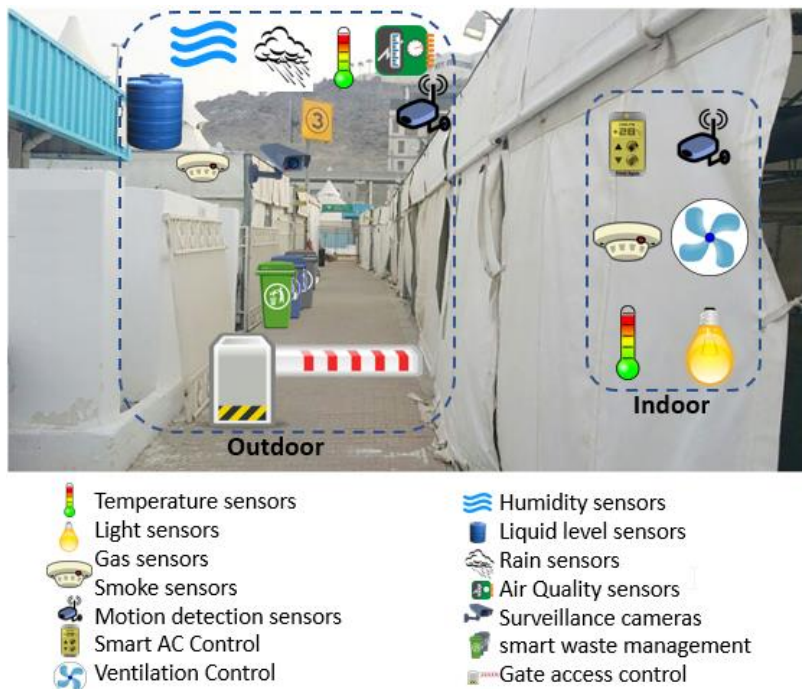


Fig. 2: Different uses of IoT-based technologies in Mina camps (indoor and outdoor).

The proposed solution enables several features through IoT-based technologies within camps.

Examples of these features are:

- Smart air conditioning control (heating, ventilation, and air conditioning (HVAC)) through the captured data from motion sensors, temperature sensors, and humidity sensors.
- Lighting system control (economical use of lights) by using light sensors, motion detection sensors, and surveillance cameras.
- Smart air quality control through the captured data from smoke sensors, rain sensors, temperature sensors, and humidity sensors.
- Automatic notification (sms) to call civil defence offices if some gases are above certain levels by using gas sensors (Co/H<sub>2</sub>S/...).
- Automatic notification (sms) to refill water tanks when empty (or below a certain level) by using liquid level sensors.
- Smart waste management: a smart recycling bin could sort waste automatically. It's sometimes difficult to know where to put different types of plastic, but computer vision could help. Also, fill level monitoring system for bins could reduce the number of unnecessary empties per day to save time and money.
- Smart camp security through utilizing gates access control, surveillance cameras, and RFID.

Another proposal that utilizes IoT-based technologies in Mina community (outdoor) is shown in Fig. 3. The proposed solution enables several features through IoT-based technologies in the surrounding community (roads, sidewalks, areas, etc.). Examples of these features are:

- Smart streetlights: Sensors detect sound or motion, and lights are programmed to turn on and off or raise dimmed lighting level according to pedestrians/vehicles detection to control energy consumption.
- Surveillance cameras: Cameras detect in real-time potential public safety issues and alert officers.
- Traffic signal priority: Sensors detect approaching buses and grant them priority of passage.
- Smart traffic lights: Sensors collect and evaluate real-time information to update traffic signal timing.
- Connected vehicles: Vehicles (buses) communicate with each other and with the infrastructure, which provides the capability to identify hazards on roads and allow receiving alerts.
- Smart guidance boards: Real-time directions and announcements can be displayed on smart guidance boards based on the collected data from street sensors.
- Air-quality sensors: Sensors collect and transmit air quality data that can help identify public or environmental health risks.
- Using IoT devices across multiple sectors by, for example, combining IoT data from traffic cameras, sensors on roads, in cars, and buses, can be combined with weather reports to optimize traffic flow.

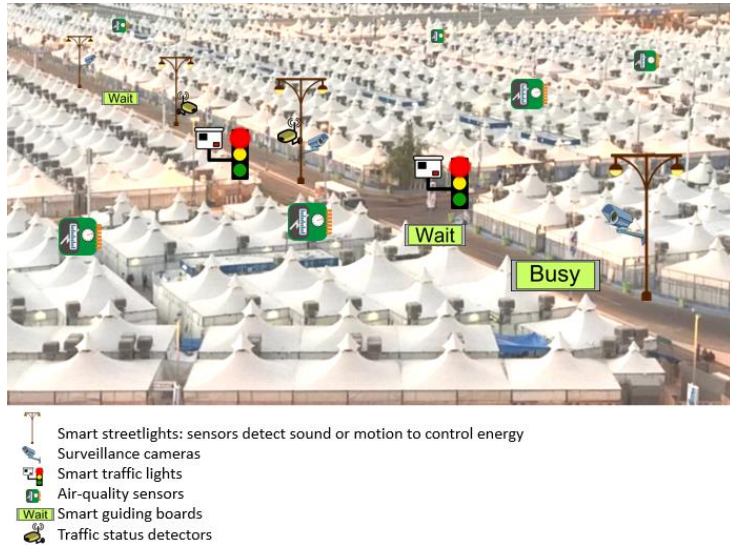


Fig. 3: Different uses of IoT-based technologies in Mina community (outdoor).

#### 4. Implementation and Experimental Results

In this section, the technology, methods and devices that were used to implement the IoT based solution is presented. In addition, an implementation of a case study is discussed.

Sensors are used for data collection by connecting them to microcomputer boards. Such microcomputers integrate and transmit the data to a cloud server. For data visualization, smart phones are used.

The used devices and general architecture of the solution is shown in Fig. 4.

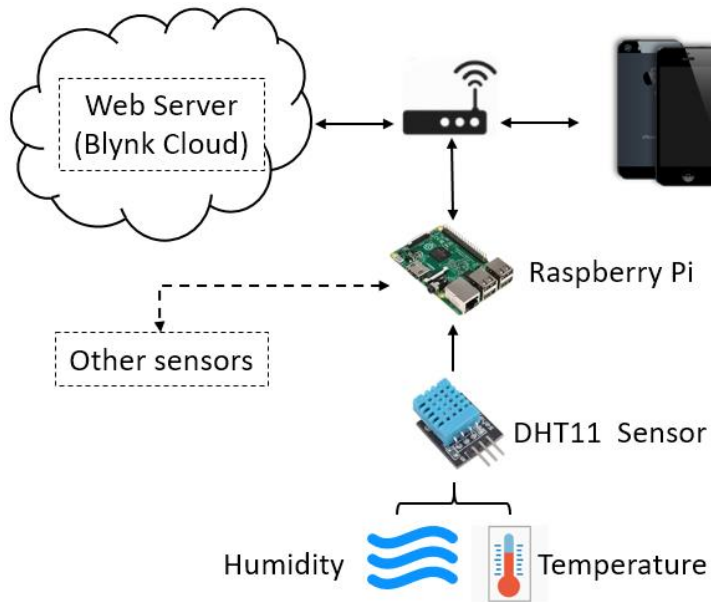


Fig. 4: The IoT Architecture used in the case study.



The main elements of the proposed architecture are as follows:

- **Cloud-Based Server:** The central node of the proposed IoT solution is deployed in Blynk Server<sup>1</sup>. Blynk is a platform for controlling hardware over the Internet. It can control hardware remotely and store (or visualize) sensor data. Blynk Server ( Blynk Cloud) is responsible for communications between the smartphone and hardware (Raspberry Pi in our case).
- **Sensors:** DHT11 sensor is used for temperature and humidity measurements. The small size of the sensor ensures low power consumption and long distance signal transmission. Sensor measurement range for humidity is 20–90 % RH (accuracy  $\pm 5$  % RH) and for temperature 0–50 (accuracy  $\pm 2$ ). The required power supply is 3–5.5 V DC. Other sensor types can be used, for example: light sensors, motion sensors, smoke sensors, etc. Fig. 5-a illustrates the wiring of the hardware board and the used sensors, while Fig. 5-b shows examples of sensors.
- **Microcomputer Board:** Microcomputer Raspberry Pi is used for collecting data from sensors and transmits them over Wi-Fi to the cloud node (Blynk Server). Raspberry Pi is a single-board computer created by the Raspberry Pi Foundation<sup>2</sup>. The key features of the used board is 900 MHz quad-core ARM Cortex-A7 CPU, 1 GB RAM, 4 USB ports, 40 GPIO pins, full HDMI port, and Ethernet port.

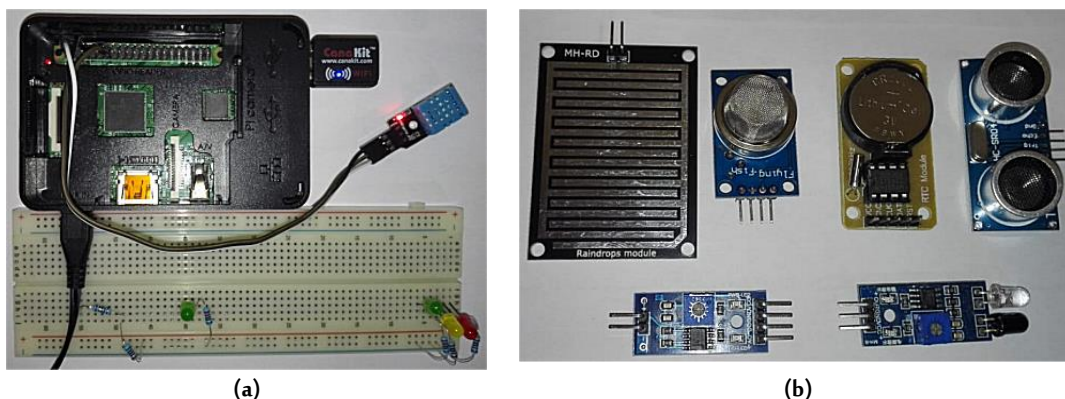


Fig. 5: (a) wiring of the hardware board and the used sensors, (b) examples of sensors.

Hardware boards and sensors can be placed in any location with a Wi-Fi connection. The devices can be powered from a standard USB cable or a portable power bank, so it is possible to collect data in places with no power sources.

A Python based program is used for implementing the data processing and transmission logic.

An Android (or iOS) smart phone is used for data visualization and allows interaction with the IoT application. The connected smart phone is supplied with real-time sensor data updates from the cloud-based node.

An excerpt from Raspberry's Python based sensor data collection program and an example of the collected data is shown in Fig. 6-a. The user-interface of the program is shown in Fig. 6-b, which shows real-time graphical representation of the acquired data (temperature and humidity).

<sup>1</sup> <https://www.blynk.cc/>

<sup>2</sup> <https://www.raspberrypi.org/>



## References:

- [1] Sami Barhamain, "Makkah and Madinah are Smart Cities Planning Perspective", in Proceedings of the 15th Scientific Forum for Hajj and Umrah Research, Madinah, KSA, May 2015.
- [2] B.S. Brad, M.M. Murar, "Smart Buildings Using IoT Technologies, Constructions of Unique Buildings and Structures", 5 (20), 2014. pp. 15-27.
- [3] "INTERNET OF THINGS: Status and implications of an increasingly connected world", GAO-17-75, Published: May 15, 2017, "<https://www.gao.gov/products/GAO-17-75>".
- [4] K. Pinka, J. Kampars, and V. Minkevičs, "Case Study: IoT Data Integration for Higher Education Institution", Information Technology and Management Science, vol. 19, 2016, pp 71-77.
- [5] M. Cata, "Smart university, a new concept in the Internet of Things", in Proceeding of the 14th RoEduNet International Conference – Networking in Education and Research, RoEduNet NER, Craiova, Romania, 2015, pp. 195 –197.
- [6] K. Sha et al., "On security challenges and open issues in Internet of Things", Future Generation Computer Systems, vol. 83, 2018, pp. 326–337.
- [7] Biljana Stojkoska and Kire V. Trivodaliev, "A review of Internet of Things for smart home: Challenges and solutions", Journal of Cleaner Production, vol. 140, 2017.
- [8] A. Botta, W.D. Donato, V. Persico and A. Pescape, "Integration of Cloud computing and Internet of Things: A survey", Future Generation Computer Systems, vol. 56, March 2016, pp. 684–700.
- [9] E. Park, Y. Cho, J. Han, and S. J. Kwon, "Comprehensive approaches to user acceptance of Internet of Things in a smart home environment", IEEE Internet of Things Journal, vol. 4, no. 6, 2017, pp. 2342–2350.

# Using Convolution Neural Network for Crowd Density Estimation for The Holy Masjed

Bandar Alkhuza'im<sup>(1)</sup>, Abdulrahman Altahhan<sup>(2)</sup>

<sup>(1)</sup> The General Presidency of the Holy Masjed and Prophet Masjed Affairs, <sup>(2)</sup> Leeds Beckett University

## تقدير كثافة الحشود بالمسجد الحرام باستخدام الشبكة العصبية الالتفافية

بندر بن محمد الخزيم<sup>(1)</sup> عبدالرحمن الطحان<sup>(2)</sup>

<sup>(1)</sup> الرئاسة العامة لشؤون المسجد الحرام والمسجد النبوي

<sup>(2)</sup> جامعة ليدز بكت

### ملخص البحث (Abstract):

مع الزيادة الهائلة في عدد سكان العالم ، هناك زيادة مباشرة في عدد المشاركين في المناسبات المختلفة ، سواء كانت رياضية أو اجتماعية أو دينية. وهذا يتطلب رعاية أكبر لسلامة وأمن أولئك المتواجدين في مثل هذه الأحداث. هناك عدد من الجوانب التي يجب مراعاتها عند تنظيم وإدارة الأحداث المختلفة من أجل ضمان سلامة الحاضرين مثل تقدير كثافة الحشود. يعد تقدير كثافة الحشود مكوناً مهماً للمراقبة المرئية ويلعب دوراً رئيسياً في مراقبة وإدارة الحشود. نظراً لأهميته ، فقد تم إجراء الكثير من الأبحاث لتقدير كثافة الحشود في مشاهد المراقبة المرئية المختلفة. في هذه الدراسة ، تم بناء وتدريب شبكة عصبية الالتفافية (convolutional neural network) لتقدير كثافة الحشود للمسجد الحرام في مكة المكرمة والتي تعتبر من بين الأماكن الدينية التي تجذب أعداداً هائلة من الناس من جميع أنحاء العالم باستخدام مجموعة من البيانات التي قدمتها الرئاسة العامة لشؤون المسجد الحرام والمسجد النبوي . على الرغم من أن دقة تقدير كثافة الحشود التي تم الحصول عليها من الشبكة العصبية الالتفافية المدربة ليست عالية بما يكفي (70%) لتكون موثوقاً بها في مكان مثل المسجد الحرام ولكن يمكن اعتبارها نتيجة مرضية مقارنة بعدد البيانات التي تم العمل عليها. وتعتبر هذه النتيجة مؤشراً جيداً على أنه يمكن أن تكون النتائج أكثر دقة إذا تم العمل على حجم بيانات أكبر.

With the huge increase in the population of the globe, there is a direct increase in the number of participants and attendance of various events, whether sports, social or religious. This requires greater care for the safety and security of those present in such events. There is a number of aspects that must be taken into account when organize and manage the various events in order to ensure the safety of those present such as crowd density estimation. Crowd density estimation is an important component of visual surveillance and plays a key role in crowd monitoring and management. Because of its importance, much research has been done to estimate the density of crowds in visual surveillance scenes. In this study, a convolutional neural network for crowd density estimation for the Holy Masjed in Makkah which considered among the religious places that attract the huge number of people across the world has been built and trained by using images provided by The General Presidency of the Holy Masjed and Prophet Masjed Affairs (GPH). Although the accuracy of crowd density estimation that obtained from the trained convolutional neural network is not high enough (70%) to be trusted in a place like the Holy Masjed but it can be considered as a satisfactory result

compared to the number of data that have been worked on. This result is considered a good indicator that it could get more accurate if the convolutional neural network trained on large images.

## Introduction

Over the past, there have been controversies on what should be considered a mass gathering. Kollek (2014) defines mass gathering as a group of 1,000 or more people with the same intentions present in a particular location over a given time. The World Health Organization, however, describes mass gathering as “an event attended by a large number of people thereby interfering with the resource planning and response of a community, state, or nation” (WHO, 2008, p.14). Examples of such gatherings include social, religious, and political events. According to Al-Tawfiq and Memish (2014), mass gatherings can be classified into two categories namely planned gatherings and spontaneous gatherings. Planned mass gatherings include various sporting, political, socio-cultural, and religious events such as music festivals, the Olympic Games, and the Hajj in Makkah (Yezli and Alotaibi 2016).

Holy Masjed in Makkah is considered among the religious places that attract the huge number of people across the world. According to Adherents (2014), the world Muslim population is approximately 1.5 billion people. All Muslims aspire to visit the Holy Masjed to perform religious rituals. According to The General Authority for Statistics (2016), the number of Muslim faithful who visited the Holy Masjed during the Hajj month in 2016 were more than 2,000,000 people. Given the large numbers of people visiting these sites, there is a need to direct more efforts to the control and management of the crowd's movements in order to ensure security. A study by Alzhrani (2017) reported various crowd management challenges at the Holy Masjed that negatively affects the level of security and safety at the mass gatherings. Alzhrani (2017) classified the challenges into broad categories namely challenges based on the nature of crowds, challenges of high density, and challenges of the rituals of Islam.

The challenges based on the nature of crowds are due to the fact that Makkah visitors differ in terms of language, ethnicity, socio-cultural environments, and the individual mental abilities. High-density challenges are based on the argument that the Makkah pilgrimage is denser compared to other world events. Islam ritual challenges, however, are due to the fact that the rituals are only performed at the designated places and at specified times of the year/month.

According to Owaidah (2014), crowd management and control incidents have led to injuries and deaths to the visitors. Besides, the incidents have led to people being lost. The incidents are associated with stampedes, overcrowding, and human bottlenecks. Table 1.1 shows a summary of the incidents, their causes, year of occurrence, and the number of casualties (Owaidah 2014, P16).

Nemade and Gohokar (2016) define crowd density as the number of people present in each unit. However, it does not count each individual for density estimation purposes. Crowd density estimation plays a key role in visual surveillance, crowd monitoring, and management. A study by Nemade and Gohokar (2016) grouped crowd density into five classes namely jammed flow, very dense flow, dense flow, restricted flow, and free flow. On the other hand, Aziz et al. (2017) classified crowd density into four categories: jammed, dense, medium, and low. The two studies discussed the various techniques that can be utilized for estimating crowd density using the computer vision. The techniques include pixel counting, object dimension identification, map-based estimation, and texture-based estimation.

Image classification forms the central idea behind crowd density estimation. Convolutional neural networks are essential for addressing issues of image classification especially due to the development of deep learning. Bhandare et

al. (2016) describe the most significant characteristics of convolutional networks. They argue that convolutional neural networks image classification can help in performing image classification without feature extraction and background. In a move to evaluate devices in CNN-based single image crowd counting and density estimation, Sindagi and Patel (2017) compared the crowd density accuracy using different datasets. Analysis of the datasets indicates that crowd density estimation using CNN-based techniques provide more accurate results compared to the traditional approaches. Some of the most commonly used datasets include UCF CC 50, WorldExpo10, UCSD, Shanghai Tech-A, Mall, and Shanghai Tech-B.

### **Significance of the Project:**

Although numerous studies have been crowd density classification and estimation, there is limited empirical literature on the Kingdom of Saudi Arabia. Thus, no data on crowd density estimation utilizing a convolutional neural network at the Holy Masjed in Makkah exist. Given the research gap, this project will not only help in designing and implementing a convolutional neural network necessary for crowd density estimation at the Holy Masjed but also contributes by creating new dataset from the CCTV of the Holy Masjed in testing and training the convolutional neural network.

### **Research Aims**

The main aim of this study is to research, design and develop a convolutional neural network for crowd density estimation at the Holy Masjed at Makkah in order to provide guidance for pilgrims and visitors to increase safety awareness.

### **Research Methodology**

Cross-industry standard process for data mining (CRISP-DM) is used in this research. It is a standard model that helps in describing the common approaches that the data mining experts apply (Sastry and Babu, 2018). It comprises of six steps that include business understanding, modelling, data-preparation, data-understanding deployment and evaluation (figure 1) . This process model can easily be customized and is flexible.

### **Convolutional Neural Network**

The paper tackles a classification problem and building a convolutional neural network (CNN) will assist in addressing this issue. In computer vision, one of the most appropriate state-of-the-art tool is CNN and hence will be applied in this project. These networks use perceptron's which are a machine learning unit for data analysis in supervised learning. CNN finds common applications in tasks such as image processing and other cognitive tasks such as natural language learning. CNN represents a complex example of deep learning comparable to information processing by the human brain (Krizhevsky, Sutskever & Geoffrey, 2012).

The convolutional networks are made up of three main type of layers. These are: convolutional layers, pooling layers and a fully connected layer . The first step to do to use a convolutional neural network in image classification scenarios to have the images in a form that the computer can accept and act on. Unlike the human brain that can look and identify images as they are, a computer can only understand images in the form of a set of numbers that each represents the intensity of a colour in specific pixel in the image. The computer assigns an image pixel values. For example, if a picture is 30\*30 and of full colour, then the computer will assign it an array of pixel values 30\*30\*3. Then it assigns a value from 0 to 255 to each of these numbers to describe the intensity of the pixel at each point.

### **The Dataset:**

The GPH is where the data has been acquired from . Three folders has been used in saving the datasets and they include training, validating and testing datasets that also contain three sub-folders each and encompass high, low and medium densities density.

### **Model Architecture**

Figure 2 shows a part of the summary of the convolutional neural network while illustrating the output shape of each layer in the model architecture. For instance, the first layer is a convolutional layer, keras which has automatically created unique names for all layers, in this case, the convolutional layer is called conv2d\_1, and it has an output of 99 × 99 and 16 feature maps. This convolutional layer needs to train and optimize 208 deferent parameters including weights and biases inside this layer.

### **Results and discussion**

Figure 3 shows the accuracy for both training and validation dataset for every epoch. Both of the training and validation accuracies is around 61%. This indicates that the model could be trained a little more to increase the accuracy, which is important since the accuracy on both datasets is still going up for the last instances. But, when the model has been trained more to increase the accuracy it faced an overfitting problem.

Figure 4 Shows the accuracy and loss for the testing data set. The figure presents the number of testing images as 210 images and the evaluation loss over never before seen images is 0.9061 while the evaluation accuracy over the never seen before images is 75%.

Although different convolutional neural network models were trained to estimate the crowd density for the Holy Masjed, most of them faced overfitting or underfitting problem. The best model accuracy is 75%. This percentage is considered low accuracy in crowd density estimation in general and particularly for crowd density estimation for the Holy Masjed. This percentage is not ideal for The Holy Masjed because of various crowd management challenges at the Holy Masjed that negatively affects the level of security and safety at the mass gatherings.

The main reason for low accuracy that obtained from the convolutional neural network which were built and trained is the number of images (the total number of images is just around 1000 images for training, validation and testing). The numbers of images or data inputs in a convolutional neural network are very important in determining the kind of output or performance expected of a network. In training a convolutional neural network, in most instances it is vitally important to have as many images or data inputs as possible. The number of images or data required will depend on; the complexity in the differences of the data one intends to separate. For example, if the images has to be classified based on colour black and white, then the images required in training might be just a few examples. However, if the images contain numerous other variations within the individual classes, training images might have to be as many as possible per class (Krizhevsky, Sutskever and Hinton, 2012). In instances where very thorough classifications are required and the differences in classes are not that separable, then the neural network needs to have a higher number of iterations on the individual classes to try and make it responsive more accurately and identify the correct data class and this is the case in the Holy Masjed, especially in the area of Tawaf. It is paramount that there are sufficient images in each category so that the system has a larger array of training images to learn from before classifying the respective images in their right categories. Otherwise the network might experience difficulties in trying to fit individual images

into their correct categories. The more the data exposed to the system the more likely the system is to pick inputs and relate them to others already exposed to it in the training and hence making it able to give more accurate results.

In fact, CNNs form one of the most popular deep learning architecture in the world due to their effectiveness in classifying images and it can be used effectively at estimating crowd density. Crowd monitoring and control of public places have become a very demanding endeavor for the past five years (Szegedy et al., 2015). The assortment of human actions, such as religious gatherings enforces crowded scenes to be common in almost all corners of the globe. For this reason, enormous challenges to crowd management, such as analysis, monitoring, identification, and detection of suspicious activities occur. Since the introduction of AlexNet in 2012, the popularity of CNNs have drastically up surged (Simonyan & Zisserman, 2014; Szegedy et al., 2015). In this regard, the convolutional neural network model is now applied to solve almost every image related issue due to its high accuracy and the ability to be successfully used in real-world scenarios. The traditional approaches for dealing with crowd have proven to be ineffective due to severe occlusions and cluttering (Szegedy et al., 2015). One of the major competitive advantages of CNN is its ability to automatically detect significant features in a particular gathering without any human supervision (Szegedy et al., 2015). Moreover, CNN model can be operated on any device due to its ability to apply special convolution and pooling operations and device sharing (Tripathi et al., 2018; Yang et al., 2014). Thus, given by the fact that the CNN model is universally attractive and can be able to achieve superhuman accuracy, it can be applied to monitor and analyze the behavior of the crowd in the Holy Masjed.

In order to ensure peaceful religious event gathering at the Holy Masjed, the planners can rely on CNN model to conduct crowd behavior analysis (Gu et al., 2018). Over the past ten years, organizers at the Holy Masjed relied on traditional approaches to analyze the religious gathering to prevent possible commotion. However, these methods were not effective due to the nonlinearity of real-world images and videos (Tripathi et al., 2018). Although human observers can be used to monitor unusual group activities, the process cannot be possible when confronted with a huge amount of video and image data and this is the case in the Holy Masjed. In this regard, both traditional approaches and human observers cannot be relied upon to monitor group activities (Gu et al., 2018). In this regard, the CNN model possesses the ability to understand and interpret complex scenes and the changes in a particular group. Hence, given by the fact that people at the Holy Masjed can exceed the estimated number, CNN model can be used to access the situation and control the influx of the people (Thoma, 2017).

In a religious gathering, such as the pilgrim at the Holy Masjed, the time factor is critical since every movement takes place in real-time. Thus, in case the observers delay to monitor the situation for seconds, it could lead to calamity. However, Convolutional Neural Networks model can be successfully applied to analyze real-time videos from the multitude. In this case, 3D CNNs model uses time as a third dimension in its analysis (Gu et al., 2018).

Contrary to the conventional methods, CNNs model has the ability to monitor and classify images and videos in densely crowded scenes which are extremely cluttered and have severe ambiguities. In this regard, CNNs model can be useful in controlling and classifying religious crowd at the Holy Masjed. Moreover, obtaining a clear idea of the crowd behaviors at the Holy Masjed without understanding the actions of each individual can be very instrumental in managing the crowd to avoid possible commotion. In this regard, due to the fact that the crowds at the Holy Masjed engage in various activities, it may not be possible to detect and extract the different patterns using traditional approaches, such as human



observation. However, the CNN model can be used to extract and finally classify the details obtained from the crowd to different categories. The neuron in the last fully connected layer within the CNN system are tasked with the classification of the information obtained while the extraction of the details is done by the convolution layers.

**Summary and conclusion:**

The major conclusions can be summarised as follows:

- CNNs form one of the most popular deep learning architecture in the world due to their effectiveness in classifying images and it can be used effectively at estimating crowd density.
- The accomplishment of CNNs in various computer vision operations led to the development of different CNN-based tactics for crowd approximation and counting.
- The results of all the reviewed literature indicated that CNN-based approaches and other techniques that are currently available can achieve enhanced performance in approximating crowd density.
- The numbers of images or data inputs in a convolutional neural network are very important in determining the kind of output or performance expected of a network.
- CNNs model has the ability to monitor and classify images and videos in densely crowded scenes which are extremely cluttered and have severe ambiguities.

**Recommendations:**

1. One of the limitations with this project is the number data samples. Therefore, one potential for future work is to increase the number of data samples processed during the learning stage for the Holy Masjed.
2. When the model obtained high accuracy the GPH can deploy the system as shown in Figure 5.
3. Further study for crowd density estimation for the Holy Masjed by counting the detected objects ( counting the head) may provide more accuracy.

Table 1 (Owaidah 2014, P16)

Date	Accidents	Casualties
1957	Fire	200 pilgrims died
1990	Suffocation	1426 pilgrims died
1994	Stampede	270 pilgrims died and 180 injured
1998		35 pilgrims died
2001		14 pilgrims died
2003		251 pilgrims died
2004		364 pilgrims died and 244 injured
2006		200 pilgrims died and 289 injured



Figure 1 CRISP-DM Methodology Steps (Sastry and Babu, 2018)

```

1 C:\Users\Mohamed\AppData\Local\Programs\Python\Python36\
python.exe "C:/Users/Mohamed/Desktop/New folder/untitled1/
HolyMosque1.py"
2 Using TensorFlow backend.
3 -----
4 Layer (type)                Output Shape
5 -----
6 conv2d_1 (Conv2D)          (None, 99, 99, 16)    208
7 -----
8 activation_1 (Activation)  (None, 99, 99, 16)    0
9 -----
10 conv2d_2 (Conv2D)          (None, 98, 98, 16)   1040
11 -----
12 activation_2 (Activation)  (None, 98, 98, 16)    0
13 -----
14 max_pooling2d_1 (MaxPooling2) (None, 49, 49, 16)    0
15 -----
16 dropout_1 (Dropout)       (None, 49, 49, 16)    0
17 -----
18 conv2d_3 (Conv2D)          (None, 48, 48, 16)   1040
19 -----
20 activation_3 (Activation)  (None, 48, 48, 16)    0
21 -----
22 conv2d_4 (Conv2D)          (None, 47, 47, 16)   1040
23 -----

```

Figure 2

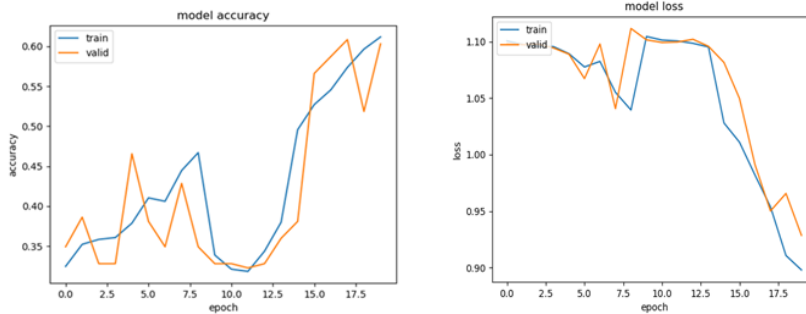


Figure 3

71 Found 210 images belonging to 3 classes.  
72 Evaluation Loss over never before seen images is: 0.9061  
73 Evaluation Accuracy over never before seen images is: 75.00

Figure 4

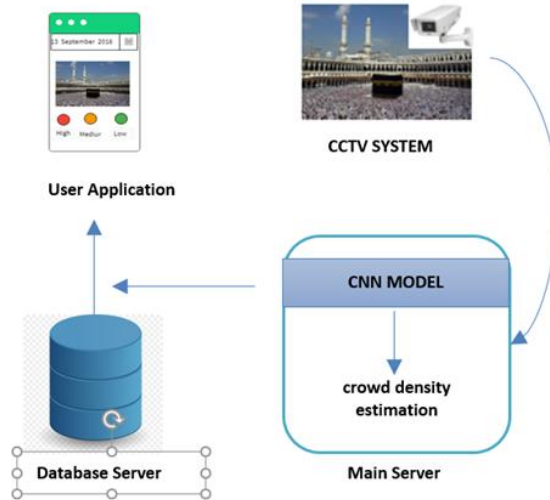


Figure 5

## References:

- Adherents (2018). Major Religions Ranked by Size. [online] Adherents.com. Available at: [http://www.adherents.com/Religions\\_By\\_Adherents.html](http://www.adherents.com/Religions_By_Adherents.html) [Accessed 13 Apr. 2018].
- Al-Tawfiq, J. and Memish, Z. (2014). Mass gathering medicine: 2014 Hajj and Umra preparation as a leading example. *International Journal of Infectious Diseases*, [online] 27, pp.26-31. Available at: <https://www.sciencedirect.com/science/article/pii/S120197121401580X> [Accessed 5 Apr. 2018].
- Alzhrani, M. (2017). جهود المملكة العربية السعودية في إدارة الحشود في موسم الحج..
- 6. Aziz, M., Naeem, F., Alizai, M. and Khan, K. (2017). Automated Solutions for Crowd Size Estimation. *Social Science Computer Review*, [online] 36(5), pp.610-631. Available at: <http://journals.sagepub.com/doi/abs/10.1177/0894439317726510> [Accessed 16 Apr. 2018].
- Bhandare, A., Bhide, M., Gokhale, P. and Chandavarkar, R. (2016). applications of convolutional neural networks. *International Journal of Computer Science and Information Technologies*, [online] pp.2206-2215. Available at: <https://pdfs.semanticscholar.org/89db/184cb8b1397a9aa35693f8dc03e1e728992a.pdf> [Accessed 16 Apr. 2018].
- General Authority for Statistics (2016). Hajj Statistics for 1437H - 2016. [online] General Authority for Statistics. Available at: <https://www.stats.gov.sa/en/4489> [Accessed 8 Apr. 2018].
- Gu, J., Wang, Z., Kuen, J., Ma, L., Shahroudy, A., Shuai, B., Liu, T., Wang, X., Wang, G., Cai, J. and Chen, T. (2018). Recent advances in convolutional neural networks. *Pattern Recognition*. [online] pp.354-377. Available at: [https://ac.els-cdn.com/S0031320317304120/1-s2.0-S0031320317304120-main.pdf?\\_tid=af75709b-fff8-443b-bf1d-2c776439e571&acdnat=1537532715\\_fd61b20463b30dca98553c2c4763b10f](https://ac.els-cdn.com/S0031320317304120/1-s2.0-S0031320317304120-main.pdf?_tid=af75709b-fff8-443b-bf1d-2c776439e571&acdnat=1537532715_fd61b20463b30dca98553c2c4763b10f) [Accessed 13 Jul. 2018].
- Kollek, D. (2014). An Introduction to Mass Gatherings. [ebook] Available at: [http://www.ceep.ca/publications/Mass\\_Gatherings.pdf](http://www.ceep.ca/publications/Mass_Gatherings.pdf) [Accessed 18 Apr. 2018].
- Krizhevsky, A., Sutskever, I. and Hinton, G. (2012). ImageNet classification with deep convolutional neural networks. *Advances in neural information processing systems*, [online] pp.1097-1105. Available at:

<http://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf> [Accessed 12 Jul. 2018].

- Nemade, N. and Gohokar, V. (2016). A Survey of Video Datasets for Crowd Density Estimation. *Global Trends in Signal Processing, Information Computing and Communication (ICGTSPICC)*, [online] pp.389-395. Available at: [https://www.researchgate.net/profile/Vinaya\\_Gohokar/publication/317927392\\_A\\_survey\\_of\\_video\\_datasets\\_for\\_crowd\\_density\\_estimation/links/5993d07fa6fdccaded1de52a/A-survey-of-video-datasets-for-crowd-density-estimation.pdf](https://www.researchgate.net/profile/Vinaya_Gohokar/publication/317927392_A_survey_of_video_datasets_for_crowd_density_estimation/links/5993d07fa6fdccaded1de52a/A-survey-of-video-datasets-for-crowd-density-estimation.pdf) [Accessed 19 Apr. 2018].
- Owaidah, A. (2014). *Hajj Crowd Management via a Mobile Augmented Reality Application: A case of The Hajj event, Saudi Arabia..* Master. Glasgow.
- Palkar, S., Thomas, J., Narayanan, D. and Shanbhag, A. (2017). Weld: Rethinking the interface between data-intensive applications. [online] Available at: <https://arxiv.org/pdf/1709.06416.pdf> [Accessed 18 Jun. 2018].
- 81. Sastry, S. and Babu, M. (2018). Implementation of CRISP methodology for ERP systems. *International Journal of Computer Science Engineering*, [online] 2(5), pp.203-217. Available at: <https://arxiv.org/ftp/arxiv/papers/1312/1312.2065.pdf> [Accessed 20 Jul. 2018].
- Simonyan, K. and Zisserman, A. (2014). Very deep convolutional networks for large-scale image recognition. *arXiv preprint arXiv:1409.1556*. [online] Available at: <https://arxiv.org/pdf/1409.1556.pdf> <http://arxiv.org/abs/1409.1556> [Accessed 17 Jul. 2018].
- Sindagi, V. and Patel, V. (2017). A survey of recent advances in CNN-based single image crowd counting and density estimation. *Pattern Recognition Letters*, [online] 107, pp.3-16. Available at: <https://www.sciencedirect.com/science/article/pii/S0167865517302398> [Accessed 17 Apr. 2018].
- Szegedy, c., Liu, W., Jia, Y., Sermanet, P., Reed, S., Anguelov, D., Erhan, D., Vanhoucke, V. and Rabinovich, A. (2015). Going deeper with convolutions. *Proceedings of the IEEE conference on computer vision and pattern recognition*, [online] pp.1-9. Available at: [https://www.cv-foundation.org/openaccess/content\\_cvpr\\_2015/papers/Szegedy\\_Going\\_Deeper\\_With\\_2015\\_CVPR\\_paper.pdf](https://www.cv-foundation.org/openaccess/content_cvpr_2015/papers/Szegedy_Going_Deeper_With_2015_CVPR_paper.pdf) [Accessed 30 Jul. 2018].
- Tripathi, G., Singh, K. and Vishwakarma, D. (2018). Convolutional neural networks for crowd behaviour analysis: a survey. *The Visual Computer*, [online] pp.1-24. Available at: <https://link.springer.com/content/pdf/10.1007%2Fs00371-018-1499-5.pdf> [Accessed 10 Jul. 2018].
- World Health Organization (2008). *Communicable disease alert and response for mass gatherings*. [ebook] Available at: [http://www.who.int/csr/Mass\\_gatherings2.pdf](http://www.who.int/csr/Mass_gatherings2.pdf) [Accessed 16 Apr. 2018].
- Yang, J., Li, J. and He, Y. (2014). Crowd Density and Counting Estimation Based on Image Textural Feature. *Journal of Multimedia*, [online] 9(10). Available at: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.658.6282&rep=rep1&type=pdf#page=20> [Accessed 11 Jul. 2018].
- Yezli, S. and Alotaibi, B. (2016). Mass gatherings and mass gatherings health. *Saudi Medical Journal*, [online] 37(7), pp.729-730. Available at: [https://www.researchgate.net/publication/304990470\\_Mass\\_gatherings\\_and\\_mass\\_gatherings\\_health](https://www.researchgate.net/publication/304990470_Mass_gatherings_and_mass_gatherings_health) [Accessed 15 Apr. 2018].

# Crowd Congestion Assessment using Multi-Resolution Clustering

Yasser Mohammad Seddiq, Ayman A. Alharbiy, Moayyad Hamza Ghunaim  
King Abdulaziz City for Science and Technology

## تقييم ازدحام الحشود باستخدام التكتل ذي الدقة المتغيرة

ياسر بن محمد صديق، أيمن بن أحمد الحربي، مؤيد بن حمزة غنيم  
مدينة الملك عبدالعزيز للعلوم والتقنية

### ملخص البحث (Abstract):

يتطرق هذا البحث لمشكلة ازدحام الحشود والتي تحدث في عدة مواقع في الحج والعمرة كمدخل المسجد الحرام وجسر الجمرات من خلال حل يعتمد على تقنية التكتل، فعند التقاط صورة علوية للحشود المراد تحليلها يبدأ الخوارزم بإيجاد الكتل ذات الكثافة العالية التي تتسم بتقارب أعضاء الكتلة الواحدة بمسافة لا تزيد عن حد معين، وبما أن الازدحام يحصل دائما في الكتل البشرية الضخمة، فإن الكتل التي يستخرجها الخوارزم تفرز حسب أحجامها حيث تستبعد الكتل الصغيرة بينما تخضع الكتل الكبيرة لمزيد تحليل ومعالجة، ولأن ثمة احتمال بأن تكون إحدى تلك الكتل الكبيرة ما هي إلا تجمع لكتل أصغر تبدو كما لو كانت كتلة واحدة، فإن الكتل الكبيرة المستخرجة في المرحلة السابقة تخضع لعملية تكتل مرة أخرى ولكن باعتبار مسافة أقرب بين أعضاء الكتلة الواحدة وبهذه الطريقة فإن الكتل الصغيرة التي كانت تميز بأنها كتلة واحدة مندمجة ستنفصل عن بعضها البعض ومن ثم تستبعد، بينما الكتل الكبيرة ستصمد أمام محاولة تقسيمها فميزها الخوارزم بأنها كتل واحدة مزدحمة، ثم يتم أخيرا تقييم درجة الازدحام إلى ثلاث درجات: أشد درجة حينما توجد الكتل الكبيرة في كلتا المرحلتين، أما أوسطها فحين تظهر الكتل الكبيرة في المرحلة الأولى ثم تختفي في الثانية، وحين لا تظهر الكتل الكبيرة عند المرحلة الأولى فتلك أقل درجات الزحام.

This work addresses the problem of crowd congestion that could happen in many places in the Hajj and Umrah such as at the gates of the Haram or the Jamarat Bridge. The proposed solution utilizes unsupervised clustering technique that is applied on a top view image of the crowd. The first stage of the algorithm determines the number of clusters whose members are within proximity threshold. Based on the fact that large clusters are likely to represent a congestion, clusters are qualified upon their sizes where small clusters are disqualified as congestion candidates. However, it is still possible that a big cluster might consist of smaller clusters that are recognized as one super-cluster due to the coarse resolution of the proximity threshold applied in the first stage. Therefore, a potential congested cluster is further analyzed using a proximity threshold of finer granularity to examine its steadfastness against sub-clustering. Finally, based on the outcomes of the two stages, the degree of congestion is assessed into three levels: the highest degree is when big clusters appear in the first stage and persist in the second, the moderate degree is when big clusters appear in the first stage, but disappear in the second, whereas the lowest degree is when no big cluster appear at all. The algorithm is tested under different scenarios of various degrees of congestion.

## **Introduction:**

Crowd congestion is a critical challenge during Hajj and Umrah. Authorities practice extreme caution observing the potential places of congestion such as gates of The Grand Mosque, Jamaraat Bridge and walking paths. Well-trained officials monitoring crowds are capable to spotting potential congestions early enough to avoid any undesired consequences. Providing those officials with smart assistive technologies would significantly boost their efficiency and enable them to solve more complicated problems in the field.

Clustering algorithms are efficient data mining tools that can be used in crowd management applications. Clustering algorithms differ on their dependence on crowd shape and centroid [1]. Thus, algorithms that are shape- and centroid-independent are the most suitable for crowd management applications due to the high agility of the shape of a crowd mass and its infinite shape possibilities.

Clustering algorithms do the job of grouping nodes in that are logically related to each other. In a crowd management problem, nodes relationships are checked based on distance such that a nodes that are within proximity of each other are deemed one cluster. Clustering algorithms are considered of NP-hardness [2]. They can be classified into two categories: (i) partitional clustering where nodes are divided into non-overlapping clusters, and (ii) hierarchical clustering, where the algorithm divides big clusters into smaller ones (top-down) or merges small clusters into bigger ones (bottom-up) [3–5]. Both types can serve in solving crowd management problems.

## **Research aims:**

This paper presents reports the work of devising an algorithm capable of detecting a congestion crowd and evaluating its severity level. The algorithm involves multiresolution clustering that enables the algorithm to distinguish the density of a crowd mass. Congestion is measured based on three-level evaluation scale. The paper presents detailed description of the algorithm and its test results.

## **Research methodology:**

The proposed algorithm measures the severity of a crowd congestion by applying two stages of clustering on the crowd scene. The algorithm involves two clustering stages: a coarse-resolution clustering roughly spotting the zones of potential congestion followed by a fine-resolution re-clustering stage focusing on those hot zones to check their persistence. By the second clustering stage, if all nodes within the hot zone clusters are busted into individual nodes that are too sparse or too few to form one cluster, then, this crowd is deemed moderately congested. The more persistent the nodes to stay in one cluster after the double clustering, the higher the congestion severity is estimated. A safe situation is declared either when no hot zones are detected by the coarse clustering stage (hence no need to start the fine clustering), or when there is initially no enough nodes to process by the coarse clustering stage in the first place. The detailed steps of the multi-resolution algorithm is described in the following.

The flow chart of Figure 1 illustrates the algorithm. A preprocessing stage is assumed that involves acquiring a top-view image of the crowd and extracting the  $(x,y)$ -coordinates of people in the scene. The algorithm starts by counting the people making the crowd. Unless the number of people exceeds threshold  $N$ , the algorithm does not proceed and a “no

congestion” decision is made terminating the process. Otherwise, the second step of clustering is applied on the data considering coarse distance resolution. At this resolution level, any two persons separated by distance less than  $r$  are considered members of the one cluster. The outcome of the coarse-resolution clustering is a set of clusters formed by people who are in close proximity of each other. Among those clusters, there could be small clusters containing too few people that do not give signs of potential congestion. Such clusters are eliminated and discarded in the subsequent steps. The remaining big clusters, which are called the hot zones, are worth worrying about and, hence, are qualified for further re-clustering. In case when no hot zones are identified by the coarse-resolution clustering, the algorithm terminates by deciding “no congestion”. Otherwise, the next step of re-clustering the hot zones starts.

The second step involves fine-resolution clustering, where people falling into the hot zone are grouped together based on distance threshold  $d$  such that  $d < r$ . The value gained by using finer distance resolution is to discover whether some hot zone is really formed by congested people or it is just a super-cluster made of smaller clusters. In this stage, the hot zones are processed one by one. The outcome of each iteration is also a set of clusters forming the hot zone under test. Similar to the previous step, the small clusters are disqualified. If all clusters within the current hot zone are disqualified, then, the current iteration ends and the next iteration starts by re-clustering the next hot zone. The algorithm proceeds tackling all hot zones, and if all busted, the algorithm declares “moderate congestion” and terminates.

If it happens that in one of the iteration described above, the re-clustering process returns at least one yet qualified cluster, then, the hot zone persists and the algorithm fails to bust that hot zone into negligible sub-clusters. In this case, the algorithm does not iterate any further, but terminates by deciding “severe congestion”.

While the fine-resolution clustering alone is adequate to detect congestion or no-congestion states, it fails to evaluate the level of severity whether it is severe or moderate as the multi-resolution approach does.

### **Results and discussion:**

The algorithm is applied on synthetic data that is generated to mimic different crowd scenarios as depicted in Figure 2. Result plots are presented in the figure as a 2D matrix where the left-most column shows the original data before being input to the algorithm, the middle column shows the output of the coarse-resolution clustering stage, and, finally, the right-most column shows the output of the fine-resolution clustering stage. Each row of the plot is a separate case being processed by the algorithm.

The first crowd case is shown in the first row of the figure (Figure 2(a)–(c)). This is a top-view of a moderate-congestion randomly scattered crowd. The coarse clustering stage manages to bust some nodes that are missing in Figure 2(b), but it still can recognize data as five big clusters (hot zones). When the algorithm tests the steadfastness of the hot zones against sub-clustering, they all disappeared. Hence, this is evaluated as a moderate congestion.

Two different no-congestion crowd cases are presented in Figure 2(d)–(f) and Figure 2(g)–(i). The nodes, in both cases, cannot stand the coarse-resolution clustering as can be observed in the empty plots in the middle. Thus, those are declared as “no congestion”.

Figure 2(j)–(l) illustrates the results of a crowd scene of people organized in groups and queues of several sizes and shapes. The two tiny groups on the top of the scene are filtered out by the coarse clustering stage. Later in the fine-resolution clustering, the rest of the groups disappear, which demonstrates a moderately congested crowd. Likewise, Figure 2(m)–(o) illustrates the results of a crowd scene of people in a walking path. The algorithm also evaluates the case as a moderate-congestion crowd.

Finally, the crowd depicted in Figure(p)–(r) mimics a severely congested crowd of people moving through a wide path getting narrower at the end. It can be clearly seen that the scattered sparse nodes disappear by the coarse-resolution stage. Also, some of the remaining nodes are filtered out by the second stage, while the major crowd mass is persistent till the end. Therefore, this is evaluated as a severe-congestion crowd.

The discussion above demonstrates the correctness of the algorithm and its quality to serve as computer-aided assistive tool for officials who watch crowd and helping them to make the right decision in the proper time.

### **Summary and conclusion:**

The paper reported the work of devising an algorithm that detects crowd and evaluates level of congestion in three-level scale: no congestion, moderate congestion, and severe congestion. The algorithm is capable of evaluating congestion severity by adopting a multiresolution clustering approach. Input data are subject to clustering stages at coarse-resolution and fine-resolution, respectively. The algorithm is implemented and test using synthetic data mimicking crowd scenes of different severity levels. The Algorithm showed correctness in processing them and made evaluation decisions matching expectations.

### **Recommendations:**

3. The research demonstrated the usefulness of the multiresolution clustering in evaluating crowd congestion severity level.
4. The algorithm has a great potential in serving in assistive technologies and computer-aided crowd management systems.
5. The current results set the foundation for more advance work in congestion evaluation applications on real data.



Figures and Tables:

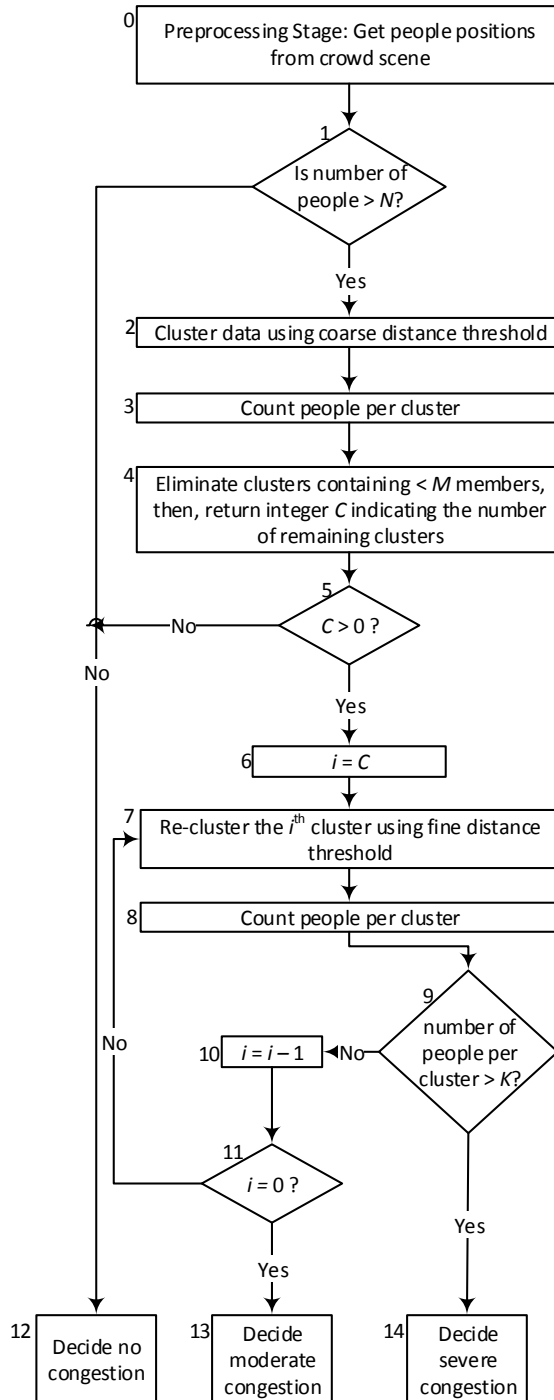


Figure 1: Algorithm flowchart

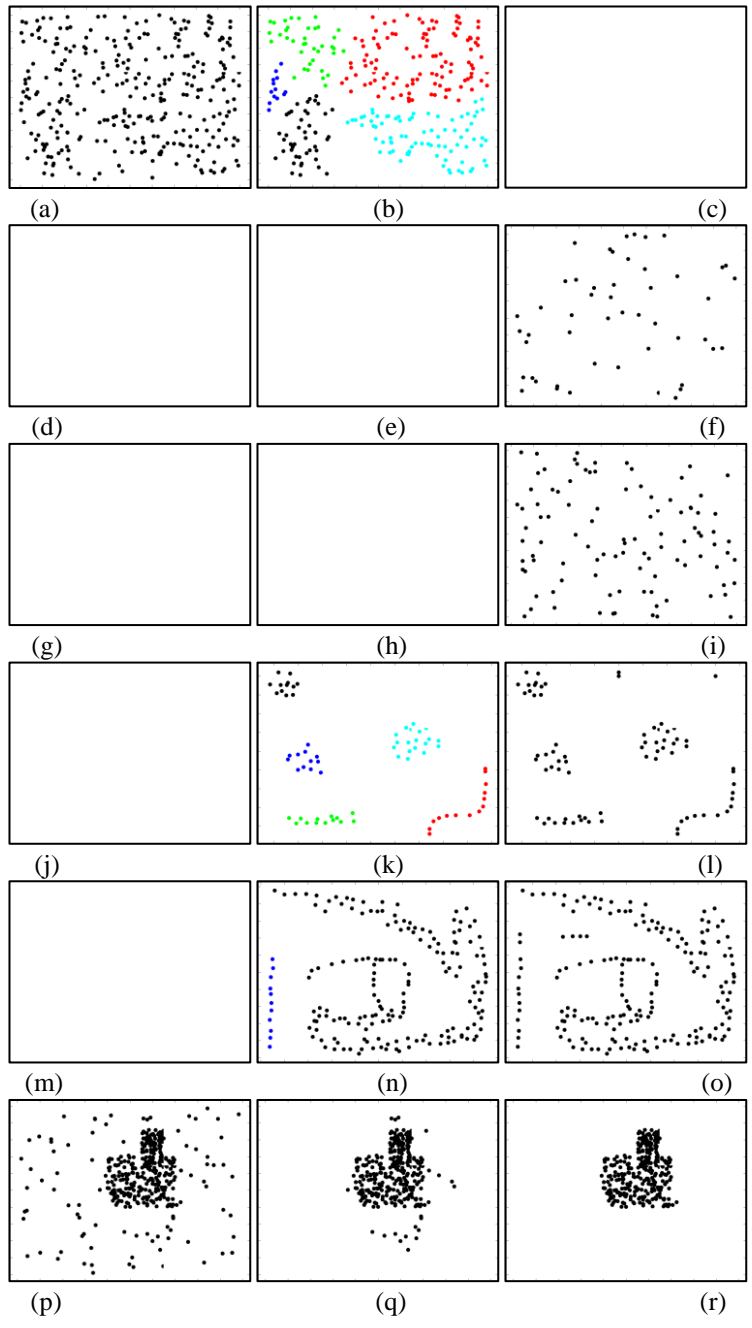


Figure 2: Algorithm test result under different congestion levels

## References:

- [1] M. Gerla and J. Tzu-Chieh Tsai, "Multicluster, mobile, multimedia radio network," *Wirel. Networks*, vol. 1, no. 3, pp. 255–265, 1995.
- [2] T. F. Gonzalez, "On the computational complexity of clustering and related problems," in *System Modeling and Optimization: Proceedings of the 10th IFIP Conference New York City, USA, August 31 -- September 4, 1981*, R. F. Drenick and F. Kozin, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 1982, pp. 174–182.
- [3] H. Steinhaus, "Sur la division des corp materiels en parties," *Bull. Acad. Polon. Sci.*, vol. 1, pp. 801–804, 1956.
- [4] Guojun Shi, Bingkun Gao and Li Zhang, "The optimized K-means algorithms for improving randomly-initialed midpoints," *Measurement, Information and Control (ICMIC), 2013 International Conference on*, Harbin, 2013, pp. 1212-1216.
- [5] L. Rokach and O. Maimon, "Data Mining and Knowledge Discovery Handbook," O. Maimon and L. Rokach, Eds. Boston, MA: Springer US, 2005, pp. 321–352.

# User Preferences- based Recommendation Algorithm

## Case Study: Hajj and Umrah Agencies

Enas Khairullah, Rehab Ashari  
Faculty of computing and information technology, King Abdulaziz University

### خوارزمية التوصية المستندة الى تفضيلات المستخدم

#### دراسة حالة: حملات الحج والعمرة

إيناس خير الله، رهاب أشعري  
كلية الحاسبات و تقنية المعلومات، جامعة الملك عبد العزيز

#### ملخص البحث (Abstract):

تفضيلات المستخدم لها دور مهم في العديد من المجالات مثل الإعلان والتجارة الإلكترونية والرأي الاجتماعي ومحركات البحث. في نظم التوصية ، تفضيلات المستخدم تؤثر بشكل مباشر على دقة التوصية التي تظهر للمستخدم بناء على رغباته. في هذا البحث ، نركز على كيفية تحسين نتائج التوصيات الخاصة ببحث تفضيلات المستخدم على مجموعة من بيانات التصنيف. في هذا البحث تم شرح استراتيجيات مختلفة من خوارزمية الترشيح على أساس تفضيلات المستخدم وإظهار دراستهم بالتفصيل . كما تم اقتراح دراسة حالة تتعلق بجهة الحج والعمرة. ويهدف إلى إنشاء تطبيق للأجهزة المحمولة من نوع أندرويد والذي يساعد الأشخاص في العثور على أفضل حملات الحج والعمرة في مدينتهم التي تلي احتياجات المستخدمين. يعرض التطبيق هذه الشركات وفقاً لموقعها ويمنح خياراً لتحسين نتائج البحث استناداً إلى ملف تعريف المستخدم والتفضيلات التي حددها المستخدمون في شاشة البحث.

User preferences have an important role in many fields such as advertisement, E-commerce, social opinion, and search engines. Mainly in recommender systems, user preferences directly influence the accuracy of the recommendation. In this research we focus on how to improve the recommendation results of user preferences-based search (PBS) on a set of rating data. We explained different strategies of filtering algorithm based on the user preferences and show their studies in details. A practical case study related to Hajj and Umrah agency is proposed. It aims to create an android mobile application that helps people in finding the best Hajj and Umrah company in their city that accommodate user's need. The application shows these companies according to their location and gives an option to optimize the search results based on the user profile and preferences that are selected by the users in the search screen.

#### Introduction

A preferences-based search (PBS) is a process that helps users to find and identify the preferred options and selections based on user's preferences list and criteria. This process is an interactive tool since user can change his/her criteria list if the search results do not lead user's satisfactions. Usually, users on mobile applications or web pages search through a huge database by entering and identifying their preferences list, which are directly mapped to a database query to retrieve a ranked list of the most appropriate options (Hill, Wesson, 2008), (Junker, 2002). PBS helps users in different

situations such as, finding the best apartments based on user's requirements to live in, selecting the best destination and trip deal that satisfy tourist budgets and activities, or buying a special electronic device that fit user's needs.

Different keys should be considered while designing and implementing one of the PBS tools (Viappiani, Faltings, 2006). The tool should be designed in easy interface that helps user to select their criteria and retrieve the satisfy solution in easy way. In addition, the algorithms that are used in the tool should be worked perfectly with the large and huge database. The Graphical User Interface (GUI) of the retrieved results should be displayed in a view that is suitable to the results type either on the map view or a list view as an example.

Hajj and Umrah are considered one of the greatest acts of worship in Islam, where Muslims from various parts of the world travel to Mecca to perform the rituals of Hajj and Umrah. There are hundreds of Hajj and Umrah companies spread in all cities of Saudi Arabia provide Hajj and Umrah Services for citizens and residents. These companies differ in terms of the quality of their services or in providing some services that are not available in other agencies such as, special service for the children, exceptional care for the special need people, serving diet meal service, low price packages, or short distance agency's location. User preferences and priorities are different from one person to another, which makes the searching results are different from one user to another to find the suitable agency to the user that fit his/her requirements in finding the Hajj and Umrah Company.

In this paper, a multi-criteria preference-based searching technique is used to retrieve the best Hajj and Umrah agency to the user from the mobile application database based on user's preferences. The paper is organized as follows. In Section II, work is reviewed that is related to the experiments reported here. In Section III, the used method and model is described. Section IV discussed the case study and the prototype of the proposed method. The paper is concluded in Section V and the future work is outlined in this section too.

## **RELATED WORK**

Using a preference based search method is challenging and is a focus point to many researchers that are interesting in helping users to find their required search results from the database as accurate as they can. Researches work hard to improve their applications and webpages through finding the best algorithms that display, suggest, or recommend the best satisfied query results to the users based on their preferences or criteria (Hill, Wesson, 2008), (Lu, Li, Xu, 2015).

There are many studies have been implemented on the preference based search algorithms in different areas such as helping students to find the better apartments (Viappiani, Faltings, 2006), guiding the tourist to select the better trip destination that fit user's needs (Hill, Wesson, 2008), (Kiseleva, Mueller, Bernardi, et al., 2015), (Hill, Wesson, 2010), or finding the interested movie that user preferred (Koutrika, Ioannidis, 2002), (Ujgin, Bentley, 2002).

Viappiani and Faltings (Viappiani, Faltings, 2006) presented Flat Finder, which is one of the preference based search tools. This tool designed for the students in order to get the best accommodation for them based on their requirements and budget. In this paper, authors showed two different examples either optimal candidate or suggestions solutions. The optimal candidate gave the flat list according the sorting of the database items based on the cost and showed the top K

query. The suggestion solution gave the list of the cheapest flat, but it might be far from the university or does not have a privet bathroom as an example.

Hill and Wesson (Hill, Wesson, 2008), (Hill, Wesson, 2010) used the preference based searching technique to display the best point of interest restaurants located in the town to the user based on user's criteria and preferences list such as: the price range and the restaurant category. The method ranked and weighted the candidate set that were selected based on the preferences. After that, the candidate with the highest weight, which presents the most preferred options, will be shown. In this paper, Hill and Wesson explained different types of display methods, compared between them, and focused part of their research on the designing requirements for both input (the requirements and preferences list) or the output (the optimal restaurants list) to be either list or map view. The application that authors presented supports all of the interaction, functional, and visualization requirements.

Kiseleva, Mueller, and Bernardi (Kiseleva, Mueller, Bernardi, et al., 2015) presented a three methods that focused on tourism guide field. Authors worked on the methods that retrieve the best destinations to the user that satisfy his/her activities that users looking for in their trip. In this research, authors compared their results with the baseline, Booking.com, and their research showed that the Naïve Bayes approach gives a significant increase in user engagement.

Ujjin and Bentley (Ujjin, Bentley, 2002) built a recommender system that based on the preference based searching technique to give more accurate results and prediction to the users that he/she likes or dislikes and best recommendations to the users. In the database, movie data is stored for each user, means profile for user  $j$  on movie  $i$  as an example. The record includes, the rating of the specific movie for specific user, the age of that user, the gender, the occupation, and the movie genre frequencies (occupation and 18 movie genre frequencies: action, adventure, animation, children, comedy, crime, documentary, drama, fantasy, film- noir, horror, musical, mystery, romance, sci-fi, thriller, war, western). After the profile data is created, the recommender system can recommend and select movies for user ( $A$ ) based on the neighborhood selections that are closed to user ( $A$ ) profile.

### System Model

As a basic model, we use the PBST system proposed in (Hill, Wesson, 2008). This algorithm is able to take into account multiple criteria as a user's preference and find the corresponding results. Moreover, it is provide the range procedure for one of the choosing criteria, which gives an ability to the user to determine a prefer range for any criteria not only one value. We custom this algorithm by allowing a user to determine a rang for more than one criteria.

We consider an environment with multi criteria  $C$  and multi users  $N$  randomly practice the proposed method. Each user  $i \in N$  has its own preferences list  $L_i \subseteq C$  over provided criteria. The multi criteria area  $C$  contains all provided criteria such as  $C = \{c_1, c_2, c_3, \dots, c_m\}$  where  $m$  is the maximum number of criteria. The length of preference list  $L_i$  is  $L_i, len$  located within  $0 \leq len \leq m$ . There are two different kinds of criteria: i) checked criteria, that would have 0 or 1 based on the checked-boxes selected by the user, and ii) range criteria, are a continuous attributes with a maximum  $max$  and minimum  $min$  limit. Thus, user  $i$  submits its preferences list as:

$$L_i = [c_1^i, c_2^i, c_3^i, \dots, c_m^i] \quad (1)$$

The value of criteria  $j$  for user  $i$  has many possibility, such as:

$$c_j^i = \begin{cases} 0 & \text{if } j \text{ is a checked criteria dose not chosen by } i \\ 1 & \text{if } j \text{ is a checked criteria has been chosen by } i \\ \{min, \dots, max\} & \text{if } j \text{ is a range criteria} \end{cases} \quad (2)$$

The practical steps of the algorithm are discussed in the following subsections:

### A. Calculate Total Weight

At the beginning, total weight is initializing to zero. Then one is added to the total weight for each check-box selected, in case of checked criteria type. In case of range criteria, the corresponding value that reflects how many ranges have been selected must be added to the total weight. For example, the range of criteria  $j$  has five available ranges, in case user  $i$  selects only one range, as result 5 is added to the total weight, thus 5 is the optimum score. In case user  $i$  selects two ranges, the optimum score 4 is added to the total weight, and so on. In case no range is selected 1 is added to the total weight.

### B. Determent the Score for Range Criteria

For each criteria from type (range criteria), the algorithm generates an array to determine the score for each range. Range criteria RCj has five ranges= {R,RR,RRR,RRRR,RRRRR}, where min = R and max = RRRRR. Figure 1 shows generated array when user  $i$  choose the second and third ranges as preferred reneges. While, figure 2 shows generated array in case the chosen range is first one. The score for each range is determined based on the optimum score, as mentioned in III-A. The optimum score is placed on the selected range(s). Then the score for all surrounding range(s) is determined based on the distance from the selected range(s), such that 1 is decremented for each foreword/backward range.

R	RR	RRR	RRRR	RRRRR
3	4	4	3	2

Figure 1. Array generated if RR and RRR are selected

R	RR	RRR	RRRR	RRRRR
5	4	3	2	1

Figure 2. Array generated if R is selected only

### C. Allocated Ranking

For each candidate row in the candidate set a score is calculated. At the beginning, the score  $R_i^S$  for candidate  $R_i$  is initialized to zero. Then 1 is added to  $R_i^S$  for each criteria matches the check-box selected. Moreover, a value of rang criteria is added to the  $R_i^S$  based on which range the candidate falls into. Finally, the  $R_i^S$  is divided by the total weight to get the rank for  $R_i$ .

### D. Example

Table 1 shows the database of available Hajj and Umrah agencies. The preference list of user  $i$  is:  $L_i = [1, 0, 0, \{3000-10000\}, \{3-6\}]$ . Figure 3 shows the available ranges for price criteria, while Figure 4 shows the available ranges for distance criteria.

Table 1. Hajj and Umrah Agencies

Hajj and Umrah Agencies	Spacial Need	Child Care	Diet	Price	Distance	Quality
1	√	√	×	15000	3km	***
2	√	×	√	10000	3km	***
3	√	×	×	5000	6km	*
4	√	√	√	20000	2km	****
5	×	√	×	3000	7km	*

R	RR	RRR	RRRR	RRRRR
1000 - 3000	4000 - 9000	10000 - 14000	15000 - 190000	20000 - 30000

Figure 3: Price Ranges

D	DD	DDD	DDDD	DDDDD
14-15	11-13	7-10	4-6	1-3

Figure 4. Distance from Jamarat Ranges

The total wight is :  $1(\text{spacial need}) + 3(\text{price range R\&RR\&RRR}) + 4(\text{distance range DDDD\&DDDDD}) = 8$ . Price and distance arrays are generated as appear in Figure 5 The final score for agencies number 1 is:  $1(\text{spacial need}) + 2(\text{price range}) + 4(\text{distance}) = 7$ , as a result the ranking is  $(7/8)/100 = 70\%$ . The ranking for all other agencies respectively are: 100%,100%,60%,60%. Thus, the recommended agencies are agencies number 2 and agencies number 3.

R	RR	RRR	RRRR	RRRRR
3	3	3	2	1

D	DD	DDD	DDDD	DDDDD
1	2	3	4	4

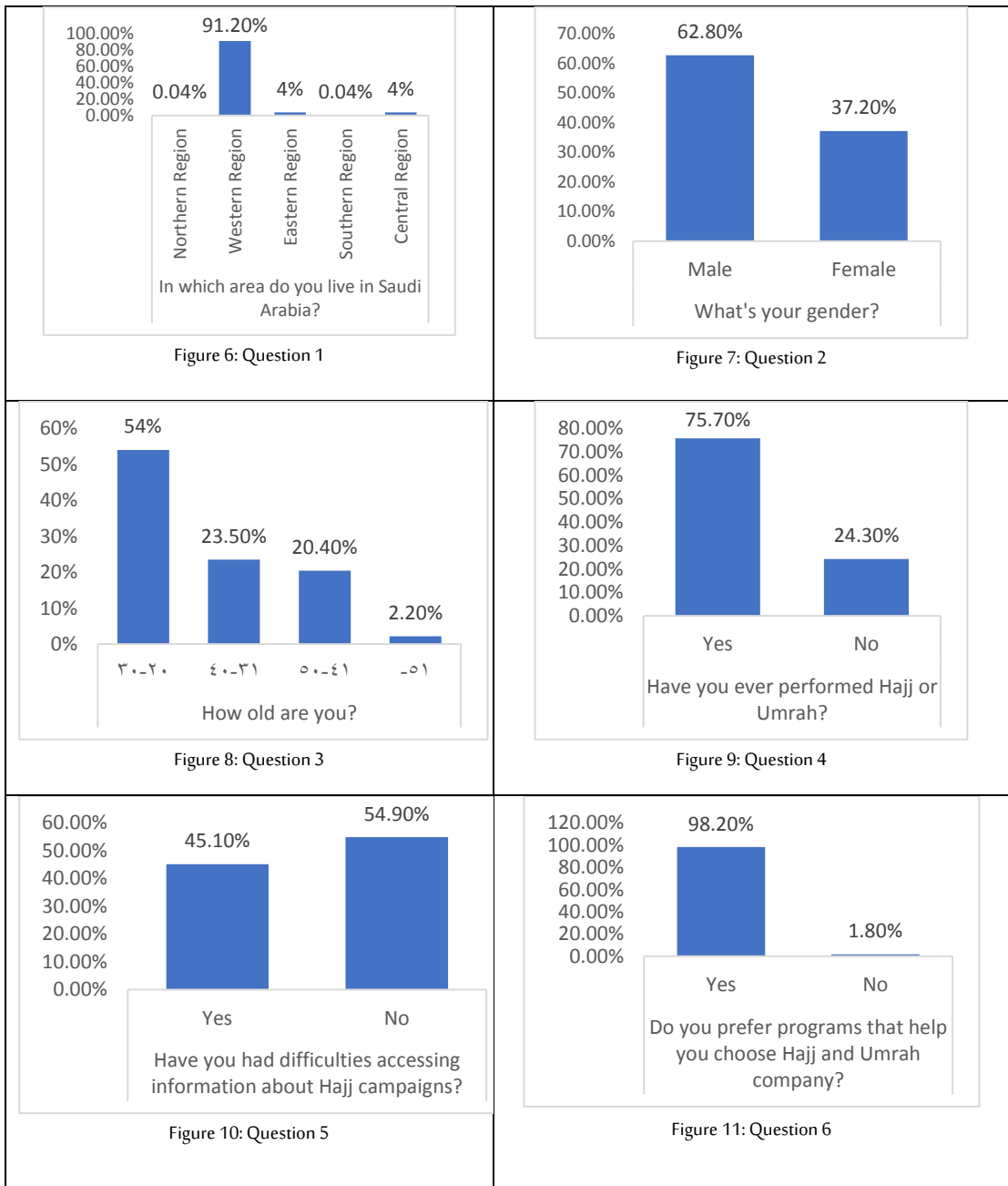
Figure 5. The two generated arrays for the price and distance ranges

### Need for an Application

The Ministry of Hajj and Umrah issued an initial license to more than 780 Hajj and Umrah agencies, so they can start their activities (The Middle East Newspaper,2017). This increase in the number of agencies working in the field of Hajj and Umrah aims to increase the level of services provided to pilgrims and to meet the objectives of Saudi Vision 2030 in the Hajj and Umrah sector. These agencies offer different services in terms of transport, hotels, health facilities as well as services related to children. The level of services offered to pilgrims varies based on the total cost of the Hajj or Umrah.



Thus, choose the best agency is difficult because pilgrims need to contact many agencies to inquire about their service and prices. The traditional way of asking about these agencies through mobile or even asking friends leads to the loss of time and effort and lack of access to accurate information. A questionnaire was designed and distributed through Google forms via the Internet and the results were as follows, which are collected from participants.



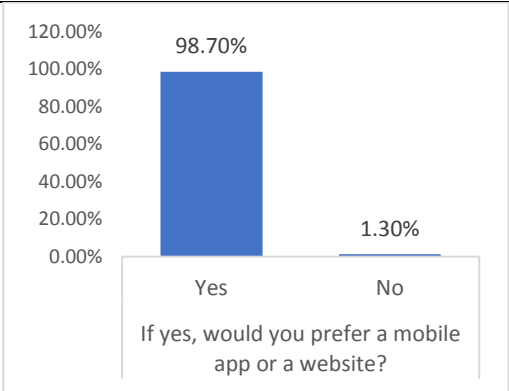


Figure 12: Question 7

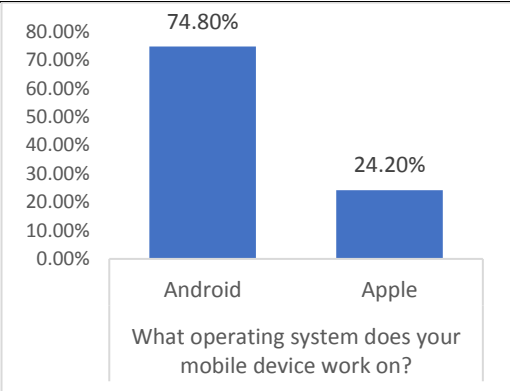


Figure 13: Question 8

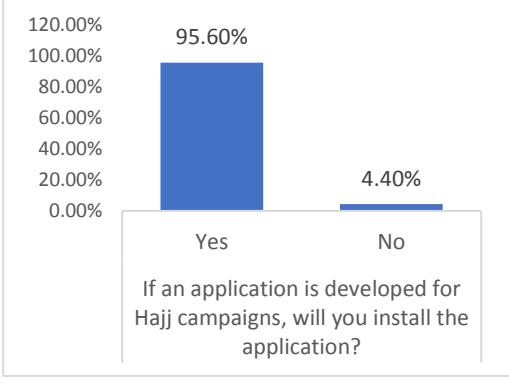


Figure 14: Question 9

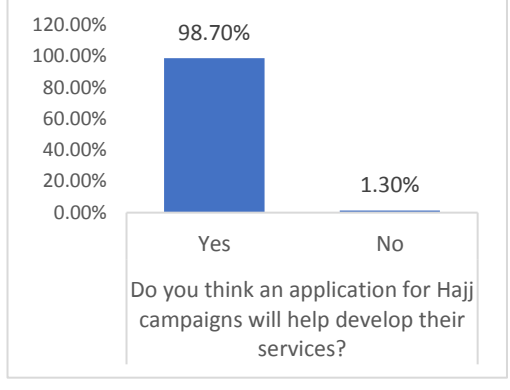


Figure 15: Question 10

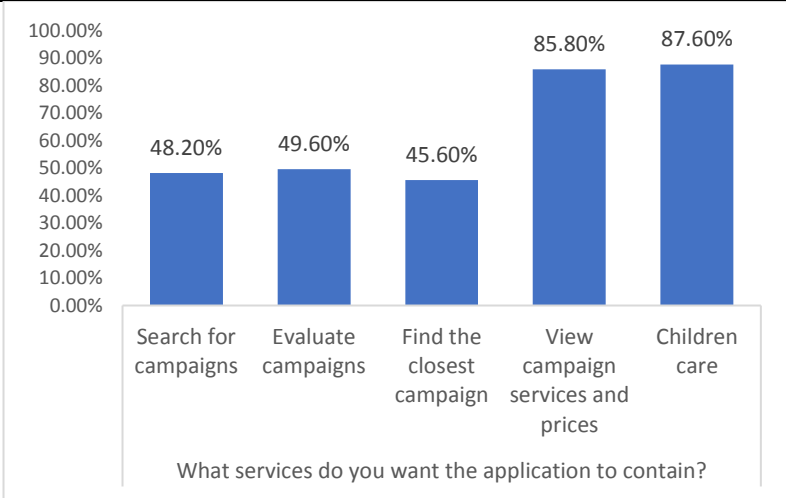


Figure 16: Question 11

## Yusur Application

We use the explained algorithm to create a preference-based search application for Umrah and Hajj agencies called Yusur. Figure 17 shows the start screen of the application in a, and the login in b. As appears in a Yusur application supports Arabic and English language.

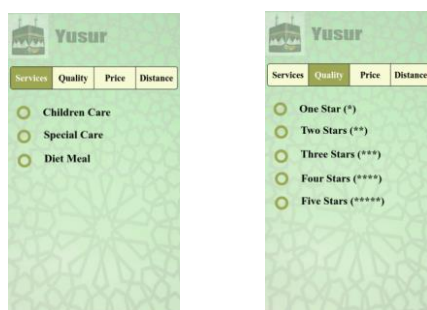


(a) Start Screen

(b) Login Screen

Figure 17. Start and Login Screens

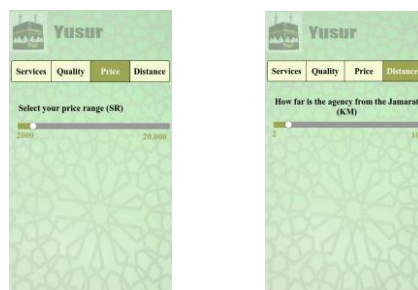
Yusur application provides four main subcategories: services, quality, price, distance, as appears in Figure 18 and Figure 19. Where services includes children care, special care, and diet meal. A user can choose as many as wants from these subcategories, then Yusur uses these chosen subcategories as preference list of the user.



(a) Services

(b) Quality

Figure 18. Subcategories (Checkbox Type)



(a) Price

(b) Distance

Figure 19. Subcategories (Range Type)

The recommendation of Yusur appears as list as Figure 20. The user can get more information about each agencies by clicking on icon next to agencies name, as Figure 21 Also, a map view is provided as Figure 22, that show the distance of agencies from the main point.

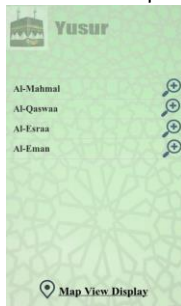


Figure 20. Results in a List view



Figure 21. Results List Details

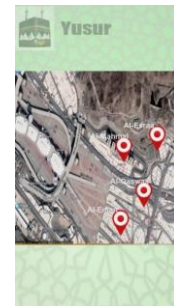


Figure 22. Results in a Map view

Users at the end of the application should give the satisfaction rate of their experience in using YUSUR and show if this application helped them for choosing the best agency that meet their preferences and requirements as shown in Figure23



Figure 23. User's Satisfaction

## SUMMARY AND CONCLUSION:

In this paper we discussed a preferences-based search algorithm, that generates a ranking result reflects user preferences. Then use this method to purpose the Yusur application. Yusur is a mobile application helps users to find the Hajj and Umrah agencies that satisfied their requirements.

## RECOMMENDATIONS:

4. Create a complete database.
5. Adding more features.
6. Displaying the closest important services to the resulted agencies like hospitals as an examaple.

## References:

- Hill, R. and Wesson, J. (2008): Using Mobile Preference-Based Searching to Improve Tourism Decision Support. In Proceedings of SAICSIT '08: Annual research conference of the South African Institute of Computer Scientists and Information Technologists on IT research in developing countries, Wilderness, South Africa. 104–113, ACM

- JUNKER, U. 2002. Preference-Based search and multi-criteria optimization. In Proceedings of the National Conference on Artificial Intelligence (AAAI'02). 34–40.
- Viappiani, P., and Faltings, B. 2006. Design and implementation of preference-based search. In Springer., ed., The 7th International Conference on Web Information Systems Engineering, LNCS4255, 72–83.
- J. Kiseleva, M. J. Mueller, L. Bernardi, C. Davis, I. Kovacek, M. S. Einarsen, J. Kamps, A. Tuzhilin, and D. Hiemstra. Where to go on your next trip?: Optimizing travel destinations based on user preferences. In Proc. Of SIGIR'15, pages 1097–1100, 2015.
- Hill, R., and Wesson, J. "A- Pointer: an adaptive mobile tourist guide", In Proceedings of the 2010 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists, pp. 113- 122, October 11-13, South Africa. (2010)
- G. Koutrika and Y. E. Ioannidis. Personalized queries under a generalized preference model. In ICDE, pages 841–852, 2005.
- Ujji, S. and Bentley, P. J. 2002. Learning User Preferences Using Evolution. In Proceedings of the 4th Asia-Pacific Conference on Simulated Evolution and Learning. Singapore.
- Lu Y, Li Y, Xu M, et al. A user model based ranking method of query results of meta-search engines. In Proceedings of the International Conference on Network and Information Systems for Computers (ICNISC'15), Wuhan, China; 23-25 January 2015. p. 426-430.0
- The Middel East Newspaper, "Hajj and Omrah companies," [Online]. Available: <https://aawsat.com/print/1092291>, 2017.

# Multi-Level Multi-Stage Agent-Based Simulation Model of Crowd Dynamics in last Floor of Al- Haram Al-Sharif

Raghda Alqurashi<sup>(1)(2)</sup>, Tom Altman<sup>(2)</sup>

<sup>(1)</sup> Umm Al-Qura University

<sup>(2)</sup> University of Colorado Denver

## نموذج متعدد المستويات والمراحل قائم على الأفراد لمحاكاة حركة الحشود على سطح الحرم المكي الشريف

رغداء القرشي<sup>(1)</sup>، توم ألتمان<sup>(2)</sup>

<sup>(1)</sup> جامعة أم القرى

<sup>(2)</sup> جامعة كولورادو دنفر

### ملخص البحث (Abstract):

في هذا البحث قمنا بتطوير نموذج متعدد المستويات ومتعدد المراحل يقوم على محاكاة حركة الأفراد ويعمل على تطوير عمليات اتخاذ القرار أوتوماتيكياً خلال عمليات الإخلاء الجماعي في الحوادث الخطيرة. يتمثل النموذج المقترح في بنية متعددة المستويات لإدارة السلوك العام للحشود والسلوكيات الفردية باستخدام نهج النمذجة القائمة على الأفراد داخل البيئات المتغيرة ديناميكياً نتيجة الحرائق، والازدحام، إلخ. يُحاكي النموذج المكونات، والتغيرات السلوكية الفردية والظواهر في النظم المعقدة داخل الحشود الهائلة التي تتمثل في المصلين في المسجد الحرام. على وجه التحديد قمنا بتطبيق النموذج المقترح على إدارة الحشود المتمثلة في المصلين في الطابق العلوي للحرم المكي الشريف (سطح الحرم). سيقوم النموذج المقترح بتوليد مرشدين بين الحشود ديناميكياً وتمكن عملية التوليد هذه من توليد تلقائي للقرارات المثالية للأفراد المجاورين. ويشمل الإطار متعدد الاستخدامات المبادئ الأساسية للنمذجة التي تُطبق عادةً على حركة الحشود. ينقسم نموذج صنع القرار في محاكاة حركة الجمهور إلى ثلاثة مستويات: استراتيجية وتكتيكية وتشغيلية. يتم رسم الخطة وهدفها النهائي في المستوى الاستراتيجي. في هذا المستوى، لا يتم تقديم أي معلومات حول الظروف الحقيقية. في المستوى التكتيكي، تُنفذ جميع الأنشطة لتسهيل الخطة الموضوعية. يتناول هذا المستوى القرارات قصيرة الأجل مثل تجنب العقبات أو تغيير الخطط استناداً إلى معلومات جديدة. يتناول المستوى التشغيلي الإجراءات والأنشطة البدنية التي تم تطويرها على المستوى التكتيكي. الهدف من هذا البحث هو محاكاة السلوكيات والظواهر الحقيقية بدقة مما يسمح باتخاذ قرارات مطورة لتحسين عملية إدارة الحشود المعقدة في ظروف مختلفة. وكذلك أن نكون قادرين على محاكاة السلوكيات الذكية والتنظيم الذاتي للحصول على نتائج موثوقة. سوف تمكننا نتائج النموذج من تقييم الظروف التي قد تحدث داخل الشبكة، وتحسين فهمنا للافتراضات والتطورات المستقبلية التي يمكن أن يكون لها أثر كبير في إدارة الحشود

We develop a multi-level, multi-stage, agent-based framework that automates decision-making processes during crowd evacuations in dangerous scenarios. We model a hybrid architecture for managing crowd individual behaviors, and overall crowd behavior, using a heterogeneous agent-based modeling approach within dynamically changing environments due to external stimuli such as fires, congestions, etc. Our novel multi-component, agent-based modeling framework is applied to simulate the components, varying individual behaviors and phenomena of complex systems within massive crowds that represented among prayers in the last floor (the upper level) of Al- Haram Al-Sharif Mosque.

The proposed framework integrates a probabilistic model with a dynamic generating process of intelligent guide agents, which enables the automatic generation of decisions that are optimal for neighboring agents. The versatile agent-based framework we have developed encompasses the fundamental principles of modeling as commonly applied to crowd dynamics. Our crowd dynamics decision-making modeling is organized into three levels: strategic, tactical and operational. The formulation of a plan and its final objective are drawn at the strategic level. At this level, no information is provided about the real circumstances. At the tactical level, we compute and perform all activities to facilitate the formulated plan. This level addresses short-term decisions like avoiding obstacles or changing plans based on new information. The operational level addresses the physical actions and activities developed at the tactical level. We aim to accurately simulate the real crowd behaviors and phenomena, allowing for improved decisions taken to enhance the complex process of crowd management under various scenarios. Also, our goal is to be able to mimic intelligent, self-organizational behaviors and gain reliable results. The model results will enable us to evaluate the conditions that might occur within the network and improve our understanding of which assumptions and future developments could have the most impact in managing crowd.

### **Introduction**

Multi-agent systems are used to model and simulate complex systems, which range across various contexts and both biological and social systems. This simulation method is known as agent-based modeling (ABM) [1, 2]. The ABM approach which models complex systems is a form of optimization of individual solutions [3, 4]. The agents in the decentralized system have no direct information about their global position but do have information about their nearby neighbors and their environment locally. However, they can use this local knowledge to collectively construct a coordinate system [1-4].

Here we present a novel multi-component, agent-based modeling framework that simulates the components, behaviors and phenomena of complex systems [5, 6]. A decentralized multi-agent control strategy is proposed and investigated on an autonomous microgrid. In a crowd complex system [2, 4], agents adjust their behavior according to their current states, to other agents' states and to their environment. Thus, ABM is a suitable approach to use to study crowd behaviors. Our model [6] is a computational discrete-time simulation scheme. We outline our support system with finite-state machines and use a genetic algorithm to optimize the selections and decisions taken by crowd individuals. We build the model to explain and predict observed interactions among real agents [6].

### **Research aims**

We aim to accurately simulate the crowd behaviors and phenomena, thereby improving crowd management decisions. To ensure the effectiveness and robustness of our model in supporting crowd management decisions, we build a novel, multi-component, agent-based modeling framework. To this agent-based framework we introduce an adjustable approach for simulating human perception and decision-making in dangerous scenarios. The events that occur during a crowd evacuation are complex and have far-reaching implications for the safety of individuals [7]. Our framework will support crowd management decisions by elaborating what-if scenarios. Also, we aim to support event planners' and building designers' decisions. We use modeling and simulation as a means for developing a deep understanding of both complex systems and complex adaptive systems behavior. Because of the emergent phenomena of complex systems, ABM is an effective approach to address the question of how a system's behavior connects to the behaviors and

characteristics of its individual components. The main goal of this work is to create a model that is able to simulate varying individual behaviors within massive crowds that represented among prayers in the last floor (the upper level) of Al- Haram Al-Sharif in Makkah [8] (Fig. 1), during evacuation.

### **Research methodology**

In this proposed model we exploit the ABM approach and the non-homogeneous CA [9-18] to provide a multi-layered decision support system in cases of crowd evacuation. The work we propose here develops a new simulation method to understand the movement of large crowds during evacuations from buildings. Our work introduces a multi-levelled model where pedestrian dynamics are divided into three main levels of decision making [16, 18]: strategic, tactical, and operational. The planning for pre-trip of the route and the final destination is designed at the strategic level. At this level, no information is provided about the real circumstances [19]. At the tactical level, decisions for short term, like avoiding obstacles or change of route depending on the real situation, are addressed. Additional information about the crowd such as the flow of agents is available at this point [20]. The operative level represents the agents' movement that includes the connection with other pedestrians [21].

Our simulation model consists of multiple sub-models, as it is shown in the system overview in Fig. 2, starting with the model of how the agent selects its goal destination. Then, we model the act of avoiding obstacles as well as collision with neighbored agents. Also, our hybrid version of agent-based model includes simulating the leading and following behaviors of agents after dynamically upgrading certain agents to the intelligent level and enabling them to perform some sort of guidance behavior, as detailed below. Besides avoiding collisions with neighboring agents, the framework also includes a model of avoiding high density areas in order to reduce the overall travel time. Our work represents an approach for modeling and simulating complex and dynamic crowd systems, both at microscopic and macroscopic levels. The highest layer represents the macroscopic phenomena of the crowd that would be difficult to model in CA frames. This layer represents the connections between intelligent guide agents to enhance the decisions for the whole system as it will be described below. The base layer is composed of a high determination CA framework for every open space, which shows how the agents' neighborhood moves as well as the development of decision-making at the microscopic level of the system. Fig. 3 demonstrates the two-layered structure of the proposed system.

The environment component of this ABM model defines the elements of the physical space, such as a city, building, roads, etc. The simulation environment is presented as a lattice, which is a two-dimensional array of  $n \times n$  cells. We have designated specific types of cells in a lattice of a non-homogeneous cellular automaton. These are obstacle cells, which are unreachable, target cells, which represent exits in the evacuation scenarios, and the reachable cells, which are considered as the movement space. In this model, static floor field (SFF) [22] is used to indicate the distances to a destination for every agent in the environment. A target static floor field value is assigned to every cell to describe the distance to the earliest chosen target (exit).

The agents in our model are randomly assigned with objective and subjective parameters at the beginning of the simulation. The individuals' characteristics, or subject parameters, include awareness of the environment, education level, cooperativity, adaptability, flexibility, perception of potential risks, acceptance to follow orders, and ability to access global information about the environment. On the other hand, agents' objective characteristics include age, health status, propensity to panic, mobility, and communication capability.



### 1. Target-driven decision-making model

The optimal initial target decision is impacted by different factors that the agents perceive from the environment. In our model there are four important factors: the distance to a target, the width of the target (exit), the speed of the agent, and the density at the target. For each agent  $a$  we calculate the initial target decision ( $ITD$ ) function for each target. For  $j$  targets in the environment, the  $ITD$  function is calculated as follows:

$$ITD(a) = \min\left(\frac{d_j}{s_a} + \frac{td_j}{w_j}\right), \quad (2)$$

### 2. Transition decision-making model

At every time-stamp, the agent  $a$  will move to the neighbor empty cell with the highest transition probability,  $p_{ij}$  to move to an unoccupied neighbor cell  $(i, j)$  that is determined by the four factors: dynamic floor field, target floor field, obstacles floor field, and the density around the next target cell. In each time-stamp, the dynamic floor field  $D_{ij}$  decays with some probability and diffuses with some probability to one of its eight neighbor cells. In order to calculate the dynamic floor field, we first initialize all the cells to 0, i.e., at  $t = 0$ ,  $D_{ij}^0 = 0$  for all cells. Then we calculate the dynamic floor field ( $DF$ ) according to decay and diffusion as follows:

$$D_{ij}^{t+1} = (1 - \alpha)(1 - \delta)D_{ij}^t + \frac{\alpha(1-\delta)}{4} (D_{i+1,j}^t + D_{i-1,j}^t + D_{i+1,j+1}^t + D_{i+1,j-1}^t + D_{i,j+1}^t + D_{i-1,j+1}^t + D_{i,j-1}^t + D_{i-1,j-1}^t), \quad (3)$$

In our model, we also consider that people usually avoid walking close to walls and obstacles. In our model, the repulsive obstacle potential is inversely proportional to the distance from the obstacles. Thus, the impact of the target static potential field is affected by the obstacles floor field ( $OFF$ ). The values for the cells occupied by obstacles is set to be the higher values of the cells in the environment. The obstacles' static potential field is calculated as follows:  $OFF(x,y) = \min(D_{max} d_{x,y})$ , (4)

For each agent  $a_i$  we calculate the transition probability to each empty cell  $(x, y)$  in its Moore neighborhood as follows:

$$P(x, y) = N \exp(-k_T TFF(x, y) + k_D DFF(x, y) + k_O OFF(x, y) + k_{den} Den(x, y) + k_I I), \quad (5)$$

### 3. Agent status upgrading model

The third stage in the ABM simulation is to classify different types of agents in the environment. The agent-based model here represents two sets of evacuees: the first set who is familiar with the building geometry, and the other one who is unfamiliar. In our proposed model, this is a major stage as we examine the agents' expected behaviors. This classification is done based on subjective and objective characteristics of the individual agents, as shown in Algorithm 1. Being an intelligent agent means that agent is relied upon during the decision-making processes by other agents. Particularly, unfamiliar agents apply only the operational level of crowd modeling by following or mimicking intelligent agents' movements, thus maintaining the collective pattern.

---

**ALGORITHM 1:** Agents' Status Upgrade

---

```
for each agent  $a$  in the simulation environment do
     $a.Objective-Parameter = \text{Random } [0,1];$ 
     $a.Subjective-Parameter = \text{Random } [0,1];$ 
end
Divide the environment space into equal regions;
for each environment region do
    if ( $Density > Density-T\ hreshold$ ) then
        if ( $a.Objective-P\ arameter < Objective-T\ hreshold$ ) and
        ( $a.Subjective-P\ arameter > Subjective-T\ hreshold$ ) then
             $a.Status = Intelligent;$ 
             $a.MooreNeighbors.Status = Follower;$ 
        end
    end
end
```

---

#### 4. Evaluation of trustworthiness model

Trust between agents is defined as the agent's expectation about another's perspectives. In our model, we investigated a trust evaluation algorithm for agents in a multi-agent system based on the trustworthiness of related intelligent agents. We introduce here the trust concept as the agent's confidence in the ability of a related intelligent agent (information source) to deliver accurate information. Particularly, the probability that a following agent would approve of an intelligent agent's opinion on a specific target is dependent on the approval of the neighboring agents about the decision taken by the intelligent agent. Suppose an intelligent agent  $p$  provides knowledge, or decision  $q$  to agent  $a$ . Suppose  $n$  neighboring agents have contributed to the current decision  $q$ . In other words, agent  $a$  trusts intelligent agent  $p$  if trustworthiness probability value is greater than or equal to a predefined threshold. The trustworthiness probability about the decision  $q$  is calculated as follows:

$$P(q) = \xi \sum_{i=1}^N \sum_{j=1}^2 P(q|a_i^j)P(a_i^j), \quad (6)$$

#### Results and discussion

The ultimate aim is to test the capability of the presented model in improving the crowd behaviors during evacuation. Also, one of the main criteria for the performance evaluation of our crowd simulation model is the total travel time needed for the agents to reach their individual goals. We should ensure the shortest possible trip time for the agents to reach their destinations. Different attributes of the crowd have to be considered in the implementation of the model. This includes, but is not limited to, the individual characteristics of the agents, such as language, culture, age, and environment obstacles that could be caused by external events or the agents themselves.

Fig. 4 shows the variation of density to each target's static floor field (TFF). The blue radiance represents the higher force of attraction of the TFF value, while the yellow radiance illustrates avoiding areas that delay agents from reaching their exit.

The distribution of agents is random throughout the environment at the beginning of the simulation. When an agent reaches its target, he is considered evacuated from the environment, and removed from the simulation. The simulation

model was run with ten thousand agents (prayers) in two different cases. The first case represents our model where the tactical level is involved. In the second case we only implemented agent-based simulation without involving the tactical level. That means there is no existence of intelligent agents in the simulation, and no application of trustworthiness.

Our approach has yielded three main insights. The first finding illustrates the model's capability of improving the crowd flow pattern. Fig. 5 shows that agents' flow rate was higher in our proposed model (case 1) than the traditional ABM application (case 2). That indicates the ability of our model to improve the overall crowd flow during evacuation. We also found that the agents' average speed during the simulation was higher in the proposed model. Fig. 6 shows the estimation of the average speed of 400 agents during the simulation.

The second result is related to demonstrating the model's efficiency in promoting the crowd overall travel time during evacuation. Specifically, we observed that all agents in the environment have been evacuated in a short and reasonable time, while it took the agents a longer travel time to evacuate in the traditional ABM model, as shown in Fig. 6 that shows the total travel time for 200 agents in both cases. This result proves the benefit of relying on an intelligent agent to improve the evacuation overall travel time.

The results demonstrate the efficiency of our models in accurately simulating the events during crowd evacuations. Considerable changes of crowd dynamics have been detected during the simulations such as transitioning from a random to a coordinated motion and avoiding obstacles and high-density areas. We observed significant improvement of crowd flows during simulations compared to that observed with traditional applications of ABM. These observations could influence multiple aspects of how evacuations are planned. For example, design of where the exits are located in buildings, and how individuals are trained to behave during an evacuation. Taken together, our results show that the proposed multi-leveled multi-staged agent-based model outperforms the traditional ABM approach in improving the crowd dynamics during evacuation in a high-density simulation logic.

### **Summary and conclusion:**

Our proposed ABM model was able to improve crowd management solutions by considering the diversity of prayers and their characteristics involved. The aim of our model in such cases is to help Hajj and Umrah crowd management authorities build successful schemas by predicting the crowd's behaviors. Our model uses a finite state machine, in conjunction with an agent-based model, to determine how agents interact with each other locally in order to generate collision-free trajectories. The results of our model showed the ability to support the heterogeneity and high density observed among the massive number of prayers of Al- Haram Al-Sharif. That includes using small time steps in order to consider different pedestrian speeds and reduced mobility of some of them, e.g., elderlies. Our experimental results provide evidence that the hybrid, multi-layered approach can be successfully applied to efficiently simulate agent behaviors in intensive crowd environments. This research will provide promising solution to facilitate crowd management in case of increasing number of pilgrims based on 2030 vision; where the number of pilgrims will increase to approximately four and a half million in Hajj and thirty million in Umrah [23].

### **Recommendations:**

One of the essential applications of our model will be crowd management during the enormous annual gathering of the Hajj [24]. The Hajj involves over two million people from approximately 150 countries. The complex multi-agent system represented by their Hajj includes many agents, such as people with substantial variety of objective and

subjective characteristics, vehicles, communication systems, disaster and crowd management authority, etc. The Hajj crowd consists of a heterogeneous set of pilgrims with varying physical capacities and activities. Due to the special features of the Hajj, which include the massive number of people and approximately 30,000 vehicles contained in a limited space over a short period of time, crowd disasters such as stampedes and overcrowding are common [25, 26]. The crowd density during pilgrimages is extremely high. Many studies have been conducted attempting to improve crowd management during Hajj to avoid such disaster [24, 25, 27]. The model's implementation focus will include several real-world, expected scenarios during pilgrimage. These include evacuations under risky conditions, control of the crowd in case of panic, regimentering the massive number of pedestrians and vehicles quickly and in a safe manner, and improving the crowd management processes in the event of an increased number of pilgrims.

**Figures and Tables:**

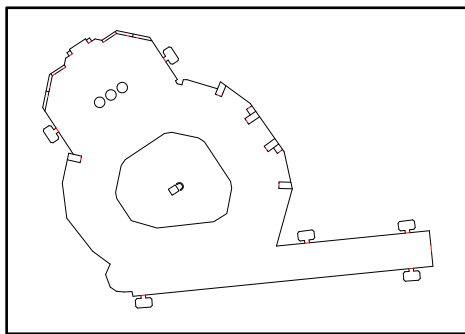


Figure 1

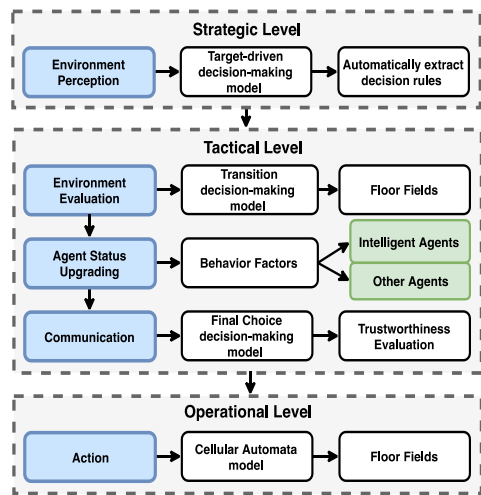


Figure 2

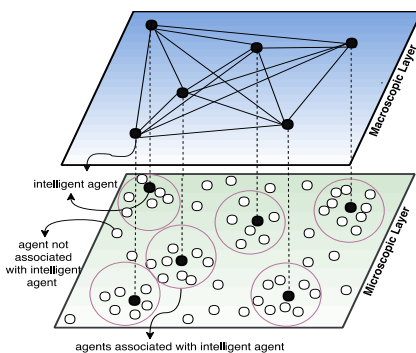


Figure 3

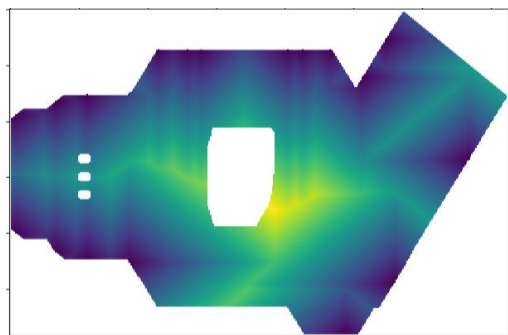


Figure 4

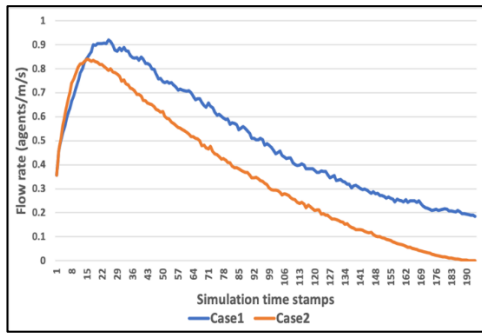


Figure 5

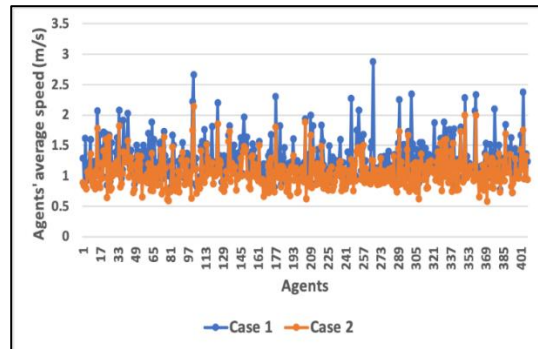


Figure 6

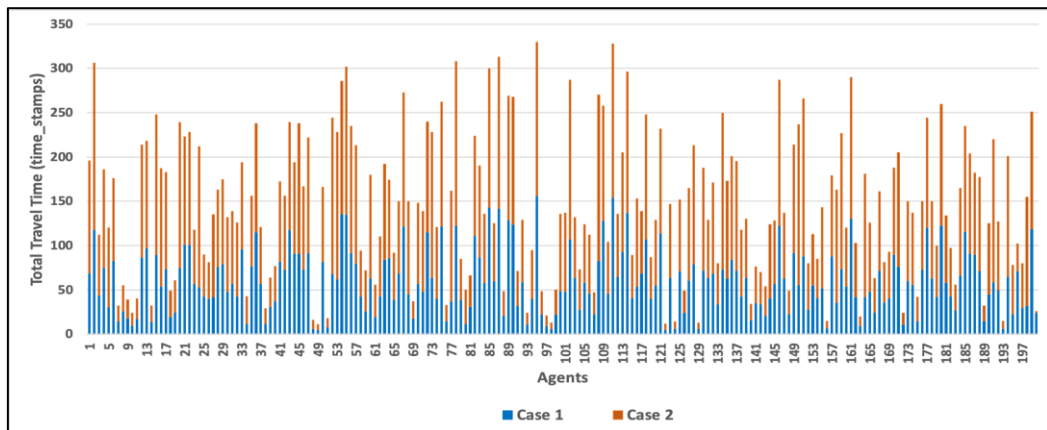


Figure 7

## References:

- [1] M. Niazi and A. Hussain, "Agent-based computing from multi-agent systems to agent-based models: a visual survey," *Scientometrics*, vol. 89, (2), pp. 479, 2011.
- [2] J. Waş and R. Lubaś, "Towards realistic and effective agent-based models of crowd dynamics," *Neurocomputing*, vol. 146, pp. 199-209, 2014.
- [3] N. Medina, A. Sanchez and Z. Vojinovic, "The potential of agent based models for testing city evacuation strategies under a flood event," *Procedia Engineering*, vol. 154, pp. 765-772, 2016.
- [4] B. Ni, Z. Li and X. Li, "Agent-based evacuation in passenger ships using a goal-driven decision-making model," *Polish Maritime Research*, vol. 24, (2), pp. 56-67, 2017.
- [5] R. Alqurashi, and T. Altman, "Multi-class agent-based model of crowd dynamics," in *Proceedings of the 2017 International Conference on Computational Science and Computational Intelligence*, pp. 1801-1802, 2017.
- [6] R. Alqurashi, and T. Altman, "Multi-level multi-stage agent-based decision support system for simulation of crowd dynamics," in *Proceedings of the 23rd International Conference on Engineering of Complex Computer Systems (ICECCS 2018)*, pp. 82-92, 2018.
- [7] O. Richardson, A. Jalba and A. Muntean, "The effect of environment knowledge in evacuation scenarios involving fire and smoke-a multiscale modelling and simulation approach," *arXiv Preprint arXiv:1709.07786*, 2017.
- [8] <https://www.gph.gov.sa/ar-sa/Pages/default.aspx>

- [9] J. Wąs *et al.*, "Agent-based approach and cellular automata-A promising perspective in crowd dynamics modeling," *Acta Physica Polonica B Proceedings Supplement*, vol. 9, pp. 133-144, 2015.
- [10] J. M. Czerniak *et al.*, "A Cellular automata-based simulation tool for real fire accident prevention," *Mathematical Problems in Engineering*, vol. 2018, 2018.
- [11] L. Crociani *et al.*, "Avoid or follow? Modelling route choice based on experimental empirical evidences," *arXiv Preprint arXiv:1610.07901*, 2016.
- [12] S. Sarmady, F. Haron and A. Z. Talib, "A cellular automata model for circular movements of pedestrians during Tawaf," *Simulation Modelling Practice and Theory*, vol. 19, (3), pp. 969-985, 2011.
- [13] K. Yamamoto and R. Nonomura, "Evacuation dynamics in room with multiple exits by real-coded cellular automata (RCA)," in *International Conference on Cellular Automata*, 2016.
- [14] R. Lubaś, J. Wąs and J. Porzycki, "Cellular Automata as the basis of effective and realistic agent-based models of crowd behavior," *The Journal of Supercomputing*, vol. 72, (6), pp. 2170-2196, 2016.
- [15] S. Bandini and G. Vizzari, "Heterogeneous dynamics through coupling cellular automata models," in *International Conference on Cellular Automata*, 2016.
- [16] L. Crociani *et al.*, "Cellular automaton based simulation of large pedestrian facilities-a case study on the Staten Island ferry terminals," *arXiv Preprint arXiv:1709.03297*, 2017.
- [17] D. Schaumann *et al.*, "A computational framework to simulate human spatial behavior in built environments," in *Proceedings of the Symposium on Simulation for Architecture & Urban Design*, 2016.
- [18] S. Bandini, A. Gorrini and G. Vizzari, "Towards an integrated approach to crowd analysis and crowd synthesis: A case study and first results," *Pattern Recognition Letters*, vol. 44, pp. 16-29, 2014.
- [19] L. Crociani *et al.*, "A CA-based model of dyads in pedestrian crowds: The case of counter flow," in *International Conference on Cellular Automata*, 2016.
- [20] L. Crociani *et al.*, "Adaptive tactical decisions in pedestrian simulation: A hybrid agent approach," in *Congress of the Italian Association for Artificial Intelligence*, 2015.
- [21] L. Crociani, G. Lämmel and G. Vizzari, "Multi-scale simulation for crowd management: A case study in an urban scenario," in *International Conference on Autonomous Agents and Multiagent Systems*, 2016.
- [22] L. Lu *et al.*, "A study of pedestrian group behaviors in crowd evacuation based on an extended floor field cellular automaton model," *Transportation Research Part C: Emerging Technologies*, vol. 81, pp. 317-329, 2017.
- [23] <https://vision2030.gov.sa/en/node/51>.
- [24] Y. A. Alaska *et al.*, "The impact of crowd control measures on the occurrence of stampedes during mass gatherings: the Hajj experience," *Travel Medicine and Infectious Disease*, vol. 15, pp. 67-70, 2017.
- [25] S. Jamil *et al.*, "Hybrid participatory sensing for analyzing group dynamics in the largest annual religious gathering," in *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 2015.
- [26] B. Basak and S. Gupta, "Developing an agent-based model for pilgrim evacuation using visual intelligence: A case study of Ratha Yatra at Puri," *Computers, Environment and Urban Systems*, vol. 64, pp. 118-131, 2017.
- [27] S. Gupta and B. Basak, "Alternate terminal location planning using accessibility analysis for improved pilgrim movement," *Anatolia*, vol. 28, (3), pp. 351-362, 2017.

# Using a multi-agent architecture to handle the negotiation between the Hajj authorities and the Hajj travel agents

Dr. Magdi Amer<sup>(1)</sup>, Afnan Almatrafi<sup>(2)</sup>

<sup>(1)</sup> Department of Computer Science, College of Computer and Information Systems, Umm Al-Qura University

<sup>(2)</sup> Department of Computer Science, Jamoum University College, Umm Al-Qura University

## استخدام نظام متعدد الوكلاء (MAS) لتنظيم المفاوضات بين إدارات الحج ومنظمي الحملات لتفويج الحجاج خلال أوقات الذروة

د. مجدي عامر<sup>(1)</sup>، أ. أفنان علي المطرفي<sup>(2)</sup>

<sup>(1)</sup> كلية الحاسب الآلي ونظم المعلومات - جامعة أم القرى

<sup>(2)</sup> قسم الحاسب، الكلية الجامعية بالجموم - جامعة أم القرى

### ملخص البحث (Abstract):

أحد أكبر المشاكل التي تواجه السلطات خلال الحج هي الاختناقات المرورية التي تحدث خلال انتقال الحجاج من عرفة إلى مزدلفة. في هذه الورقة يقترح المؤلفون استخدام الذكاء الاصطناعي (AI) لبناء الجدول الزمني الذي ينظم تفويج الحجاج خلال هذا الوقت. يتم ذلك باستخدام بنية نظام متعدد الوكلاء (MAS) لتنظيم التفاوض بين إدارات الحج ومنظمي الحملات. تقترح الورقة أيضًا استخدام بوابات RFID الآلية والتي بدورها ستكتشف تلقائيًا وتفرض أي حافلة لا تحترم الجدول الزمني المسند إليها. يتوقع من خلال استخدام نظام معلى يوزع الجدول الزمني بين منظمي الحملات بطريقة واضحة وعادلة، ستمكن إدارات الحج من فرض الجدول الزمني مما يسمح بفرض غرامات على أولئك الذين لا يحترمون الجدول الزمني.

One of the biggest problems facing the Hajj Authorities is the traffic jams that occurs when pilgrims go from Arafah to Muzdalifah. In this paper the authors propose the use of Artificial Intelligent (AI) to build the schedule regulating the transport of pilgrims during this time. This is done using uses a Multi Agent System's (MAS) architecture to regulate the negotiation. The paper proposes also the use of automated RFID gates that will automatically detect and fine any bus that does not respect the schedule. By using an open system that distributes the schedule between the hajj travel agents in a clear and fair way, the authorities will be able to enforce the schedule and will allow them to impose fines on those who do not respect the schedule.

### Introduction:

Saudi Arabia, under the leadership of King Salman bin Abdulaziz, makes every effort to overcome the difficulties facing the pilgrims. This is aligned with the Kingdom's Vision 2030, which includes plans to the improvement of services provided to pilgrims and plans to increase the number of Muslims performing Hajj with the highest standards of comfort and safety. Experts and researchers are encouraged in conducting research related to Hajj that helps achieve these goals.

One of the most difficult problems that the Hajj authorities face every year are the congestion and traffic jams that occurs during the transport of pilgrims from Arafah to Muzdalifah. This is due to the huge number of pilgrims that aims to reach Muzdalifah at the earliest time, resulting in road congestions that elongate the time needed and that threatening the safety of the pilgrims as it reduces the ability to carry out safety procedures at the same time.

This motivated the research described in this paper that proposes the use of a solution based on Artificial Intelligent (AI) that regulates the flow of pilgrims during peak times. The proposed solution uses a Multi Agent System's (MAS) architecture to regulate the negotiation between the Hajj authorities and the hajj travel agents to build a schedule for to transport pilgrims from Arafah to Muzdalifah. By using an open system that distributes the schedule between the hajj travel agents in a clear and fair way, the authorities will be able to enforce the schedule and will allow them to impose fines on those who do not respect the schedule.

The researchers will propose techniques to enforce buses to respect schedule and to allow the authorities to issue traffic fines to discourage attempts to disrespect the schedule. The use of AI will facilitate the implementation of the system and would allow each hajj travel agent to adapt the behavior of the system to his preferences and his financial constrains. The cost of the implementation will be covered with the revenue that the system will generate.

In the next section, research related to this topic will be described. Next, the overview of the MAS will be presented and the details of operation. The use of RFID to implement smart gateways for issuing fines will be explained in the section after that. Finally, the conclusion and future work will be presented.

### **State of the art**

There is consensus that one of the biggest problems facing pilgrims is overcrowding during peak periods. In [1], the author prove that the problem of congestion is not the result of infrastructure's limitations, but instead it is due to the difficulty of organizing the process of crowding and enforcing the pilgrims to respect the schedule allocated to them. Moreover, [2] also stressed the previous results, saying that if pilgrims were committed to pre-booking various activities during the Hajj season, this would ease congestion and suggested several alternatives to support the idea that people should not doing the same activities at the same time. This confirms the assumption made in this paper that regulating the schedule will have a clear impact in avoiding congestions during Hajj.

The first step for enforcing Hajj travel agents to abide to the schedule is create the schedule assigned to each travel agent through negotiation. The Hajj authorities need the schedule finalized long before the start of Hajj to prepare for the services needed to accommodate the large number of pilgrims. Direct human negotiation will not possible due to the large number of Hajj travel agents and due to the fact that many of them do not have a representative in the Kingdom. Hence, the negotiation between the Hajj authorities and the Hajj travel agents need to be automated.

Automated negotiation has been an active field of Artificial Intelligent research as a reliable approach for coordination between agents. Agents are software entities that act on behalf of a user to achieve the user's goal within the constrains determined by the user [3]. Agents are distinguished from standard programs by many characteristics [4]. First of all, agents are expected to be autonomous, acting without human intervention. Agents should also be reactive, capable of sensing its environment and responding to changes that occur in it. Agents does not simply act in response to the environment instead, they control their actions to achieve their goals. Agents have often social abilities, allowing them



to interact with other agents through collaboration and competition to achieve their goals within the constraints imposed by the user.

To simplify the architecture needed to implement the agent's intelligence, many researchers were inspired by the insect world. In fact, an individual ant or bee has limited mental abilities, but when different simple ants or bees, each with a specific ability and goal, interact together, the resulting behavior of the group of insects is intelligent and the group is capable of solving complex problems. This inspired the research of Multi-agent Systems (MAS), which has proven its capability to resolve multiple complex real-life problems using limited resources [3, 4, 5]. A multi-agents system allows agents to work together to find answers to problems that are beyond the individual capabilities or knowledge of each agent [5].

Conflict may occur between multiple agents when their goals are at odds with each other. When this occurs, negotiation and arbitration are used to help resolve conflicts [6]. Negotiation can be purely competitive, purely cooperative or mixed depending on the behavior of the agents. Competitive negotiation is used when agents have independent goals that conflict with each other. Cooperative negotiation is used when agents have a common goal to achieve or a single task to execute. Most of cases contains element of both competitive and cooperative [7,8].

Auction is one of the forms of negotiation between agents. An auction is a procedure used for selling and buying items by offering them up for bid. Auction theory is important in both practical and theoretical terms, and is widely used in the economic fields of countries, companies and individuals [9]. Bidders are bidding to buy with the lowest prices and sell at the highest possible prices. Due to the widespread use of auctions in various fields, there has been growing interest in designing different forms of auctions to suit the diversity of deals and bidders [10].

There are three main types of auctions; the English auction, the Dutch auction and first price sealed. In the English auction, bidders compete to buy an item by raising the price. The bidder with the highest offer will be the one winning the auction. In the Dutch auction, the auctioneer starts at a very high price and then lowers the price periodically, the first bidder who accepts the current price proposed by the auctioneer wins the item. In the First-price sealed auction, each bidder independently submit a single bid without seeing others' bids and the item is sold to the bidder who makes the highest bid [10].

In the following section, the architecture used for negotiation between the Hajj authorities and the Hajj travel agents will be described.

### **Proposed Architecture**

As discussed in the previous section, traffic congestion during Hajj is mainly due to the fact the most Hajj travel agents do not respect the time schedule assigned to them. In this paper, we propose the use of negotiation between the Hajj authorities and the Hajj travel agents so that the process of assigning the schedule to the Hajj travel agents is done in a fair and open way, allowing the Hajj travel agent to affect the schedule based on his needs and his financial limitations. The use of Multi-Agent Systems (MAS) to automate the negotiation process is proposed as organizing an event were such negotiation can take place is not possible. In fact, the Hajj authorities need to finalize the schedule long before the start of the Hajj so it will have enough time to make the necessary preparation to provide the services and accommodations needed. Many of the Hajj travel agents will not be present at the Kingdom of Saudi Arabia so they

cannot be present in such an event. Moreover, due to the large number of Hajj travel agents organizing such an event will not be possible even if they have representatives in KSA.

The time of travel of pilgrims from Arafah to Muzdalifah will be divided into several time slots. Let's assume that each time slot represent an hour from 6 PM to 12 PM. The Hajj Authorities (HA) will create an Information Agent (IA) and a Request Processing Agent (RPA). The HA will conduct a Dutch auction for each time slot. At the beginning of each cycle, the IA will publish the cost of reserving a place for each time slot and the number of available places. Agents representing the Hajj travel agent may send requests to reserve places if the conditions announced by the IA satisfies the Hajj travel agent's criteria. These request will be processed by the RPA. If the number of reservation requests is smaller than the number of available places for a given time slot, the HA will reserve these places for these travel agents for the agreed upon price. During the next iteration, the price of the time slot will be reduced by a predefined percentage and the IA will publish the new price and the number of available places for each time slot. On the other hand, if the number of reservation requests is bigger than the number of available places for a given time slot, no reservation will be made and the price of the time slot will be increased by a predefined percentage. Similarly, the IA will publish the new price and the number of available places for each time slot.

Each Hajj travel agents will have a Company Agent (CA) acting on his behalf. The agent is composed of an Arbitrator Agent, several Quality Agents (QA) and a database containing the Hajj travel agent's preferences, rules and constrains. The travel agent will provide the maximum price his is willing to pay for each time slot, the time slot that he prefers and the flexibility of his preference, which indicates if he is willing to consider other time slots.

A QA will be created for each time slot and the preferences of the Hajj travel agent regarding the maximum price corresponding to the time slot. The QA will calculate the fuzzy parameter Price Satisfaction (PS) that reflects who much the price of this time slot satisfies the requirements of the Hajj travel agents. The QA will use the data of the place sales in the previous rounds to estimate the risk of running out of places after the current round of negotiation. Based on these two fuzzy variable, the QA will use the rules shown in Figure 1 to calculate the Proposal Criteria Satisfaction (PCS) that reflects the amount of necessity for the QA to request a reservation for this time slot with the current price for the time slot. The system uses the JFuzzyLogic [11] library to implement the fuzzy rule system shown in Figure 2.

The Arbitrator Agent (AA) will receive the PCSs sent by each QA. The AA will calculate the global risk of running out of acceptable place for all the time slots that the Hajj travel agents may accept based on his preferences. The AA will use fuzzy rules based on the global risk, the PCS of each QA and how much the corresponding time slot satisfies the preferences of the Hajj travel agent to evaluate the fuzzy variable Global Proposal Satisfaction (GPPS) for each QA. If one GPPS or more exceed the value of minimum acceptable GPPS as defined by the Hajj travel agent's preferences, the AA will choose the GPPS with the highest value and will send it to the Hajj Authorities' RPA. If no GPPS exceeds the minimum acceptable GPPS, the Hajj travel agent will not request any reservation in the current round.

This process is repeated for each round till all the Hajj travel agents have reserved the required places. An overview of the system shown in Figure 3.

```

RULEBLOCK No1
AND : MIN;           // Use 'min' for 'and' (also implicit use 'max' for 'or' to fulfill DeMorgan's Law)
ACT : MIN;           // Use 'min' activation method
ACCU : MAX;         // Use 'max' accumulation method
    RULE 1 : IF risk IS low AND priceSatisfaction IS low THEN proposalSatisfaction IS low;
    RULE 2 : IF risk IS low AND priceSatisfaction is medium THEN proposalSatisfaction IS low;
    RULE 3 : IF risk IS low AND priceSatisfaction is high THEN proposalSatisfaction IS medium;

    RULE 4 : IF risk IS medium AND priceSatisfaction is low THEN proposalSatisfaction IS low;
    RULE 5 : IF risk IS medium AND priceSatisfaction is medium THEN proposalSatisfaction IS medium;
    RULE 6 : IF risk IS medium AND priceSatisfaction is high THEN proposalSatisfaction IS high;

    RULE 7 : IF risk IS high AND priceSatisfaction is low THEN proposalSatisfaction IS medium;
    RULE 8 : IF risk IS high AND priceSatisfaction is medium THEN proposalSatisfaction IS high;
    RULE 9 : IF risk IS high AND priceSatisfaction is high THEN proposalSatisfaction IS veryHigh;

    RULE 10 : IF risk IS critical AND priceSatisfaction is low THEN proposalSatisfaction IS high;
    RULE 11 : IF risk IS critical AND priceSatisfaction is medium THEN proposalSatisfaction IS veryHigh;
    RULE 12 : IF risk IS critical AND priceSatisfaction is high THEN proposalSatisfaction IS veryHigh;

END_RULEBLOCK

```

Figure 1: Sample of fuzzy rules used by QA to calculate PCS

```

FUZZIFY risk
// Fuzzify input variable 'risk': {'low', 'medium', 'high', 'critical'}
    TERM low := (0, 1) (20, 0) ;
    TERM medium := (10, 0) (20,1) (30,1) (40,0);
    TERM high := (30, 0) (40, 1) (50, 1) (70,0);
        TERM critical := (50, 0) (70, 1) (100, 1);
END_FUZZIFY

FUZZIFY priceSatisfaction
// Fuzzify input variable 'priceSatisfaction': {'low', 'medium', 'satisfied'}
    TERM low := (0, 1) (10, 0.8) (30,0);
    TERM medium := (0,0) (30, 1) (50,1) (80,0);
    TERM high := (60, 0) (100, 1) (120, 1);
END_FUZZIFY

DEFUZZIFY proposalSatisfaction
// Defuzzify output variable 'proposalSatisfaction' : {'low', 'medium', 'high', 'veryHigh' }
    TERM low := (0, 1) (20, 0.75) (40,0) ;
    TERM medium := (20, 0) (40,1) (60,1) (80,0);
    TERM high := (50, 0) (70, 1) (80, 1) (100,0);
        TERM veryHigh := (80,0) (100,1);
    METHOD : COG;           // Use 'Center Of Gravity' defuzzification method
    DEFAULT := 0;         // Default value is 0 (if no rule activates defuzzifier)
END_DEFUZZIFY

```

Figure 2: Sample of fuzzification and defuzzification of Fuzzy-Logic system

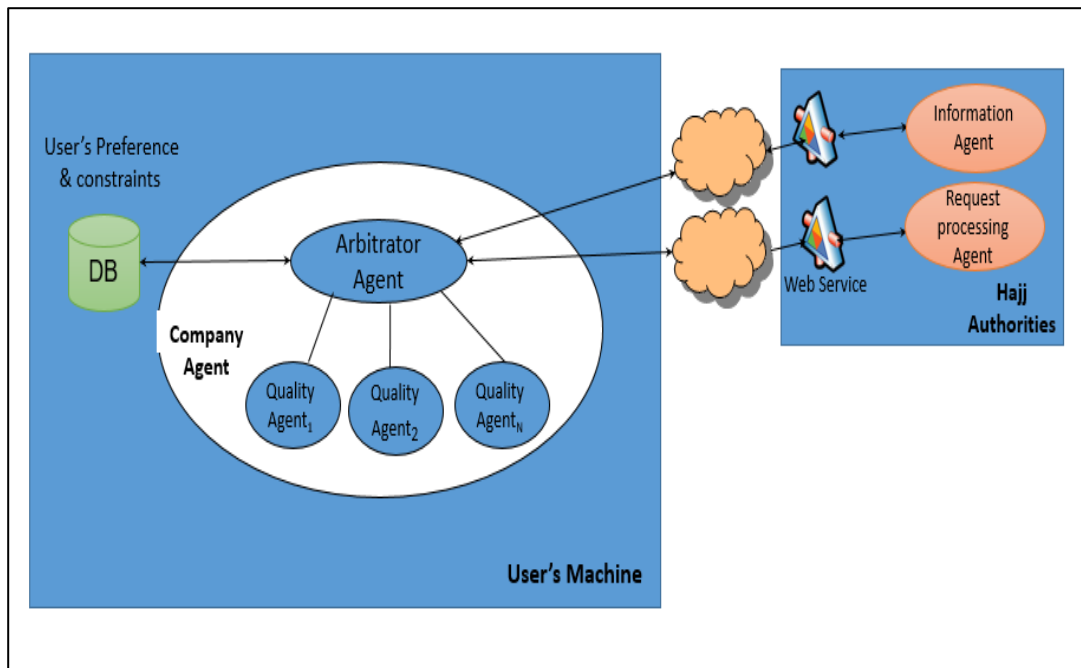


Figure 3: Overview of proposed system

After the automation of the negotiation, the next step is to implement a practical method to force the Hajj travel agents to abide to the assigned schedule. This paper proposes the use of Radio Frequency Identification (RFID) cards that is assigned to each bus. The RFID contains a key that uniquely identifies the Hajj travel agent that has participated in the automated negotiation and has reserved a place in the schedule. Automated gates will be placed at the entrance of Mecca to prevent any bus without a valid RFID to access the Holy city. During Hajj, automated gates can also be placed at the exit of Arafah that would only allow buses to pass if the time slot they have reserved have already started.

Any bus without a valid RFID for the current time slot will be fined. This fine should exceed the maximum possible value for any time slot. Using a fair and open system to distribute time slots and implementing a strict system that would penalize complain organizers that do not abide to the schedule is expected to resolve the problem of traffic congestions and improve the quality of the Hajj experience for all pilgrims.

### Conclusion:

Traffic congestions that occurs during Hajj is not the result of insufficient infrastructure, instead it is due to the fact that the Hajj travel agents do not respect the schedule assigned to them.

In this paper, the authors propose to use a multi agent system to automate the negotiation between Hajj authorities and Hajj travel agents to make the process of schedule assignment open and fair. The use of automated RFID gates is also proposed to prevent buses without a valid card to access the holy city and to fine those buses without identification travelling during Hajj time.

It is expected that the use of such a system will be able to force Hajj travel agents to respect the assigned schedule, hence to resolve the problem of traffic congestions during Hajj.

## Recommendations :

1. Using the proposed multi agent system to automate the negotiation between Hajj authorities and Hajj travel agents to make the process of schedule assignment open and fair.
2. Using automated RFID gates to prevent buses without a permission to access the holy city and to fine those buses without identification travelling during Hajj time.

## References:

- [1] M. Edrees, Location Based Scheduling to Jamarat Bridge, 16th Scientific Symposium for Hajj, Umrah & Madinah Visit – Scientific Portal for 1437AH
- [2] F. M. Y. Othman, Practical Vision for Increasing the Capacity of the Hajj, In 16th Scientific Symposium for Hajj, Umrah & Madinah Visit – Scientific Portal for 1437AH
- [3] M. Wooldridge, "An introduction to Multi-Agent systems". Wiley, 2009.
- [4] S. Franklin, A. Graesser, Is it an agent, or just a program?: A taxonomy for autonomous agents, In Proceedings of the Third International Workshop on Agent Theories, Architectures and Languages, Springer Berlin Heidelberg, 1996. On-Line: <http://www.mscl.memphis.edu/~franklin/AgentProg.html>
- [5] R. A. Flores-Mendez, "Towards a standardization of multi-agent system framework". In ACM Crossroads Student Magazine, Volume 5 issue 4, 1999.
- [6] F. Lopes, "Negotiation and Argumentation in Multi-Agent Systems: Fundamentals, Theories, Systems and Applications", In Bentham Science Publishers.
- [7] F. Bellifemine, G. Caire, D. Greenwood, "Developing Multi-Agent Systems with JADE", Wiley, 2009.
- [8] F. Lopes, M. Wooldridge, A.Q. Novais, Negotiation among autonomous computational agents: principles, analysis and challenges, In Artificial Intelligence Review; Springer Netherlands, Dordrecht Vol. 29, Iss. 1, (Mar 2008): <https://doi.org/sdl.idm.oclc.org/10.1007/s10462-009-9107-8>
- [9] McAfee, Dinesh Satam; McMillan, Dinesh (1987), "Auctions and Bidding", Journal of Economic Literature, American Economic Association (published June 1987), 25 (2).
- [10] Klemperer, P. 1999. Auction theory: A guide to the literature. Journal of Economic Surveys.
- [11] Cingolani, P., & Alcalá-Fdez, J. (2012, June). "jFuzzyLogic: a robust and flexible Fuzzy-Logic inference system language implementation", In Fuzzy Systems (FUZZ-IEEE), 2012 IEEE International Conference on (pp. 1-8). IEEE, <https://doi.org/10.1109/FUZZ-IEEE.2012.6251215>

# **Fifth Theme**

# **Awareness and media**

# Using Printable Integrated Multimedia Maps for telling Islamic Heritage Sights in Al-Madinah Al-Monawarah

FOUZIA ALZHRANI, KAWTHER SAEEDI, DANIA ALJEAID  
Faculty of computing and information technology, King Abdulaziz University

## استخدام نموذج التفاعل المتكامل لسرد قصص التاريخ الإسلامي في المدينة المنورة

فوزيه الزهراني، كوثر صعيدي، دانية الجعيد  
كلية الحاسبات و تقنية المعلومات، جامعة الملك عبد العزيز

### ملخص البحث (Abstract):

خريطة الوسائط المتعددة المدمجة (IMM) هي نموذج لسرد قصة يجمع بين صيغ الوسائط المتعددة المختلفة والمرتبطة بخريطة جغرافية بهدف إخبار قصة. في وقتنا الحالي، هناك عدد محدود من الحلول المتاحة لخريطة الوسائط المتعددة المدمجة التي تركز على تقديمها على الشاشات الإلكترونية مع خرائط قابلة للنقر. يقدم هذا المشروع نموذجًا تفاعليًا متكاملًا بين موقع المستخدم ورسائل خريطة الوسائط المتعددة المدمجة القابلة للطباعة ومحتويات الوسائط المتعددة المعروضة في تطبيق الجوال. من خلال هذا الحل، يمكن للمستخدمين الاستمتاع بقصة تفاعلية مع خرائط مطبوعة باستخدام تطبيق الجوال المصاحب. تستهدف هذه الخرائط قطاعات السياحة والتعليم والصحافة، مع إمكانية استخدامها في مجالات أخرى أيضًا. توضح هذه الورقة استخدام نموذج خريطة الوسائط المتعددة المدمجة المقترح لسرد قصة حول مشاهد التراث الإسلامي في المدينة المنورة. يمكن الوصول إلى القصة من خلال خريطة قابلة للطباعة أو خاصية اكتشاف الموقع في الهاتف الذكي للزائر. يقوم تطبيق الجوال بعرض قائمة بالخرائط ذات الصلة بالقصص. بمجرد أن يحدد الزائر قصة، يعرض التطبيق محتوى ذلك الموقع، ويستعرض أحداث أخرى ذات صلة أثناء الانتقال إلى مواقع مختلفة. علاوة على ذلك، تقدم خريطة القصة لمحة عامة عن الحدود الجغرافية للقصة، لإرشاد الزائر خلال سيرهم داخل مواقع القصة، ويمكنهم من الاطلاع على علامات الخريطة إذا كانوا يقرأون القصة خارج الموقع. تستعرض هذه الورقة النظام المعمول به في نموذج التفاعل المقترح بالتفصيل، مما يسهل المرونة في إضافة قصص جديدة ببيانات الوسائط المتعددة وبيانات المواقع ذات الصلة.

An Integrated multimedia map (IMM) is a storytelling model that combines different multimedia formats associated with a geographical map to tell a story. Nowadays, there are a limited number of available IMM solutions and they focus on presenting IMM on electronic screens with clickable maps. This project introduces an integrated interactivity paradigm between the user's location, printable IMM and multimedia contents displayed on a mobile application. Through this solution, users can enjoy an interactive story guided with printed maps using a companion mobile application. Printable IMM is targeted at tourism, education and journalism sectors, though it can be used in other areas as well. This paper demonstrates the use of the proposed IMM paradigm to tell a story about Islamic Heritage Sights in Almadinah Almunawarah. The story can be accessed through a printable map or location detection feature in visitor smartphone. The mobile application will display a list of map related stories. Once a visitor selects a story, the

application displays the content of that location. The application also notifies visitor with relevant events while moving to different locations. Furthermore, the story map provides an overview of the geographical borders of the story, to guide visitors during their walk within the story locations, as well as they can scan map markers if they are reading the story off-site. This paper will detail the system architected of proposed interactivity paradigm, which facilitates flexibility to add new stories with relevant multimedia and location data. Then presents the software system that has been successfully implemented which consists of two applications: one is the maps creation tool as a web application and the other is the content extractor as an Android App. For evaluation, the applicability of the proposed paradigm is demonstrated through a storytelling scenario about a story happened in Almadinah Almunawarah.

### **Introduction:**

Maps are a powerful language that can be easily understood. The first known map of the world was a simple circular illustration dating to 550 BCE (Pontis, 2012). Traditionally, maps were based on paper and were hand drawn with limited applications and distribution. The main uses of maps were to aid in exploration and to guide in navigation. Otherwise, they were impractical. Nowadays, the power of maps has expanded to reveal, explore, and share information in an interactive way. The widespread use of location-aware applications familiarized users with interacting with maps and, consequently, users become enthusiastic to use these maps in creative ways. Together with technology advancements, the need to turn old-fashioned maps into interactive, content-rich maps have resulted in the development of integrated multimedia maps (IMMs), widely known as story maps. These IMMs can be generated using online story maps applications such as Story Maps by Esri (Environmental Systems Research Institute, 2016) and StoryMap JS by the Northwestern University Knight Lab (Wise, 2013). The role of IMM applications is expanding in numerous fields. For education, teachers and students can demonstrate compelling maps about subjects of interest. In critical fields, such as health and military, users can gather important data and present them on an interactive map in order to reveal interrelationships and examine causes and effects. Moreover, IMMs help businessmen track the progress of a sales or advertising campaign, for example. They can enrich maps with supplementary digital materials from different places to summarize, compare and contrast situations. Museums, as an instance of the tourism sector, can use IMMs to turn old-fashioned historical stories presentation into an attractive style. They can show changes over time in an interactive location-based demonstration, resulting in good experiences for visitors.

This project aimed to provide a new interactivity paradigm between users and IMMs by providing a software solution for generating and interacting with printable IMMs. The idea behind IMMs is to enrich maps with multimedia content, such as audio, video, and photos, within a single intuitive platform. The map is used for organizing multimedia elements. The purpose of this integration is to emphasize the message beyond the actual map. A web-based application is built to produce printable multimedia maps with hidden content accessed using Data Matrix codes (ISO/IEC, 2011). A companion mobile application is built to interact with the Data Matrix codes on the printed maps. The evaluation of the paradigm is conducted through a scenario in which an Islamic Heritage Sights in Madinah is visited through guidance of an IMM application. The historian collects multiple notes, videos, photos, and audio records from different Islamic



Heritage Sights in Madinah. Afterward, he uploads these multimedia files to an online IMM application. The application allows him to assign every multimedia file to a location on the map. Then application displays a clickable map on the computer screen that contains markers for every location in the story. The generated code can be printed with or without a map in different printable format such as poster, flyer, brochure etc. On the mobile app once the code is scanned, full story with a clickable map on location marker is viewed and multimedia contents related to that location will appears on the screen .

The aim of this paper is to demonstrate the proposed interactivity paradigm through a story telling scenario about Islamic Heritage Sights in Almadinah Almunawarah. The scenario chosen to demonstrate the proposed paradigm is taken form (تاريخ طبيه في خير القرون) book (Alfaidi,2014). All the stories in this book or other sources can be added through graphical user interface of the proposed application. The paper starts with a background introduces the principles of IMM and related technologies. Then the paper outlines the core functions of the application in two main parts: Adding story by an app administrator and navigating story by application users. Successful demonstration of the story on the app demonstrates the visibility of proposed paradigm. Then the paper concluded with suggestion and further recommendation for the developed application and plan for its operation.

## **PRINCIPLES OF PRINTABLE IMM PARADIGM AND RELATED TECHNOLOGIES**

The IMM applications are similar in terms of the key input and output procedures. Its involve a user who creates a story must manually assign a location for every multimedia file even though such files are often already geotagged by modern photography devices. Additionally, the product of these solutions is a screen-only clickable map. This output mechanism limits the availability of IMM to computer screens and thus constrains the usability of them, which may add additional setup and maintenance costs. For example, journalism publications can use IMM applications for only their online publications. Similarly, museums may have to attach wide screens on walls or distribute multiple screens around to allow IMM to be accessible by visitors. Likewise, in education, the use of IMM applications during classes is restricted by the availability of computer labs. The printable IMM paradigm supports the current IMM applications with printable code, in the location map or any physical material, to allow access the relevant contents using smart phone. The following brief of the emerging technology encourage the development of such application.

### **Encoding (Data Matrix):**

This allows multimedia content to be embedded within printed maps. A Data Matrix code is a two-dimensional symbol that can store binary, numeric, and alphanumeric characters in a square or rectangular symbol. Its square type has 24 symbol sizes ranging from 10x10 to 144x144 modules. Three factors make a square Data Matrix an optimal encoding technology for printable IMM. First, its data capacity. A Data Matrix code has the ability to store 50 characters in a symbol that is 2 or 3 mm<sup>2</sup>, which is similar to the size of map markers. Second, its readability. Data Matrix codes are readable at a low contrast ratio, making them a favoured choice because different marker icons on maps may have

different contrast ratios. Third, its reliability. The codes can be successfully read even if more than 20% of the symbol is damaged or poorly printed (ISO/IEC, 2011). Data matrix code shown in Figure 1.

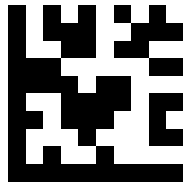


Figure 1: A Data Matrix code stores the text: "IMM"

### **Mobile Augmented Reality (AR)**

AR refers to a real-time interaction between digital information and physical objects. For printable IMMs, AR allows a mobile device's camera to be pointed at a map marker and display the hidden information on the mobile screen. Mobile AR takes digital information (e.g., photos and videos) and overlays it on a physical object (e.g., a printed map) through a mobile device's screen when a user points the mobile device's camera at specific map markers, which is a mechanism known as vision-based AR (raig, 2013).

### **Web Map Service (WMS)**

A WMS adds the markers of the places in a story on top of a map generated by an online web map service, such as OpenStreetMap. WMS is a web-based platform aimed at producing georeferenced map images from a geospatial database and serving them over the Internet to clients. For printable IMM system, a map service was built using OpenLayers library and the mapping data was provided by OpenStreetMap (Open Geospatial Consortium, 2006).

### **Multimedia**

Multimedia is a combination of different content forms within one digital element. It is made up of any combination of graphics, animation, photos, drawings, audio, text, and any other media forms. Multimedia elements are produced, stored, and represented on digital devices though some of them are printable as well. Multimedia can be embedded within the map markers of a story map. (Grimes & Potel, 1991).

### **Geotagging**

Geotagging is the process of assigning geographical information as geospatial metadata to various digital media such as photos and videos. Usually, longitude and latitude coordinates are the main contents of the metadata. Further location information such as accuracy, distance, altitude, bearing, and place names may be included in addition. Multimedia files can be geotagged in different ways such as attaching the multimedia file to a map or at the time the photo or video is taken (Larson et al., 2011; Goldwasser, 2004). In printable IMMs, multimedia files are geotagged by assigning to them longitude and latitude coordinates when they are uploaded to the server.

### **Interactivity**

Interactivity, in this context, comprises the request and response flow between the user and the system in a selective, intuitive, and associative way. These actions include a user's request to play a video, click on a hyperlink, scroll through a text panel, change the zooming degree, and navigate through the map and the proper feedback from the system (Kioussis, 2002).

## Geovisualisation

Geovisualisation refers to geographic visualisation, which is an interactive visualisation technique restricted to a spatial domain that contributes to knowledge construction about geographical phenomena (Dykes, MacEachren & Kraak, 2005; Nöllenburg, 2007). For example, maps can be overlaid with colour-coded temperature data. In printable IMM, geovisualisation is the use of a map as an organiser for story elements and the content is presented as map markers

## Application description

This paper consists of two applications: The first one is a web-based map-creation tool that acts as a story map writer, called Storymap Writer. This tool is accessed by a storyteller who writes and uploads relevant contents of the story. The second one is an Android application displays different forms of multimedia contents stored for the story through scanning the matrix code or location identification, called story map reader. The components of this application are illustrated in Figure 2.



Figure 2: Components of IMM application

Using the Storymap Writer provides a login page to the storytellers where they can upload their multimedia files (MP3, MP4, JPEG, etc.) to the application's server. As a part of the uploading process, they select the geographical location of these files and upload them on the server. Afterwards, the application generates a printable map with Data Matrix codes as location markers. Each code stores a string ID assigned to the related content. The Data Matrix code does not encode a URL in order to protect the access to the data; only the Storymap Reader app can extract the content of a printed story map. In other words, if any other barcode scanner is used to read the Data Matrix codes, it will not be able to access the multimedia content. Then, users can interact with the printed map by scanning the Data Matrix markers using the Storymap Reader application, which extracts the hidden content by firstly decoding the encoded string and then downloading the content from a standard web server. Then the content is displayed on the mobile screen via the application interface.

Publications can include multiple images for multiple locations in a single map image instead of spreading the images over pages. Furthermore, these publications can be enriched with non-printable contents such as videos and audios instead of distributing supplementary CDs or DVDs. Journalists can print attractive, location-based stories and support these stories by various multimedia content and allow users to uncover and explore additional information about the stories. For example, an article about the spread of coronavirus (Geller, Varbanov & Duval, 2012) may be supported by a story map that points to places affected by the virus, and the reader can explore additional information by scanning the map markers of those places. On the other side, Story map readers can interact with various printed story maps by using only one application that is able to extract the content from any map as long as this map is generated using the companion map creation tool.

## Demonstration of a storytelling scenario

The battle of the trench (Ghazwh al-Khandaq) is a battle between the Muslims, which led by the Prophet Muhammad peace be upon him, and the Confederacy (Ahzab): Quraish and his allies Kenana (Ahabeesh) and the tribe of Ghattafan al-Assad and Salim and others. The battle took place in Medina where Muslims dug a trench upon the suggestion of Salman al-Farsi to prevent Confederacy armies from entering Medina. When the Confederates reached the borders of Medina, they were unable to enter and forced three weeks of siege. This siege has caused harm to Muslims and starvation. The battle ended with withdrawal of the Confederates because of their exposure to extreme cold winds. The following illustrated steps show the main process of using the Printable IMM system through a process of generating a story map for the Battle of the Trench:

1. The user uploads the multimedia files and assign them a location on the map. The user can upload multiple multimedia files at a time if they are belonging to a single geographical location. Figures 3 and 4 present the process of uploading files. The map initially shows the globe view, and it then zooms in to focus the view on the selected location.
2. A story map can be generated in a single step by clicking [Create Storymap] link from the top menu. It displays a form contains a list of all the available files that have been uploaded by the user at any time. The story map can be generated by simply selecting the desired files from the list, and optionally adding a description for the story and captions for the selected files (see Figure 5). Then, the application generates a story map contains multiple encoded markers that indicate the important places of the Battle of the Trench.

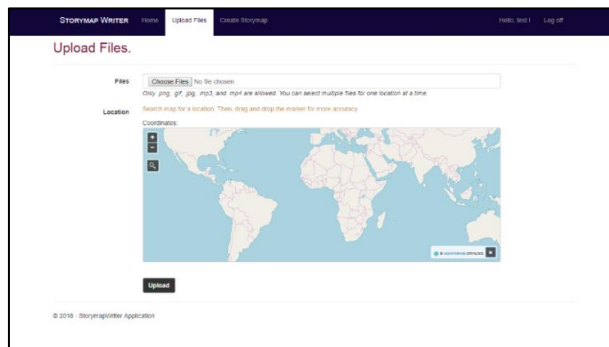


Figure 3: The initial view of the file upload form.

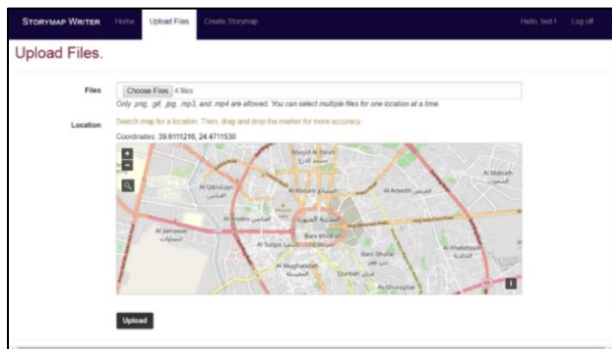


Figure 4: the map view is changed zooming in to focus on Almadinah Almonawarah region.

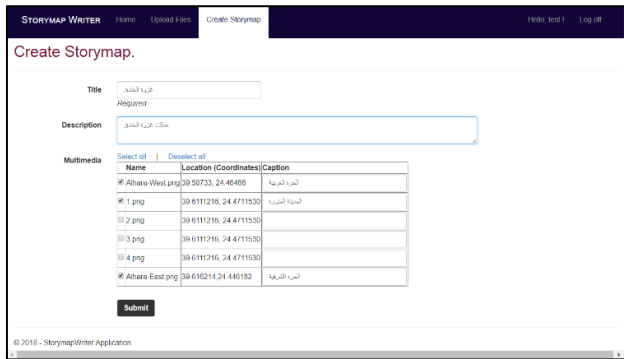


Figure 5: The form of creating a story in process. It displays all uploaded files by the user.

3. In order to read the Battle of the Trench story map, the Storymap Reader app is used. By clicking the app icon on the mobile Home screen, the app is opened and displays the home screen that contains the [Scan] button as shown in Figure6.

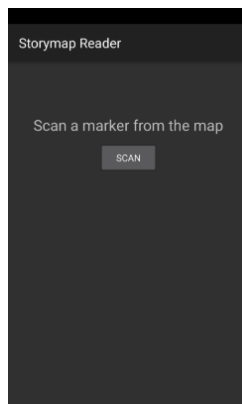


Figure 6: Home screen of StoryReader app

4. By scanning a valid Data Matrix code, the app displays the multimedia view screen. This screen contains dynamic tabs based on the retrieved multimedia count string. The [Photo] tab is displayed only if the count of image files is greater than zero. And the same is for [Video] and [Audio] tabs in relation to their counts, see Figure7.



Figure 7: The view of an image after scanning a map marker

### Summary and conclusion:

The printable IMM solution provides a new way to tell and read stories with geographical maps. Unlike other currently available solutions, printable IMM provides a straightforward and single-step way to create a story map. In contrast with the available solutions, printable IMM provides an innovative way to read story maps. The solution relies on the encoding technology using Data Matrix codes, which is economical and feasible. It is suitable for any location-based topic linked to different locations. Such solution can be used in education, tourism, journalism and any other domain. This can enhance the grasping level of a story in an interactive and visual fashion. To demonstrate the usability of the solution, the paper proved how to write story of Muslim heritage in Madinah using Storymap Writer application and how to access the story through the location based mobile application using Storymap Reader mobile app. The story was chosen from (تاريخ طيبة في خير القرون) book (Alfaidi,2014), which includes a wide range of interesting stories related Islamic heritage in Almadinah Almunawarah with pictures and locations. The book was carefully selected as an example of trusted resource to Islamic heritage stories. However, the authors faced difficulties to allocate the accurate location due to new naming of the area.

### Recommendations:

1. This solution provides the technological platform for storytelling and we recommend this platform to be the host of Islamic heritage in Saudi Arabia. The platform is developed as a working prototype of the Printable IMM paradigms. In order to take the application into operation, a technological infrastructure and technical team support are needed.
2. A trusted historians and reliable historical resource are required to feed the solution with rich and interesting contents with different languages.
3. The multimedia contents have key role for attract application users and help to enjoy the visiting experience. The solution entails talented and creative multimedia team to develop high quality contents for the application.

### References:

- Alfaidi Tnidb, (2014). تاريخ طيبة في خير القرون.
- E Craig, A. B. (2013). Understanding Augmented Reality: Concepts and Applications. Newnes.
- Dykes, J., MacEachren, A. M., & Kraak, M. J. (2005). Exploring geovisualization. Elsevier.
- Environmental Systems Research Institute. (2016). Story maps. Retrieved May 10, 2016, from <https://storymaps.arcgis.com/en>
- Geller, C., Varbanov, M. & Duval, R. (2012, November 12). Human Coronaviruses: Insights into Environmental Resistance and Its Influence on the Development of New Antiseptic Strategies. Retrieved from <http://dx.doi.org/10.3390/v4113044>
- Goldwasser, D. (2004). A Brief Introduction to GPS Photo Linking. Jun, 15, 1-5.
- Grimes, J., & Potel, M. (1991). What is multimedia?. IEEE Computer Graphics and Applications, 11(1), 49-52.
- ISO/IEC. (2011). Information technology – Automatic identification and data capture techniques – Data Matrix bar code symbology specification. Technical Report, International Standard ISO/IEC, Switzerland.

- Kiouisis, S. (2002). Interactivity: a concept explication. *new media & society*,4(3), 355-383.
- Larson, M., Soleymani, M., Serdyukov, P., Rudinac, S., Wartena, C., Murdock, V., ... Jones, G. J. (2011, April). Automatic tagging and geotagging in video collections and communities. In *Proceedings of the 1st ACM international conference on multimedia retrieval* (p. 51). ACM.
- Nöllenburg, M. (2007). Geographic visualization. In *Human-centered visualization environments* (pp. 257-294). Springer Berlin Heidelberg.
- Open Geospatial Consortium. (2006). OpenGIS Web Map Service version 1.3. 0.
- Pontis, S. (2012, January 16). 20 Information Design Milestones. Retrieved February 23, 2016, from <https://sheilapontis.wordpress.com/2012/01/16/20-information-design-milestones/>
- Wise, Z. (2013). StoryMap JS - telling stories with maps. Retrieved September 23, 2016, from <https://storymap.knightlab.com>

# Applying game-based learning system to facilitate the Manasik of Hajj and Umrah

Marwa Atta Sultan

Department of Engineering and Applied Sciences (computer science), Makkah Community College, Umm Al Qura University

## تطبيق نظام التعلم القائم على الألعاب لتسهيل مناسك الحج والعمرة

مروة عطا أحمد سلطان

(قسم العلوم الهندسية والتطبيقية (علوم الحاسب)، كلية المجتمع ، جامعة أم القرى

ملخص البحث (Abstract):

نظام التعلم القائم على الألعاب في التعلم يشمل عدة مميزات منها تحقيق مستوي عالي من التفكير والمهارات الإدراكية للحاج المستخدم لهذه الألعاب ، وأيضا زيادة سعة ذاكرة الحاج حيث أن عليهم تذكر المناسك والأذكار من أجل حل اللعبة وحفظ التسلسلات المطلوب تأديتها للمناسك مما يساهم في تقليل الأخطاء أثناء الحج أو العمرة. كما انها تساعد في التفكير الاستراتيجي السريع وحل المشكلات لأن معظم الألعاب تتطلب من الحاج أن يفكر بسرعة. علاوة على ذلك ، عليهم أن يستخدموا منطقهم لكي يفكروا في خطوات قادمة لحل المشاكل ومستويات اللعبة. لذا تعد أنظمة التعلم المبنية على الألعاب تساعد في بناء المهارات للحجاج. كما تحتوي الكثير من الألعاب على جوانب فنية تساعد الحاج ذوي المهارات الخاصة علي الاستيعاب بشكل أفضل للمناسك. بالإضافة لذلك اضافة عنصر المرح والتشويق في عمليه التعليم للمناسك وبالتالي زيادة الارتباط بين الحاج واللعبة والاستفاده المثلي من محتوياتها.

يهدف البحث الي لتقديم نموذج متكامل مخصص لأي نظام قائم علي الألعاب يهدف الي تعليم مناسك الحج والعمرة وذلك عبر دراسة تحليلية لأهم العناصر والعوامل التي يجب أن تتوفر في أي نظام تعلم قائم علي الألعاب خاص بهذا الغرض. ويمكن استغلال هذا النموذج أيضا في انشاء تطبيقات ألعاب الكترونية تقوم بعرض التحذيرات والأرشادات المطلوبه علي الحجاج والمعتمرين مما يساهم أيضا في تفادي الوقوع في المشكلات التي يمكن أن تحدث أثناء الحج أو العمرة.

There are many benefits for using games in Manasik learning process, these games can enhance cognitive and mental skills of players as it makes them think about Manasik aspects and remember Manasik sequences to complete playing the game. Also games motivate players for learning by the result this will make Manasik learning process is interesting. Games help learners to think in a strategic way as it requires players to think fast and in logic order to can solve the game problem or complete game levels.

The research work aims to exploit the advantages of the game-based learning system on the comprehension of the Manasik of Hajj and Umrah. these electronic game applications should simulate the Manasik electronically and offer warnings and guidance to pilgrims and Umrah in an interesting and effective way, which also helps avoiding problems that may occur during Hajj or Umrah caused by miss understanding or ignorance of such rules and Manasik.



The research introduces a theoretical model for game-based learning system that is specialized for all Manasik learning aspects. It introduces four main components that should exist to develop a complete game for this purpose. These components are Cognitive, Motivation, Affect and Religious.

### **Introduction:**

In this section I will introduce the definition of game and game-based learning. Then I will discuss some reasons that help games effective learning environments.

Salen et al (2004) defined a game as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome".

Shaffer et al (2005) defined a Game-based learning as "it is a type of game play with defined learning outcomes". As a result to this definition the design of a game for learning purpose should balance between the need to cover the content with the desired outcomes (Plass, Perlin, & Nordlinger, 2010).

Actually, there are a number of factors that affect on games and make it effective learning environments (motivation, player engagement and Adaptivity) (Jan L. Plass, Bruce D. Homer & Charles K. Kinzer 2015).

**1. Motivation:** this means that the game will be able to stick player over long periods on the game. To achieve this games should contain many features like stars, points, leaderboards, badges, and trophies. (Hidi & Renninger, 2006; Rotgans & Schmidt, 2011). Beside these features a religious motivation will be added that makes pilgrim stay engaged to the game for Islamic purpose.

**2. Player engagement:** this factor is very close to motivation factor, player engagement means that the game has the ability to let the player continue playing and sticked to the game.

The type of engagement depends on the goal of learning and the characteristics of the learner. Here the goal of learning is Islamic (i.e., understanding the Manasik and all related issues) and the designed game should be suitable for pilgrims taking into consideration the age category, culture, language and other characteristics.

I base my discussion of engagement on the "INTERACT" framework introduced by Jan L. Plass et al (2015), this model differentiates among many types of player engagement which are cognitive engagement, affective engagement, behavioral engagement. The research added a new type of engagement, Religious engagement (i.e., Manasik interactions embedded within a religious context of quran and sunnah). Figure 1 shows the different types of engagement for the proposed game learning model. All these types of engagements will be discussed in later sections.

For example, a game can engage the pilgrim learner behaviorally by using gestures as input or inviting players to perform specific physical actions as part of play, and it can engage pilgrim cognitively by allowing the pilgrim think about all Manasik issues and how to complete them. A Game can engage the pilgrim learner religiously by supporting Manasik guidelines and the matters that are prohibited during Hajj and Umrah referencing to the Quran and sunnah text.

The goal of all these types of engagement, is to relate cognitive engagement of the pilgrim learner with the learning process. Games that do not achieve cognitive engagement are not likely to be effective in helping the learner achieve their learning goal.

3. **Adaptivity:** is the capability of the game to engage each pilgrim learner in a way that reflects his or her specific characteristic. This can be related to the learners' current level of knowledge, to cognitive abilities of pilgrim player, to the learners' emotions, religious background or to a range of other variables.

The first requirement of adaptive design is to assign the variables that the game is supposed to be adapted for, such as in our situation if the pilgrim has prior knowledge of Manasik or the mental capability for the pilgrim. In case of a handicapped pilgrim or any type of handicap.

The next step is to provide a suitable response to the pilgrim learner. "This may involve a modification of the type and complexity of the problems and guidance presented to the learner" (Azevedo, Cromley, Moos, Greene, & Winters, 2011; Koedinger, 2001) or the use of "guidance and feedback in a way that responds to the player's in-game actions" (Steinkuehler & Duncan, 2008).

### **Research aims:**

The aim of this research is to propose a simplified model of game-based learning dedicated for the purpose of Manasik learning. It will help game designers to develop an interactive, effective and qualified learning digital games environments.

that digital games are able to engage pilgrim learners on an affective, behavioral, cognitive, sociocultural and religious level in ways few other learning environments are able to, which will make pilgrim motivated in the learning process.

### **Research methodology:**

The methodology followed in this research is a detailed study of previous game-based learning systems and reviewing the elements, arguments and components of game-based learning systems.

Then introducing a new game-based learning model more dedicated to Hajj and Umrah Manasik learning process.

The research adapted the types of engagement on the INTERACT model of learner activity (Jan L. Plass, Bruce D. Homer & Charles K. Kinzer 2015) to be specialized for the purpose of Manasik learning or other Islamic rules learning purpose, the INTERACT model distinguishes among cognitive engagement, affective engagement, behavioral engagement. The current research adds a new engagement type, Religious engagement (i.e., Manasik within a religious context of Quran and Sunnah) see Figure 1.

### **Results and discussion:**

In this section I will introduce the elements of game design and foundation of game-based learning for the proposed model in Figure 2.

#### **1. Elements of game design for learning:**

**1.1 Game Learning Mechanics:** it is a set of Manasik steps and activities repeated by the pilgrim player during the game. These activities are considered learning mechanics.

**1.2 Visual Aesthetic Design:** it determines the way that tools, feedback and cues of the game can be visualized. This may include cognitive beside aesthetic function. (Jan L. Plass, Bruce D. Homer & Charles K. Kinzer, 2015).

**1.3 Narrative Design:** The narrative of a game is the story that is introduced via dialogues, views, actions, and voice-overs.

**1.4 Reward System:**The Reward system of a game includes features that motivate and encourage players to continue playing. Reward system may include badges, scores, points, stars, power-ups, and many other rewards. (e.g., see Kinzer et al., 2012)

**1.5 Musical System:** is the background sounds and sound effects of the game, which used to pay the player's attention to the important actions or warning in the game or the success or failure of a specific task during the game.

**1.6 Content and Skills:** The last element is the intended skills and subject content of the game. All the previous game elements (visual design, narrative design, reward system and musical system) depend on the content and the skills that the game supposed to teach. (Plass & Homer, 2012). In case of Manasik learning the content will be all information and related to Hajj and Umrah process. (Plass, Perlin, et al., 2010) stated four functions of games that describe to what extent and with what learning goal this content is covered which are: "Preparation of future learning", "Develop 21st-century skills", "Teach new knowledge and skills" and "Practice and reinforce existing knowledge and skills".

The proposed game model should Teach new knowledge and skills by introducing new knowledge to the pilgrim learners.

Also, the proposed model should reinforce existing knowledge by practicing existing knowledge for pilgrim about Manasik and basic cognitive skills in order to automate the game.

## **2. Foundations Of Game-Based Learning**

The game design is affected by many foundations, these foundations are cognitive, motivation, emotion and religious.

The extent to which these foundation affect the game design depends on the game's content, desired objective and game type.

I describe in Figure 2 a general game learning design patterns, that is, suitable solutions to the process of Manasik learning and also can be suitable for teaching any Islamic issue. Game design patterns describe solutions on an abstract level that will help game designer to develop complete game for Manasik learning.

### **2.1 Cognitive Foundations Of Game-Based Learning**

The goal of cognitive foundation is to construct a mental model for learner. "(Mayer, 2005, 2014). There are many cognitive theories, one of them is introduced by (Mayer, 2014) in which the pilgrim learner will select information existed in the game, organize this information in working memory and then integrate the acquired knowledge with one another with the prior knowledge.

The designers should consider which game elements suitable for the cognitive processing of Manasik learning content. And should determine how these content represented to engage the pilgrim learner for reaching the intended outcomes. Designers also have to take into consideration the cognitive processing of the meaning of the various game elements and relate them to Quran and Sunnah.

Next some factors facilitate cognitive processing will be discussed, which are dynamic assessment, information design, interaction design, and gestures and movement.

**Dynamic Assessment:**As the nature that Manasik consists of many steps and processes, the game design should have accurate dynamic assessment to know when pilgrim learner change to next step of Manasik. A first step for dynamic assessment is to clearly identify some factors to be assessed like Manasik learning goals, as well as other pilgrim's individual-level variables that can affect learning outcomes (age, language, culture,...).

Evidence-Centered Design (Mislevy & Haertel, 2006) provides a useful framework for thinking about in game assessments (see Plass, Homer, et al., 2013, for more detail).

**Information Design:** it means visual representation of Manasik information, this visual design gives games the strength in learning process.

The design of this visual information for purposes of learning can be based on research on "multimedia learning and its principles" presented by (Mayer, 2014), as well as on principles related to "cognitive load theory" presented by (Plass, Moreno, & Brünken, 2010).

**Learning Mechanics:** (Homer & Plass, 2014) defined it as mapping process between game learning objectives and game strategies based on suitable learning theories. One of these theories is "Evidence-Based Design" introduced by (Mislevy & Haertel, 2006). The effective learning mechanics should be suitable for the learning goals of the game.

**Gestures and Movement processing:** it considers how to map game gesture or movement to key features of the game content. This process has perceptual and cognitive effects on the player.

(Black, 2010) (Gibbs, 2006) (Kwah, Milne, Tsai, Goldman, & Plass, 2014).

## 2.2 Motivational Foundation Of Game-Based Learning

From a motivational perspective, the game should be able to engage and motivate players to make them enjoy and desire to continue playing the game. This will be achieved by providing different game features and taking into consideration all reasons that make players want to play a game.

In case of Manasik learning the game designer should consider the Islamic motivator for the pilgrim player and try to investigate how to enhance pilgrim learners' motivation.

There are many theories of motivation that can help inform the design of game features that enhance learners' motivation.

In fact, there are some factors that may affect the motivation process, the main factor is the learning objectives of the game, which will be mainly facilitating Manasik process in an interesting way. Other factors may be considering the target population of pilgrim players (i.e., their age, gender, educational level, etc.), and even the Islamic style of the game.

In game learning motivation, there are many theories that organize player motivation. For example, Eccles et al. (1998) formulated three questions which are ("Can I do this?" "Do I want to do this, and why?" and "What do I need to do in order to succeed?"). These questions are related to any learning situation, including Islamic educational games.

Well-designed games are built in ways to ensure that pilgrim players know what to do and feel confident that they can succeed (which includes failing gracefully, and trying again). Jan L. Plass et al. (2017) suggest many factors of why players will be motivated to play a learning game such as intrinsic and extrinsic motivation of the learners, specific goals of the learners, and learners' individual interest.

## 1.3 Emotional Foundation Of Game-Based Learning

An emotional foundation of game-based learning interests in learners' emotions, attitudes, and beliefs.

It focuses on how the design of the game affects learners' affective through emotional engagement. It also focuses on how it is related to cognitive, motivational, and religious aspects of learning. There are many models and theories that show the relation and mutual influence of cognition and emotion during learning, these theories such as "the differential emotions theory" introduced by (Izard, 2007), "the control value theory of achievement emotions" introduced by

(Pekrun, 2000), and “the integrated cognitive affective model of learning with multimedia” introduced by (Plass &Kaplan, 2015).

One way to integrate affect in games is by taking advantage of specific game elements, such as the aesthetic design, game mechanics, narrative, or musical score, to encourage emotions in players. When taking an affective perspective on game-based learning, emotional aspects of play and their impact on learner engagement are considered, whether they are facilitating or hindering learning process. This means that the goal of the design of a playful learning game is to maximize player engagement and stickiness of the game.

#### **1.4 Religious Foundation Of Game-Based Learning**

The religious foundation of game relate learning to Islamic context and use religious influences as motivators for learning through Islamic design of game. Religious foundation of learning couldn't separate from the other foundations discussed above, as cognitive and affective foundations interact with each other within religious contexts.

The religious aspects can affect on game designers when they design their games ,for example we can't find muslim designer use any content or internal design for other region eventhough its content is not for Islamic purpose.Designers should take into consideration while designing Islamic games some factors like the Islamic design patterns , motivation , cognitive contents from Quran and Sunnah and Islamic sound effects .

#### **Summary and conclusion:**

As my review has shown, many of the foundations that are important in the design of games in general and Islamic games in specific, such as motivation, have parts relating to each of the areas i discussed, and missing any one of them would result in an incomplete design of games and will affect on their ability for learning.

Above, I have shown how all four different foundations of game learning framework should be integrated to form a complete design of game based learning that are able to engage learners , with the goal to enhance cognitive engagement with Manasik learning goals.

When talking about cognitive perspective of proposed game-based learning model ,we will find that it will help in building cognitive skills for pilgrims. For example, the proposed games will contain maps which pilgrims will have to read. This obviously helps their map reading skills and practical thinking, increasing pilgrims' memory capacity as they have to remember Manasik aspects in order to solve the game, memorize Manasik sequences ,and Finally, it helps with fast strategic thinking and problem solving because most games require pilgrim to think quickly.

When talking about the motivation perspective of proposed game-based learning model ,it will relate to the religious interests for pilgrim. While the Affective perspective should introduce suitable Emotional design interaction and representation that makes Manasik learning done in an interesting way.All these perspective should be done within the religious context of Quran and sunnah.

#### **Recommendations:**

1. Based on the previous review i encourage a comprehensive focus of social, and cultural perspectives.

**Figures and Tables:**



Figure 1: integrated design framework of game based learning

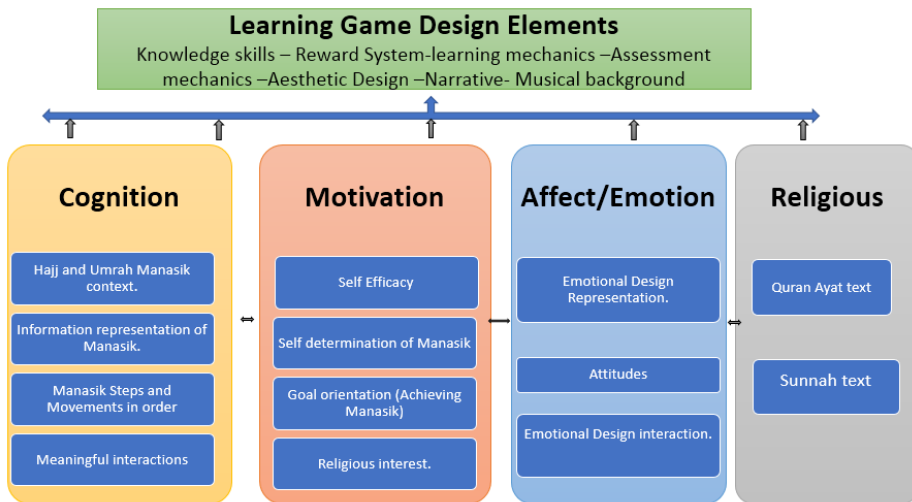


Figure 2: General game design pattern for Manasik learning

## References:

- Azevedo, R., Cromley, J. G., Moos, D. C., Greene, J. A., & Winters, F. I. (2011). Adaptive content and process scaffolding: A key to facilitating students' self-regulated learning with hypermedia. *Psychological Testing and Assessment Modeling*, 53, 106–140.
- Black, J. B. (2010). An embodied/grounded cognition perspective on educational technology. In M. S. Khine, & I. Saleh (Eds.), *New science of learning: Cognition, computers and collaboration in education* (pp. 45–52). New York, NY: Springer. [http://dx.doi.org/10.1007/978-1-4419-5716-0\\_3](http://dx.doi.org/10.1007/978-1-4419-5716-0_3).
- Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon, & N. Eisenberg (Eds.), *Handbook of child psychology*, 5th ed.: Vol. 3. Social, emotional, and personality development (pp. 1017–1095). Hoboken, NJ: Wiley & Sons.
- Gibbs, R. (2006). *Embodiment and cognitive science*. Cambridge, MA: Cambridge University Press.
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41, 111–127. [http://dx.doi.org/10.1207/s15326985Sep4102\\_4](http://dx.doi.org/10.1207/s15326985Sep4102_4).
- Jan L. Plass, Bruce D. Homer & Charles K. Kinzer (2015). Foundations of Game-Based Learning. *EDUCATIONAL PSYCHOLOGIST*, 50(4), 258–283, 2015 Copyright \_ Division 15, American Psychological Association ISSN: 0046-1520 print / 1532-6985 online DOI: 10.1080/00461520.2015.1122533.
- Kinzer, C. K., Hoffman, D., Turkey, S., Gunbas, N., Chantes, P., Dvorkin, T., & Chaiwinij, A. (2012). The impact of choice and feedback on learning, motivation, and performance in an educational video game. In K. Squire, C. Martin, & A. Ochsner (Eds.), *Proceedings of the games, learning, and society conference: Vol. 2* (pp. 175–181). Pittsburgh, PA: ETC Press. 280 PLASS, HOMER, KINZER.
- Koedinger, K. (2001). Cognitive tutors as modeling tools and instructional models. In K. D. Forbus, & P. J. Feltovich (Eds.), *Smart machines in education* (pp. 145–167). Cambridge, MA: MIT Press.
- Kwah, H., Milne, C., Tsai, T., Goldman, R., & Plass, J. L. (2014). Emotional engagement, social interactions, and the development of an afterschool game design curriculum. *Cultural Studies of Science Education*. Advance online publication. doi:10.1007/s11422-014-9621-0.
- Izard, C. E. (2007). Basic emotions, natural kinds, emotion schemas, and a new paradigm. *Perspectives on Psychological Science*, 2, 260–280. <http://dx.doi.org/10.1111/j.1745-6916.2007.00044.x>.
- Mayer, R. E. (2014). *Computer games for learning. An evidence-based approach*. Cambridge, MA: MIT Press.
- Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). Mayer, R. E. (2014). *Computer games for learning. An evidence-based approach*. Cambridge, MA: MIT Press.
- Mislevy, R. J., & Haertel, G. D. (2006). Implications of evidence-centered design for educational testing. *Educational Measurement: Issues and Practice*, 25(4), 6–20. <http://dx.doi.org/10.1111/j.1745-3992.2006.00075.x>.
- Plass, J. L., & Kaplan, U. (2015). Emotional design in digital media for learning. In S. Tettegah, & M. Gartmeier (Eds.), *Emotions, technology, design, and learning* (pp. 131–162). New York, NY: Elsevier.
- Plass, J. L., Moreno, R., & Brünken, R. (Eds.). (2010). *Cognitive load theory*. Cambridge, MA: Cambridge University Press. <http://dx.doi.org/10.1017/CBO9780511844744>.
- Plass, J. L., Perlin, K., & Nordlinger, J. (2010, March). The games for learning institute: Research on design patterns for effective educational games. Paper presented at the Game Developers Conference, San Francisco, CA.
- Rotgans, J. I., & Schmidt, H. G. (2011). Situational interest and academic achievement in the active-learning classroom. *Learning and Instruction*, 21, 58–67. <http://dx.doi.org/10.1016/j.learninstruc.2009.11.001>.
- Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Cambridge, MA: MIT Press.
- Shaffer, D. W., Halverson, R., Squire, K. R., & Gee, J. P. (2005). *Video games and the future of learning* (WCER Working Paper No. 2005-4). Madison: University of Wisconsin—Madison, Wisconsin Center for Education Research (NJ1).
- Steinkuehler, C., & Duncan, S. (2008). Scientific habits of mind in virtual worlds. *Journal of Science Education and Technology*, 17, 530–543. <http://dx.doi.org/10.1007/s10956-008-9120-8>.

# Requirements for achieving psychological security for pilgrims through religious awareness

Amal Mohamed Hassan Otaiba

Umm Al Qura University – College of Education – Islamic education Department

## متطلبات تحقيق الأمن النفسي لضيوف الرحمن من خلال التوعية الدينية

آمال محمد حسن عتيبة

جامعة أم القرى – كلية التربية – قسم التربية الإسلامية والمقارنة

### ملخص البحث (Abstract):

هدف البحث الحالي إلى: بيان مكانة مكة التي شرفها الله تعالى، وجعلها بلداً آمناً، وقال فيها: ﴿أَوْلَمْ نُمَكِّنْ لَهُمْ حَرَمًا آمِنًا﴾ (القصص: ٥٧). وإبراز الأخلاق الإيمانية التي يجب أن يتمتع بها الحاج والتي تؤكد على تخلقه بالأمن النفسي. والكشف عن بعض المواقف السلبية التي تصدر من بعض الحجيج؛ كالسباب وتوجيه الشتائم والمشاجرات والغضب والعصبية. وإبراز المتطلبات اللازمة للتوعية الدينية والداعي؛ وأثرها في تحقيق ورسوخ الأمن النفسي للحجيج. واستخدام البحث: المنهج الوصفي التحليلي. ومن أبرز النتائج التي توصل إليها: المتطلبات اللازمة للتوعية الدينية والداعي؛ لأنه كلما زاد مستوى التوعية الدينية لضيوف الرحمن في الجانب النفسي، كلما تحلى الحجيج بضبط النفس وعدم اللجوء إلى العصبية، والبعد عن المشاحنات والسباب والمشاجرات، وتحقق الأمن النفسي لهم ولغيرهم من ضيوف الرحمن فسعدوا وأمنوا جميعاً.

The purpose of the current research **is aims to**: Declare the status of Makkah, which Allah honored, and make it a safe country. And to highlight the religious ethics that must be realized by the pilgrim, which emphasizes the creation of psychological security. As well as to highlight the requirements for religious and religious awareness; and the impact of their realization in the consolidation of psychological security of pilgrims. The research used **descriptive analytical approach**. **The most results are**: the requirements for religious and religious awareness; because the higher the level of religious awareness of the pilgrims on the psychological side, the more the pilgrims exercise restraint and not resort to nervousness and distance from the quarrels and quarrels and quarrels and achieve psychological security for them and other guests of the Rahman.

### Introduction:

Praise be to Allah, Lord of the Worlds, and peace and blessings be upon our Prophet Muhammad peace be upon him and his family and companions, and after: Security is a human need, and a human demand instinct, and perhaps one of the causes of civilization and urbanization, and the human need for security is one of the highest needs, It is true that we recognize the importance of security in all its dimensions in human life and feel divine care through the miraculous Quranic instructions that push towards the education of the people. Security conscious of the Menen

And the House of God is the title of faith and security, God has made Mecca a safe country and denied it on the day of the creation of the heavens and the earth; it is the country of God haraam as promised great punishment for those who wanted atheism or injustice. It is the safety zone, it is the Kaaba, where tranquility is replaced by fear and peace is replaced by rivalry.



And that the Hajj pilgrimage to the House of God to reflect the principle of psychological security for the sake of its image, who contemplates the time of pilgrimage and its place and provisions see that safety is one of the most prominent features of this duty, pilgrimage pilgrimage faith and the call to create virtues of ethics through which to achieve security and self-confidence; Worship is a justified argument. The performance of the worship of Hajj may be accompanied by a loss of psychological security for a number of reasons, including: fatigue, stress, erections, congestion, distress, defamation, etc., especially with the large number of pilgrims; some negative behaviors appear, which may be seen by some pilgrims; In the end, with the behaviors that Islam has affirmed, especially in the pilgrimage season, such worship and great poetry.

And highlights the effects of religious education in the Hajj; in maintaining the psychological security of the pilgrims in dealing with each other according to the cultural basis of the teachings of Islam. Religious education is fundamental in the consolidation of psychological security and reassurance, so that spirit and soul will be brought up for good morals and good morals. And to calm the sedition and calm souls; hence the researcher wanted to study the requirements of achieving psychological security for the guests of the Rahman through awareness.

#### **Research aims:**

1. Explain the concept and importance of psychological security in the Islamic perception.
2. Declaring the status of Makkah, which was honored by God and made it a safe country and forbade it on the day of creation of the heavens and the earth.
3. A statement of the religious ethics that must be enjoyed by the pilgrim, which emphasizes the creation of psychological security.
4. To raise the requirements of religious education and religious education to achieve psychological security for the guests of Rahman.

#### **Research methodology:**

The researcher used the **analytical descriptive approach** in the study of the subject, which was as follows

#### **The first topic: the concept and importance of psychological security in the Islamic perception**

##### **1) The concept of psychological security in Islamic perception:**

Security Language: Security Origin: "Self-confidence and the demise of fear," security and safety in the original sources. Ibn Masur <sup>(1)</sup> believes that "security" is a language that means safety and honesty, and I have secured security and security against fear, and it is said that his disbelief is against his concealment, and in the dear download: "They are safe from fear." (Peace and blessings of Allaah be upon him) (Zagag said)<sup>(2)</sup>:"I will do this, and I will warn you against evil." He says (Ibn Fares) <sup>(3)</sup> (security), Hamza, Mim and Nun, the two closest origins: the Secretariat that is against treason; meaning: the silence of the heart, and the other ratification Safety: peace of mind, and the fact that security, "not to expect hated in the age to come." In exchange for security: fear, a "predicted hated for the Emirate or presumptive information."

One of the definitions of security is: "It is tranquility, calmness and the ability to face events and emergencies without disturbance." This is what is included in the definition of psychological security, which does not cease to mean reassurance and tranquility. There have been many definitions of psychological security, which came by Muslim

scholars, but agreed that they linked psychological security by faith in God Almighty, and commitment to worship alone and no partner:

Ibn al-Qayyim <sup>(4)</sup> expressed the concept of psychological security with a sense of tranquility. He said: "The tranquility of the heart, its tranquility and stability, disappears with the end of anxiety, anxiety and disorder. This can only be achieved by mentioning God.

Abu Bakr said <sup>(5)</sup>, the psychological security is meant to be certain of something and to expect it with deep hope, as in the verse: "And God made him only a gladness to you and to reassure your hearts with him" (Al-Imran: 126).

As Abdul Rahim sees <sup>(6)</sup>, that psychological security is a constant feeling that stems from the inside of the soul and accompanies the human, it gives the reassurance and psychological comfort that is in the deep trust in God Almighty as the Almighty says: (God is not enough slave) (Alzomar: 36).

And security in the use of the Koran against fear, and means: "reassurance not to expect hated in the present and coming" <sup>(7)</sup>. The word "security" is mentioned in the Qur'an in about twenty-seven places, and with various derivations; Ford is in the form of "source" in four places, including the verse: "We have made the house perfect for the people and for our safety" (Al-Baqarah: 125) (Al-Baqarah: 126), and came (name) in four places, including the verse: (And if the order came from the security) (Women: 83) , And came (actually) in fourteen places, including the Almighty: (If Amantm) (Baqarah: 196). As well as "security" and its derivatives in the book of God in more than (eight hundred) times <sup>(8)</sup>; believers, faith, honesty and security and those who believe, all things related to the sense of security.

The term "security" refers to the term "security", with the difference that security can only be achieved when the causes of fear are removed, while "security": reassurance is achieved while the cause of fear remains<sup>(9)</sup>.

## **2)The importance of psychological security in the Islamic perception:**

As for the importance of security, we find that the Holy Quran is stronger than the Quraysh and considered it a companion to one's strength, in which he is fit to live. Allaah says (interpretation of the meaning): "I feed them from hunger and fear from fear" (Quraish, 3-4). The author of the liberation and enlightenment <sup>(10)</sup> "The meaning of the verse: remind Quraysh the grace of God to them; it pleased them unless other Arabs to security from the aggression of the aggressors and the raid of raiders."

### **The importance of psychological security as stated by Sharif (11) includes the following aspects:**

1. Stability: which in turn leads to psychological stability. When a person is afraid, the stability is elusive.
2. Distance from despair and frustration: Psychological security is able to keep away from these two diseases.
3. Integration of the personality of the Muslim: This is important and makes the Muslim reassuring ambition of much optimism, radiating around him security and reassurance.
4. Full confidence in God and his victory: confident that everything is in God's hands.

### **The second topic: Mecca security and security**

The Prophet (peace and blessings of Allaah be upon him) said: "I saw the Messenger of Allaah (peace and blessings of Allaah be upon him) on the authority of the Messenger of Allaah (peace and blessings of Allaah be upon him)" <sup>(12)</sup> It is the

safety zone established by God for mankind in the midst of conflict, it is the Holy Kaaba, where peace is replaced by fear, and peace will be replaced by peace, peace and blessings of God be upon him. Place of Dispute.

It is one of the conditions of the obligation of Hajj: the security of the road. Whoever is not safe for himself or his money or offering it in the way is not obliged to do Hajj. In the affirmation of the shariah glue, the road is safe for the guests of the Lord; what determines that safety is one of the most important human rights, but that the complete believer in his faith is the security of people for their blood and money and their symptoms. And that the complete Muslim in Islam from the Muslims peace of his tongue and hand <sup>(13)</sup>.

Just as the safety of the road is one of the requirements of Hajj, those who study the time, place and rulings of the Hajj see safety as one of the most important features of this pilgrimage. As for the time of Hajj, Allaah has made it one of the most sacred months; the month of Dhu'l-Qa'dah, during which the traveler returns to the Sacred House of Allaah from the sacred months, and the month of Dhu'l-Hijjah, So God made the time of performing the Hajj obligatory as a haraam time in which fighting is forbidden, so that the guests of the Beneficent will be safe <sup>(14)</sup>.

And as a safe time has made the place also safe; the house of the sacred is safe (and his income was safe), but the old man cast the murderer of his father is not subjected to bad respect for the sanctity of the place; (Peace and blessings of Allaah be upon him), and he will make sure that he is safe, and it is not correct for those who find anything that is lost, however precious it is to take it or to pick it up, <sup>(15)</sup>.

The house is the best house for the people to worship, and it is the House of Mubarak, where Allaah has made great good by praying in it, by circling around it, praying around it and worshipping all of the reasons <sup>(16)</sup>, (Al-Baqarah: 125) God has made this house perfect for people to be reconciled to Him; for He has made God in the hearts of the believers from his love and longing to come to Him, Because they find great good in it. And this is why the Prophet (peace and blessings of Allaah be upon him) warned about this on the day of the conquest of Makkah and he said that he was deprived of a safe place and that Allaah forbade him on the day that he created the heavens and the earth. And does not pick up his cat except for knowledge) <sup>(17)</sup>, and means peace be upon him this sanctity of this house. It is obligatory for Muslims, as Ibrahim and Ishmael and the Prophets and Muhammad, may Allah bless him and grant him peace, to respect and magnify him, and to warn of what God has forbidden from harming Muslims, injustice to them, and assaulting them pilgrims or Amara or others. And they must also cleanse this house, and to warn the sins of God in it, and to fear his anger and punishment, and not to hurt each other, nor to fight each other, because the bad is great, and the favors in it multiplied <sup>(18)</sup>, the Almighty said: (Al-Hajj: 25), and anyone who responds to it, is interested in it and means it. The meaning of the meaning is important; this is why Balba, by saying: (and those who are atheist injustice), any interested in atheism injustice. If it is of interest to those who want to commit a painful punishment, then he who commits the crime, and exceeds the limits of it in a more deserving punishment, and painful punishment <sup>(19)</sup>. This indicates to us that it is haraam, and that there is no difference between the akef who is the resident and the father, who is the one who comes in and comes to him from Hajj and Umrah and others. From this it is known that attacking and harming people in this safe sanctuary by saying or doing one of the harshest taboos is the most painful punishment <sup>(20)</sup>.

When Allaah opened his Prophet (peace and blessings of Allaah be upon him) to Mecca, the people spoke and said: "This country is forbidden by God on the day that the heavens and the earth were created. People did not forbid him. Of you the witness is absent) <sup>(21)</sup>. He said: "It is not permissible for anyone to shed blood, or to support a tree.

### **The third topic: the religious ethics of the pilgrim**

The pilgrimage has a special sanctity, and a unique place in the heart of every Muslim. It is the place where people can rest, and rejoice in their hearts, and find salvation in them, which is of concern to them, and escape from the fear and comfort that they feel. And the causes of stability and safety, including the mention of God Almighty, recitation of the Holy Quran, and hear in his heart everything that cleanses the hearts, purifies souls, purifies thoughts and minds, and inspires and animates spirits, in a spirit of vigilance and self-righteousness.

Whoever hopes for the rituals of the Hajj, his rituals and his deeds, he will find them as a whole to raise up in the Muslim the morals and the virtues of virtue, and deepen the sense of righteousness and piety and cultivate in it. Including the Muslim's great sense of sanctity of his Muslim brother, and that it is inviolable, no less sanctity than the Sacred House, the Sacred Land, and the Sacred Month. The Hajj is the field of raising the soul to the virtue of morality, sensing those prophetic calls and the wills of faith in the creation of the ethics of ethics and justice to the beauty of obedience<sup>(24)</sup>. The Messenger of Allaah (peace and blessings of Allaah be upon him) said: "Complete the believers in the best belief of creation"<sup>(25)</sup>. The Prophet (peace and blessings of Allaah be upon him) said: "The believer is aware of the good nature of his creation, the degree of the fasting person standing"<sup>(26)</sup>.

If the pilgrim looks at the picture and the scene in which individuals - in spite of their different countries and different traditions and different languages - create a great creation in itself that exists only in that true religion, it is the creation of fraternity; it creates the connection, solidarity and love. God Almighty and His Prophet (peace and blessings of Allaah be upon him) have decided that principle in what is not a home of the Shariah, in the verse: "Believers are the brethren." It is the result of these brothers that love, peace, cooperation and unity is the origin of the Muslim community, the pilgrim should strive to apply these Muslim brothers who gathered the pilgrims on this great rite in the most sacred parts of the earth, and in Ashraf days of the year. If the brotherhood of faith is obligatory at all, its obligation during Hajj is obligatory<sup>(27)</sup>. The Prophet (peace and blessings of Allaah be upon him) said: "As for the believers in their prayer, mercy, and sympathy, like the one body, if a member complained to him"<sup>(28)</sup>, And the Prophet (peace and blessings of Allaah be upon him) said: "The believer is the believer, like the sons of the one who binds one another"<sup>(29)</sup>.

Islam has established the rituals of Hajj and arranged them in a way that makes the pilgrim in a comprehensive peace, not only with people but with everything, trees, stone and animals and with the whole universe, in recognition of the Lord of the Worlds; Hajj is an experience of training on spiritual shipping, psychological mobilization on the ladder, And absolute peace with space and time and objects, so as to transfer them to the broader human level, adopt a peaceful approach in the rest of the places and the rest of the times and with different issues;

Hajj is a spiritual journey that draws the Muslim closer to the horizons of the higher heaven, and makes him more connected to the divine method. The Almighty said: Hajj is months of information, and it is obligatory to perform Hajj, so there is no difference or pilgrimage. The issue is forbidden for him in Hajj at all, because he may be dragged from the love of victory to the self and arguing in vain. Also, one of the most important things that Hajj should learn in the Hajj journey is that people are equal before God, not in front of Him, with their jobs, money, country, languages, affiliations or colors.<sup>(30)</sup> Neither Ajami nor Arabic nor Red on black or black on red except piety)<sup>(31)</sup>.

And the most important qualities and ethics that the pilgrim draws from the Hajj; qualities: patience, pardon, affection, dreaming, patience, compassion, kindness, humility, generosity, Modesty, righteousness,

benevolence, chastity, virility, altruism, and cooperation. And to go beyond the lapses of people beyond God, and to keep his eye and tongue and all the members of his body what angers God and harms people. Islam is the religion of civilized behavior, which is a message with great meaning, great meanings in the hearts of all people, and the sanctuary of the House of God in particular, a religion based on familiarity, love, affection, altruism, interdependence and cooperation<sup>(32)</sup>. Allaah says (interpretation of the meaning): "Cooperate with righteousness and piety, and do not cooperate in sin and transgression" (Al-Maa'idah 2).

#### **The fourth topic: The role of religious awareness in strengthening the psychological security of the guests of Rahman**

Awareness: The source of awareness is understanding, clarification and guidance. They are taken from consciousness: preservation, understanding, perception and action. The origin of consciousness is the inclusion of the object<sup>(33)</sup>. Awareness is a term: clarification of the thing or direction to desirable through a certain set of activities<sup>(34)</sup>. The term "awareness" is not found in the Islamic texts, but rather in the meaning of preaching, guidance, communication and statement. It is balanced in terms of slavery, health, environment and social aspects, as well as awareness of the security aspects. Religious education can also be defined as: "To provide individuals with the principles and supreme values of Islamic law, which work to preserve and translate religion into people's lives"<sup>(35)</sup>.

Religious education is a basis for establishing security and confidence in the soul. For preaching is more effective and more striking in the hearts of the masses, it inspires the spirit of virtuous morals and good morals,

The efforts of the Kingdom and its important and tangible steps for the relief of the pilgrims and their awareness at all levels can not be overlooked. There are requirements for the success of religious education in the establishment of psychological security in the hearts of guests of the Rahman, illustrated by the researcher as follows:

First, the primary focus of preachers, elders and religious awareness programs should be on the following matters.

- 1) Refining the self-interest: by urging integrity, goodness, ethics, good deeds, harming the rights of brotherhood, cooperation on righteousness and piety; and reminding of the reward of pardon and good forgiveness.
- 2) Broadcast the elements of psychological security in the hearts of pilgrims; including: faith in truth and deep in God, and trust him, and reminded him at all times and when, and pray. And know about the fate and fate, and knowledge about the issue of unemployment.
- 3) Preparation of an arbitrator and arrange the scheme of desired and practical objectives, and that the psychological security of the guests of the Rahman on the list of priorities of awareness programs.
- 4) Do not be excessive in intimidation, threats and intimidation, but by raising the limits of the normal soul; following the book of Allah and the Sunnah of His Messenger, peace be upon him, and stimulate the motivation for the piety and fear of God, and follow his orders and avoid his intentions, and away from taboos, The values and principles of Islamic and moral, and restraint, and self-respect and others, and the frequent repentance and forgiveness and righteousness on virtue and away from the depths of vice.
- 5) To be of a general nature that is simple to be understood by the public and the private, given the multi-lingual, cultural and social environments from which the pilgrims come.
- 6) Religious education requires continuity, direct and indirect broadcasting in all media, buses for pilgrims and large and small mosques, taking into consideration the situation. The preachers seek to rationalize the opportunities for advice by

means of the well-informed and enlightened word, preferably supported by the scientific facts about the harmful behavior of insulting behavior (insult, insults, speculation, verbal abuse, abuse, physical aggression, quarrels, quarrels, loud voices), and so on. Pilgrims, which brings them out of the spirit of tranquility and psychological security for them and others. Along with the religious instructions and advice set out for the iniquity of these heinous acts, in a season that is more worthy of the tranquility of the soul and peace of mind. The quality of advice and guidance directed to suit their thinking and the requirements of the times and problems.

7) Understanding the preacher on all circumstances and circumstances, and taking into account cultural and social pluralism.

8) It is also necessary to expand the promotion of the promotion of virtue and the prevention of vice among the pilgrims; and the dissemination of the culture of moderation and moderation, which is one of the most prominent characteristics of this nation and the range of good.

Second: One of the requirements that should be available to those who play the role of awareness, be high-minded and caring. To investigate and investigate what appeared to him wrong, and to educate the perpetrators after that. As well as taking into account the literature of conversation and saturation, and take into account in his awareness of ease and clarity, and fluency of face and dream and patience, and avoid anger and avoid controversy<sup>(37)</sup>.

#### **Results and discussion:**

1. The human need for psychological security to live a stable and quiet life.
2. The need for psychological security exceeds the need for food, drink and clothing; security is the basis of all happiness in this world and hereafter.
3. The research stressed the requirements of achieving psychological security for the pilgrims through religious awareness, such as: Prior arrangement of objectives, continuity and loyalty in emphasizing this important aspect, and follow the advice and guidance of the good word informed and informed. And the requirements that should be available to those who play the role of awareness, such as: piety and eloquence, fluency and the dream and patience and distance from the debate.

#### **Summary and conclusion:**

Praise be to God for beginning and closing, and peace and blessings upon the envoy mercy to the tents, the current research to highlight the requirements of achieving psychological security for the guests of the Rahman through religious awareness, and used the descriptive analytical method; he introduced the concept of psychological security and its importance in the Islamic perception, The religious ethics of the pilgrim, and then present the necessary requirements for the role of religious education in strengthening the psychological security of the guests of the Rahman, and the requirements for what the da'i should be. I ask Allaah to accept Him and make Him sincere to His holy face.

#### **Recommendations:**

1. To take care of the psychological security of the guests of the Rahman; it is an important article, and a main topic at the top of the list of priorities; to highlight in awareness programs and guidance, by all direct and traditional means and modern ready to achieve.
2. Intensifying the efforts of religious awareness to spread the noble principles of Islam and its supreme values, in a regulatory framework, according to methods and methods of touching the hearts, fortifying souls and following

ways and means that take into consideration the nature of the Muslim in the era of globalization and the revolution of technology;

3. Diversification of religious awareness, and include: Stochastic awareness and belief, spiritual and emotional awareness, and behavioral, psychological and behavioral awareness on the basis of the purposes of the Shari'a and the values of charity and well-known and familiarity and harmony and altruism and altruism.

#### References:

1. Ibn Manzour, Jamal al-Din ibn Muhammad Makram (d). *Sanson Al-Arab*, 3, 1, Dar al-Ma'arif: Cairo, pp 140-141.
2. Abu Ishaq al-Jaraj, Ibrahim ibn al-Sari ibn Sahl (1408 -1988). *The meanings of the Qur'an and its meanings, the realization of Abdul Jalil Abdo Shalabi, the world of books: Beirut*
3. Abu Hassan bin Fares bin Zakaria (1972). *Dictionary of Language Standards, M1, Dar Jaleel: Beirut*, p. 134.
4. *The value of walnut* (1996). Sufficient answer to those who asked about the cure, correct Mahmoud Abdel Wahab Fayed, Cairo, p. 292.
5. Abu Bakra, Essam (1993). "The Relationship between Religious Values and Psychological Security among Yarmouk University Students", MA, Jordan. P. 7.
6. Abdel Rahim, Ali Hamid (1993). "The Grace of Security in Islam", *Al-Azhar Journal*, p. 4, Islamic Research Complex: Cairo, p. 510.
7. Al-Ragheb al-Asfahani, al-Husayn ibn Muhammad (d. *Vocabulary in the strange words of the Koran, Dar Knowledge: Beirut*, p.
8. Abdel-Baqi, Mohamed (DT). *Glossary of the Holy Quran, Jamal Publishers: Beirut*, pp. 81-93.
9. Al-Qurtubi, Muhammad ibn Ahmad al-Ansari (1996). *The Whole of the Qur'an*, 2, 4, Dar Al Hadith, Cairo, p. 241.
10. Ibn Ashour, Mohamed Eltaher: *Liberation and Enlightenment, (DT), C 30, Tunisian Publishing House*, p. 560.
11. Sharif, Mohammed Musa (1424 e). *Psychological Security, I 1, Andalusia Green: Jeddah*.
12. Narrated by al-Tirmidhi and al-Nasaa'i from Qutaiba ibn Saad al-Laythi.
13. Al-Bukhaari narrated it in "The Book of Faith," section: "A Muslim is a Muslim who is Muslim by his tongue and his hand."
- 14-15-16. "Statement of the sanctity of Mecca and the status of the old house and what is mentioned in the verses and ahaadeeth and relics," the official site of the Eminence Sheikh Imam Ibn Baz. 17. Al-Bukhari: 1587 and 3189. Muslim: 3381 and 3383. And strengthen: cut. Her body is gone. Her grass is cut off.
- 18-19-20 .. "Statement of the sanctity of Mecca and the status of the old house and what was mentioned in the verses and ahaadeeth and relics," the official site of the Eminence Sheikh Imam Ibn Baz
21. Narrated by al-Bukhaari in (Book of Knowledge, Bab: to inform the absent witness), and Muslim in the book of Hajj, chapter: prohibition of Mecca.
22. Al-Bukhari narrated it in the Book of the Snapshot, Bab: How to Know the Snapshot of the People of Makkah and Muslim in the Book of Hajj, chapter on the prohibition of Mecca.

23. Hussein, Abdul Latif bin Ibrahim: "The impact of religious awareness in Hajj in the treatment of anger," research published in the symposium of the great pilgrimage: "Awareness in the Hajj," in the period 3-5 January 14-11 H corresponding to 9-11 January 2010, pp. 485.
- And also: Ismail: Abdullah Mohammed: "The Role of Religious Awareness in Achieving the Intellectual Security of Pilgrims", Research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11, .
24. Shaaban, Marwan Waheed: "Behavioral Awareness in Pilgrimage", research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11 H, corresponding to 9-11 January 2010, pp. 297-319.
25. Sinan al-Darami Abdullah bin Abdul Rahman al-Darami, Beirut, Dar al-Kitab al-Arabi, first edition, 1407.
26. The Great Sunan, Abu Bakr Ahmad bin Al Hussein Bin Ali Al-Bayhaqi, the Council of the Department of Knowledge System, located in India in the town of Hyderabad first edition -1344 e.
27. Al-Najjar, Zaghoul Ragheb: "The Behavioral Values of the Pilgrimage of the Pilgrimage", Research published in the Great Pilgrimage Symposium: "Islamic Behavioral Values in Hajj", 3-14 January 2006, pp. 191-218.
28. Bukhari in (Book of Literature, Bab: Mercy of people and animals). 6011 n Narrated by Muslim N and his words in the book of righteousness and the link and literature, the door: the mercy of the believers and their sympathy and solidarity. H 2586
29. The hadeeth of Abu Musa (may Allaah be pleased with him): "The believer to the believer is like the sons of one of them." Narrated by al-Bukhaari, , Chapter: Compassion and sympathy of the believers and their solidarity), (4/1999), number: (2585).
30. Al-Mahdi, Muhammad Al-Mukhtar Muhammad: "Religious and Philosophical Awareness of Hajj Pilgrimage", research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11 H, corresponding to 9-11 January 2010, pp.
- 31 - Musnad Imam Ahmad bin Hanbal J5, p. 411, no. 23536, comment Shoaib Arnaout: Isnada correct Foundation Cordoba, Cairo, the number of parts 6 Hadiths, the provisions of Shoaib.
32. Shaaban, Marwan Waheed: "Behavioral Awareness in Pilgrimage", research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11 H, corresponding to 9-11 January 2010, pp. 297-319.
33. Omar, Saleh bin Omar: "The concept of awareness and awareness and importance", research published in the symposium of the great pilgrimage: "Awareness in the Hajj," in the period 3-5 January 14-11 H, corresponding to 9-11 January 2010, pp.
34. Omar, Saleh bin Omar: "The concept of awareness and awareness and importance", research published in the Hajj major: "Awareness in the Hajj," in the period 3-5 January 14-11 H, corresponding to 9-11 January 2010, pp.
35. The Mahdi, Muhammad Al-Mukhtar Muhammad: "Religious Awareness and Jurisprudence in Pilgrimage", Research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11, 2010, pp.
36. Sharif, Mohammed Musa (1424 e). Psychological Security, I 1, Andalusia Green: Jeddah.
37. Alwan: Abbas Suleiman: "The Rules of Awareness and Literature in Pilgrimage", a research published in the Great Hajj Symposium: "Awareness in Hajj", 3-5 November 14-11 H, corresponding to 9-11 January 2010, pp.