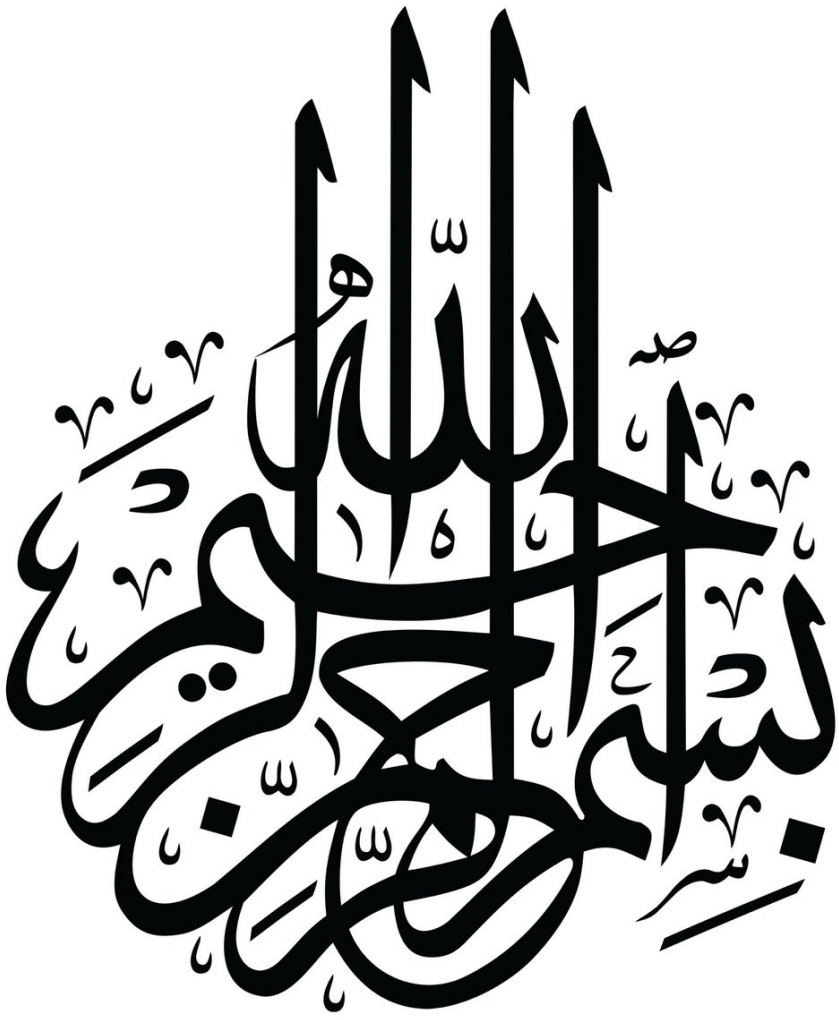
# The 18th Scientific Forum for the research of Hajj, Umrah and Madinah visit

# The Scientific Bulletin

# Articles and Papers in English


بسم الله الرحمن الرحيم

# Introduction

The Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, Umm Al-Qura University, is organizing the 18th Scientific Forum for Hajj and Umrah Research Under the patronage of the Custodian of the Two Holy Mosques, King Salman Bin Abdul Aziz Al Saud. 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 take advantage of the latest global technology and scientific developments towards the continuous development of the services being provided to the delegations of pilgrims.

The forum aims to invite specialized researchers from the Saudi universities and research institutes, who are interested in the studies of Hajj and Umrah research. Additionally, representatives of government agencies and private sectors are also invited to present their original papers through the forum's themes. The forum's themes includes; management, environmental and health, engineering, technology 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 ritules in a comforting and safe environment.

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

The Scientific Committee of the 18th 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 Excellencies; the Minister of Education, the University Director, the Dean of the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research, and 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 materials presented in the forum.

Scientific Committee of the 18th
Scientific Forum for the research of Hajj,
Umrah and Madinah visit

## The Scientific Committee of the 18th Scientific Forum for the research of Hajj, Umrah and Madinah visit

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

**15** - **16** Shaaban 1439 / **1** - **2** May 2018
**Email:** multaqa@uqu.edu.sa
**Website:** hajj.uqu.edu.sa/multaqa
……

| | |
|---|---|
| **Chairman of the Committee** | Prof. Atif H. Asghar |
| **Advisor to the Committee** | Dr. Esam A. Khan |
| **Confidant of the Committee** | Dr. Waleed E. Abou El-Saoud |
| **Committee members** | Prof. Fathy F. Shaaban<br>Dr. Othman B. Gazzaz<br>Dr. Ibrahim A. Al Khaldy<br>Dr. Mohammed K. Shambour<br>Eng. Saeed A. Barqawi |
| **Secretary of the Committee** | Mahir H. Mashat |
| **Technical supervision** | Naif M. Bashraf |
| **Linguistic review** | Dr. Omar B. Ahmed<br>Dr. Safwat S. Gabr |

# Table of Contents

# Second Theme:
# Technical and Media Studies

# Crowd Movement Analysis in Al-Masjed Al-Nabawy using Modelling and Simulation

Mohamed Seddeik Yasein, Mahmoud Al-Gamal, Mohamed Shambour
The Custodian of the Two Holy Mosques Institute of Hajj and Umrah Research, Umm Al-Qura University

**Abstract**

Crowd simulations have been always an essential tool, which help developing and understanding of crowd risks and safety for many of the world's largest events. Regulating the access to Al-Masjed Al-Nabawy is a complex crowd dynamics analysis problem that require special attention. At the heart of the old mosque is Rawdah. All visitors, attempt to pray in Rawdah. Entrance into Rawdah is not always possible as the tiny area can accommodate only a few hundred people. In addition, visitors want to come to the Ziara Place, where they visit the Prophet's grave.

Every day, many hundred thousand of visitors are keen to visit the Prophet and pray in Rawdah.

Computer simulation can be utilized as an important research tool in understanding the complexity of crowd dynamics across such a wide space. Simulating crowds' behavior in such large-scale and complex environment presents a variety of challenges in representing the interrelated processes that characterize real-world interaction.

This paper focuses specifically on the problem of simulating the dynamics of large, dense crowd in Rawdah and Ziara Place. Such crowd exhibit a low interpersonal distance and a corresponding loss of individual freedom of motion. Different simulating models are presented where concurrent groups of simulated agents interact in a modeled environment of the Al-Masjed Al-Nabawy with potential to enable direct acquisition of statistics and indications at levels of detail and accuracy. A series of simulation scenarios are carried out to provide an assessment of the effectiveness of existing systems. Moreover, it can also

contribute in proposing alternatives systems, as well as the possibility of developing indicators and readings to support decision makers.

## 1. Introduction

Crowd simulation systems have been always essential tools that help in developing and understanding of crowd risks. A wide range of crowd simulation systems have been developed and applied to crowd safety for many of the world's largest events over the past decades [1,2].

Methods of assessing crowd density and understanding of the rates at which spaces can fill is vital to avoid dangerous overcrowding. In order to do that, basic information about the space that moving crowd occupies, the rates at which crowds can move, and the rates at which spaces can fill are needed [3]. Crowd simulation systems enable us to experiment with a wide range of behavioral assumptions. Experimentations with crowds using a computer-generated environment can be conducted in a way that is not possible in real time, to get understanding of the interactions between crowds and their environment [4].

Using crowd simulations enable us to understand how risks develop into incidents and how incidents can escalate into disasters. However, simulation techniques have been expensive and time consuming. They utilize mathematical models, which describe the crowd dynamics in addition to the way individuals behave in a range of situations [5,6]. A simulation process is limited by the assumptions of the mathematical model. A simulation process would not behave properly if built in an incorrect or unsuitable set of assumptions.

An important feature of crowd density and risk assessment is to determine which areas within the space will be of high density and which areas will be of lower density, and also to determine which areas are going to be standing and static, and which areas are going to be dynamic. For example, entry and exit gates would be predominately of higher density during ingress and egress, but low density at other times. Occasionally, there may not be time to react between the crowd entering the space and the space becoming too crowded. Therefore, real time monitoring and managing crowd flow and crowd density is essential for crowd safety.

Reviewing crowd accidents from around the world, as an example the accidents in [7], shows that deficient planning before events and unsatisfactory risk management during events are the common causes to major incidents and are the key points of failure.

Many research have been conducted to study the services presented in Al-Masjed Al-Nabawy [1,2,8,9]. Events, like visiting the Prophet's mosque at peak times or praying in

Rawdah, require a significant amount of planning. This process engages a wide range of organizers, such as the emergency services, local authorities, and security authorities. During such special events, careful review of the risk analysis is critical; any risks missed during the planning process must be identified. If planning phase neglects risk assessment, risks may be realized during the operational phase of the event. Computer simulation can be utilized as an important tool in understanding the complexity of crowd dynamics across Al-Masjed Al- Nabawy wide space. Simulating crowds' behavior in such large-scale and complex environment presents a variety of challenges in representing the interrelated processes that characterize real-world interaction.

Crowd risk analysis should include the necessary examination of spaces for both static (standing) and dynamic (moving) crowds. These are spaces such as queuing systems, entry points, exit points, emergency access, etc. There also needs to have crowd monitoring and continual risk assessment during the operational phase of the event, for example, assessment of crowd flow rates for congestion during queuing, at entry points, congestion in critical locations, and whether the system is performing as planned.

This paper focuses on the problem of simulating the dynamics of large, dense crowds in Rawdah and Ziara Place. Such crowds exhibit a low interpersonal distance and a corresponding loss of individual freedom of motion. Different simulating models are presented where concurrent groups of simulated agents interact in a modeled environment of the Al-Masjed Al-Nabawy with potential to enable direct acquisition of statistics and indications at levels of detail and accuracy. A series of simulation scenarios are carried out to provide an assessment of the effectiveness of existing systems

The paper is organized as follows. Section 2 discusses problem description and crowd risk analysis. Section 3 describes proposed modeling and simulation System. In Section 4, simulation results are presented. Finally, conclusions are drawn in Section 5.

## 2. Problem Description

To control entry to an area, some sort of barrier should be put around the site. The crowd needs to access an area and leave the masjid by another gate after the visit has finished. The entry and exit points will be of limited throughput, and they need to be of sufficient capacity to minimize the risk of crushing on entry or exit. These entry/exit points affect the rate of fill, and if the high-density areas fill too quickly the situation becomes in considerable risk.

## 2.1 Crowd Risk Analysis

There are several considerations for the crowd risk analysis: site capacity, movement pathways, entry and exit systems, and facilities management during normal and emergency situations.

*Site capacity:* is typically calculated based on the available area, the suitability of that area, and the rates of evacuation in an emergency. Site capacity also based on physical and safety considerations for a site.

*Movement pathways:* Arrangements that result in unbalanced use of entry or exit routes, dead ends, or similar confusing pathway choices, are not acceptable.

*Entry and exit points:* If the arrival flow rate exceeds the entry system capacity, then a queue will develop. This results in a gradual build-up of crowd density over time. As the crowd/queue size grows, the density at the front part of the queue will be compressed. This increases the crowd density. As crowd density increases to above six or seven people per square meter, the crowd reaches a point at which individuals experience physical contact and pressure.

## 2.2 Crowd Flow to Rawdah and Ziara Place

At peak times, regulating the access to Rawdah and Ziara place requires special attention. In order to control entry to this area, some sort of barrier is put around the site. The entry and exit points will be of limited throughput, and they need to be of sufficient capacity to minimize the risk of crushing on the entry point. The whole area Al-Masjed Al-Nabawy, including Rawdah and Ziara place (in the old masjed area) is shown in Fig. 1.

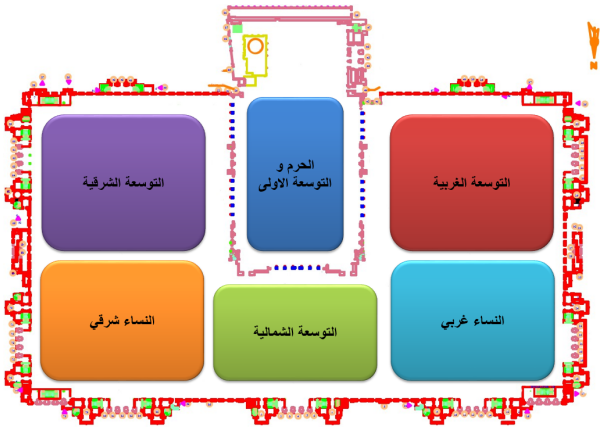


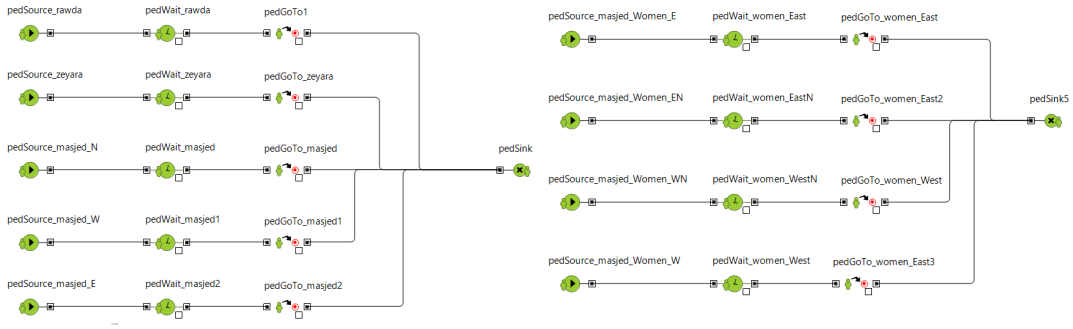

Fig. 1: The whole area Al-Masjed Al-Nabawy, including Rawdah and Ziara place.

## 3. Proposed Modeling and Simulation System

The problem of simulating the dynamics of large, dense crowds in Rawdah and Ziara Place is handled using the proposed modeling and simulation system of Al-Masjed Al-Nabawy, which focuses on Rawdah and Ziara place.

The processes structure of the model is shown in Fig. 2. In this modeled environment of the Al-Masjed Al-Nabawy, concurrent groups of simulated agents interact with potential to enable direct acquisition of statistics and indications. The main processes of the model include:

- Pedestrian Source: Generates pedestrians and is used as a starting point of the pedestrian flow. It allows defining group size, groups arrival rate, pedestrian interarrival delay, etc.
- Pedestrian Wait: Causes pedestrians to go to the specified location and wait there for a specified period of time.
- Pedestrian Go to: Causes pedestrians to go to the specified location, which can be de fined by a target line, area or a point with given coordinates.
- Pedestrian Sink: Disposes incoming pedestrians and is used as an end point of the pedestrian flow.




(a) (b)

Fig. 2: The processes structure of the model: (a) in the men's area and, (b) in the women's area.

Fig. 3 shows the main screen of the proposed simulation system, which has slide-bar controls to allow controlling parameters of the systems. These parameters model include:

- Rawda Rate: controls the pedestrian rate for entering Rawdah (pedestrian/hour).
- Zeyara Rate: controls the pedestrian rate for Ziara place (pedestrian/hour).
- Women Rate: controls the pedestrian rate for women entering from eastern, western, northern east, and northern west gates (pedestrian/hour).

- Men_N_Rate: controls the pedestrian rate for men entering from northern gates (pedestrian/hour).
- Men_W_Rate: controls the pedestrian rate for men entering from western gates (pedestrian/hour).
- Men_E_Rate: controls the pedestrian rate for men entering from eastern gates (pedestrian/hour).

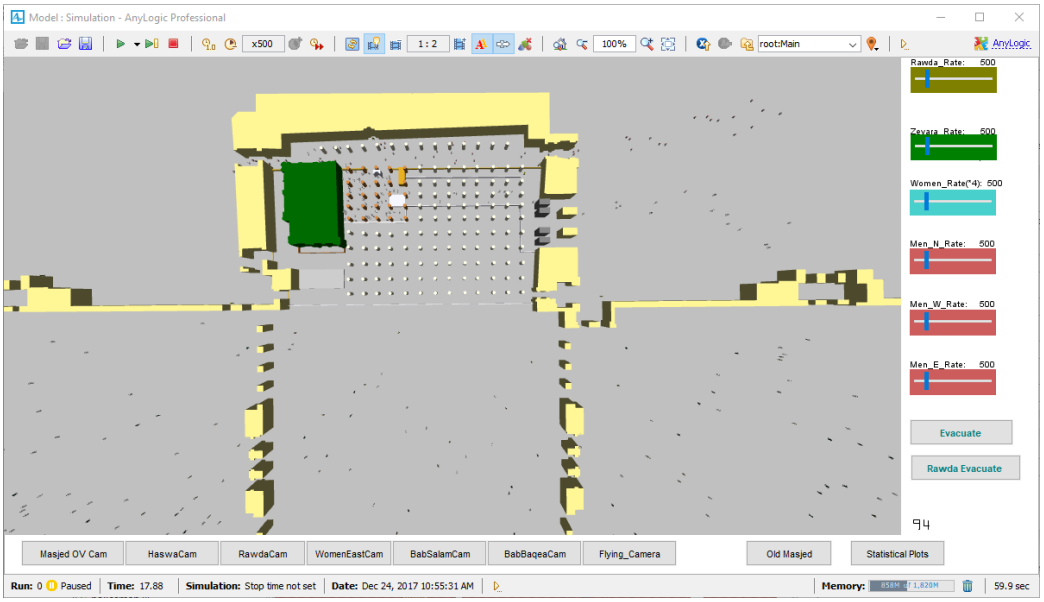



Fig. 3: The main screen of the proposed simulation system.

As shown in Fig. 3, the main screen has control buttons to allow controlling active camera viewport. The system has several cameras, which include:

- Masjed OV Cam: a camera that shows the whole area of the masjed.
- Hasswa Cam: a camera that shows the Haswa area.
- Rawda Cam: a camera that shows the Rawdah area.
- Women East Cam: a camera that shows the women's eastern area.
- Bab Salam Cam: a camera that shows Bab Al-Salam area.
- Bab Baqea Cam: a camera that shows Bab Al-Baqea area.

Examples of camera viewports of the system are shown in Fig. 4.

The main screen has, also, a control button (Statistical Plots) that shows some statistical graphs of the system.

## 4. Simulation Results

A series of simulations are carried out in order to test the behavior of the model. In this section an example of simulation scenario is presented. Experiment time, for this simulation is 120 min.

This experiment focuses on Rawdah and Ziara Place. The used pedestrian rate for entering Rawdah (Rawda Rate) is 1500 pedestrian/hour, while the used pedestrian rate for Ziara place (Zeyara Rate) is 1500 pedestrian/hour.

A screenshot of the system at time (120 min.) is shown in Fig. 5. A density map of Rawdah and Ziara Place area, after two hours running, is shown in Fig. 6.

The calculated statistics include the following:

- Bab Salam In: the number of pedestrian that have entered through Bab Al-Salam at a given time.
- Bab Baqea Out: the number of pedestrian that have exit through Bab Al-Baqea at a given time.
- Bab Salam_traffic: pedestrian rate that have entered through Bab Al-Salam (pedestrian/hour).
- Bab Baqea_traffic: pedestrian rate that have exit through Bab Al-Baqea (pedestrian/hour).
- Rawda In: the number of pedestrian that have entered Rawdah at a given time.
- Rawda Out1: the number of pedestrian that have exit through Rawdah Gate1 at a given time.
- Rawda Out2: the number of pedestrian that have exit through Rawdah Gate2 at a given time.
- Rawda In_traffic: pedestrian rate that have entered Rawdah (pedestrian/hour).
- Rawda Out1_traffic: pedestrian rate that have exit through Rawdah Gate1 (pedestrian/hour).
- Rawda Out2_traffic: pedestrian rate that have exit through Rawdah Gate2 (pedestrian/hour).

The calculated statistics, after running the simulation for two hours, are shown in Fig. 7.

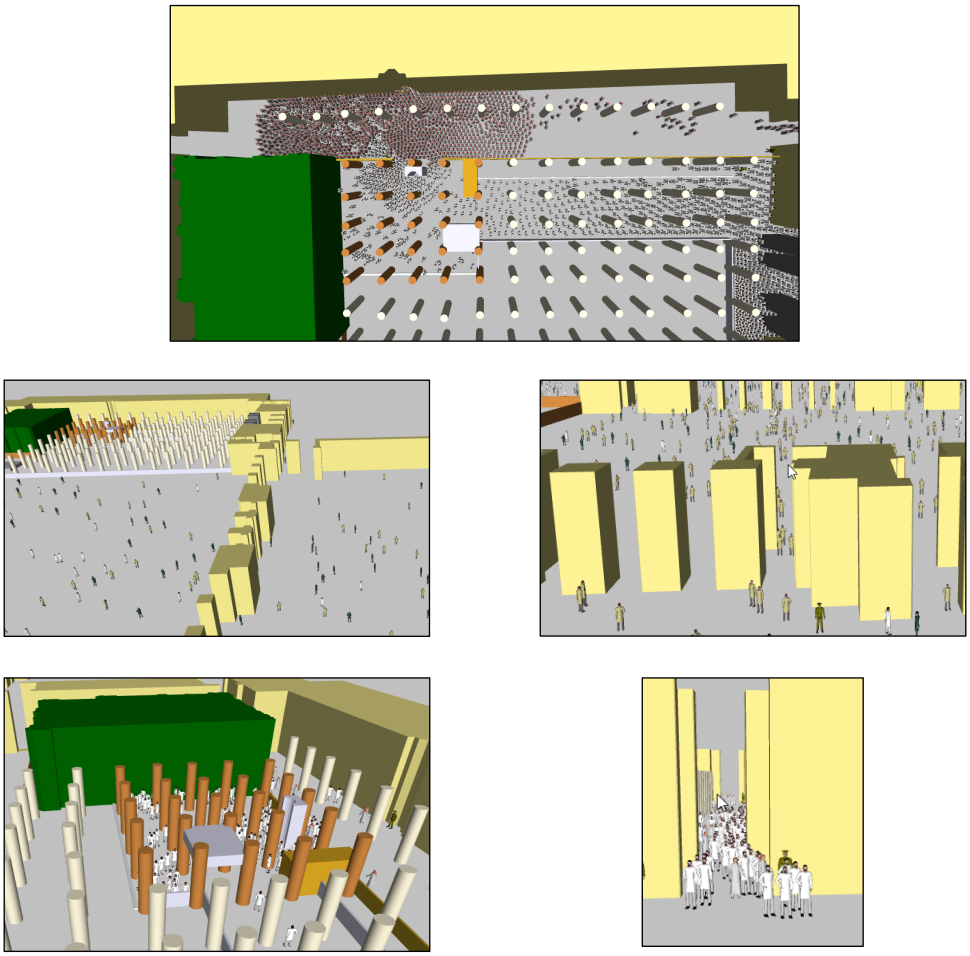


Fig. 4: Examples of camera viewports of the system.

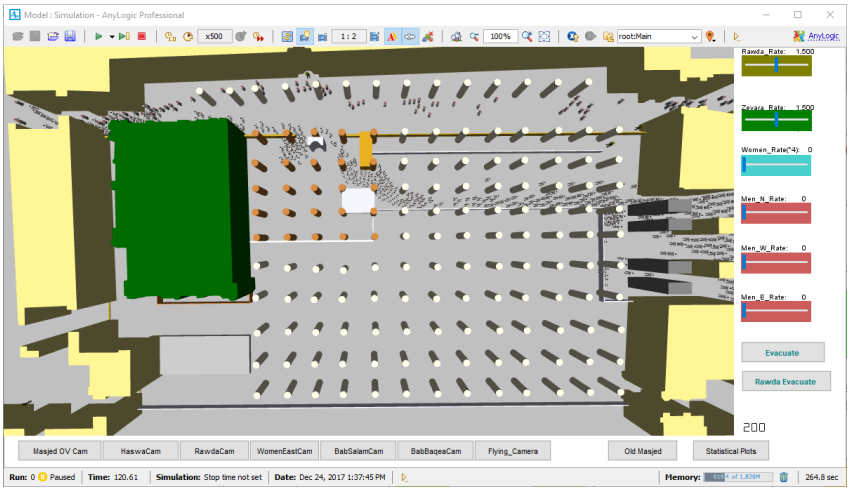



Fig. 5: A screenshot of the system at time (120 min.)

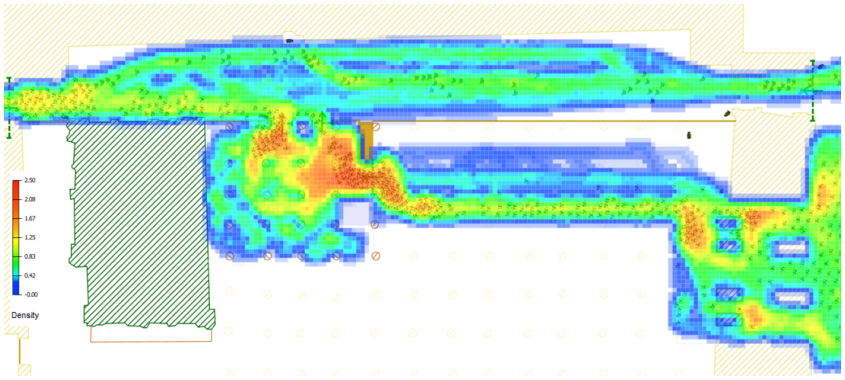



Fig. 6: Density map of Rawdah and Ziara Place area, after two hours running

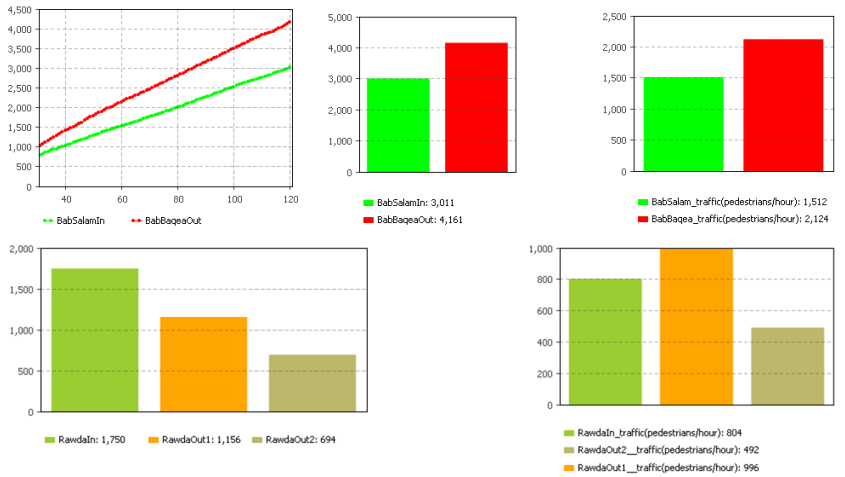



Fig. 7: Simulation results, after running the simulation for two hours.

## 5. Conclusions

In this paper, a modeling and simulation system of Al-Masjed Al-Nabawy, which focuses on Rawdah and Ziara place, has been presented. Concurrent groups of simulated agents interact in the modeled environment of the Al-Masjed Al-Nabawy with potential to enable direct acquisition of statistics and indications at levels of detail and accuracy. A series of simulation scenarios have been carried out to provide an assessment of the effectiveness of existing systems. The obtained results can also contribute in proposing alternatives systems, as well as, the possibility of developing indicators and readings to support decision makers.

## Recommendations:

It is necessary to apply studies that are based on modeling and simulation using computers to evaluate any proposals for the arrangements of entry, exit, or visit to the Prophet's Mosque (and the Holy Mosque), as modeling and simulation provide:

- indicators and readings that can evaluate the effectiveness of existing systems and identify their advantages and disadvantages.
- an initial view for decision makers that helps in evaluating the development plans to be implemented to overcome the high costs of real experimenting.
- The possibility of detecting obstacles or potential accidents that are not considered during the planning phase, and the possibility of providing solutions that reduce the effects of obstacles, which can be avoided if foreseen using modeling and simulation.

## References


[1] Mohamed S. Yasein, "Regulating Access to El-Salam Gate in the Prophet's Mosque at Peak Times During Holidays using Simulation" in Proceedings of the 16th Scientific Forum for Hajj and Umrah Research, Makkah, KSA, May 2016.

[2] A. Alshehri, M. Arif, M. Alkhemi, Emad Felemban, “Analysis of Crowd Movement in the Prophet (SAW) Mosque in the City of Madinah, Saudi Arabia.” 3rd Intl. Conference on Advances in Computing, Electronics and Electrical Engineering CEET 2015 pp. 151-160, 2015

[3] Marcel Bouchard, Jennifer Haegele & Henry Hexmoor, “*Crowd dynamics of behavioral intention: train station and museum case studies*”, in proceeding of Connection Science Journal, Volume 27, Issue 2, April 2015, pages 164-187.

[4] Eric Kolstad, “*A virtual crowd-sourcing approach for pedestrian simulation*”, in proceedings of the 2014 SpringSim , Society for Computer Simulation International, San Diego, CA, USA, 2014.

[5] Hao Jiang, Wenbin Xu, Tianlu Mao, Chunpeng Li, Shihong Xia, and Zhaoqi Wang, “*A semantic environment model for crowd simulation in multilayered complex environment*”, in proceeding of the 16th ACM Symposium on Virtual Reality Software and Technology (VRST 2009), ACM, New York, USA, pages 191-198.

[6] Rahul Narain, Abhinav Golas, Sean Curtis, and Ming C. Lin, “*Aggregate dynamics for dense crowd simulation*”, ACM Trans. Graph. 28, 5, Article 122, December 2009.

[7] BBC News 2005: Television News Report, “*Crush chaos at IKEA store opening*”, 10th February 2005.

[8] علاء الدين عادل الألفي, "*تطوير حلول ومقترحات لتسهيل الوصول والصلاة في الروضة الشريفة وزيارة الحجرة النبوية الشريفة المسجد النبوي*", رقم 43312001.١٤٣٣ ,

[9] محمد عبدالله إدريس, "*دراسة فراغية للمسجد النبوي لتنظيم صفوف المصلين و منع التكوينات المنفصلة*", رقم 42312187, 1423

# Optimal Distribution of Service Points in Holy Places

Ahmed A. Morgan[1] and Khalid M. J. Khayyat[2]
1- Department of Information Systems, 2- Department of Computer Engineering,
College of Computer and Information Systems, Umm Al-Qura University

## Abstract

According to the 2030 Saudi vision, the annual number of pilgrims and visitors would increase to 30 million by 2030. In order to properly serve this large number of pilgrims and visitors, the maximum performance of already available service points should be exploited. In this paper, we propose a Genetic Algorithms (GA)-based methodology to optimize the distribution of these service points in any field, in order to realize their maximum performance. Our methodology could be used in the holy places, like Mina, Arafat, and the two holy mosques, to optimize the distribution of many service points, like police cars, ambulance cars, fire trucks, surveillance cameras, sensing circuits for different environmental parameters, and cars for food, water and beverage. Our methodology aims at minimizing the distance that should be traversed to acquire these services. Two distance metrics are considered for optimization, average and maximum distances. The former metric abstracts the average-case performance, whereas the later one represents the worst-case performance. As a proof of concept, a case study of distributing ambulance cars in Arafat is considered. Obtained results indicate that our methodology outperforms current as well as random distribution strategies with respect to both average and maximum distance metrics. The case study clearly shows the efficiency of our methodology in exploiting the maximum performance from any group of service points.

## I. Introduction

Millions of Muslims from all over the world wait their turn to perform Umrah, and hopefully hajj. Every year, only few millions from this huge awaiting number manage to carry out their holy trip to Makkah and Madinah. In fulfilling its duty toward Muslims, the Saudi government

aims at increasing the number of pilgrims and visitors that could annually be accommodated. According to the Saudi 2030 vision, the annual number of pilgrims and visitors would increase to 30 million by 2030 [1]. Indeed, this number is limited by the infrastructure and the services that could be introduced in holy places. Many services are currently available to serve pilgrims and visitors. Examples of these services are hospitals, medical centers, ambulance cars and jets, fire trucks, police cars, transportation buses, and cars for food, water, and beverage. Furthermore, in the future, many smart electronic equipments might be deployed throughout holy places for continuous monitoring, disaster prevention, and automatic control of critical situations. Examples of these smart electronic equipments are surveillance cameras and sensing circuits for different environmental conditions, like temperature and fires. In order to properly serve the increasing number of pilgrims and visitors, the performance of these services and equipments should be optimized. One aspect of this optimization problem is how to perfectly distribute these services and equipments to exploit the maximum performance from them. In this paper, we target this optimal distribution problem by presenting a methodology to perfectly spread services and equipments in holy places. For the rest of this paper, we use the term service points to represents both services and equipments.

According to deployment locations, distributing service points in any field could be formulated as an unconstrained or a constrained problem [2]. In the unconstrained distribution, service points could be placed anywhere in the field. Contrarily, the constrained formulation restricts the distribution of service points onto certain candidate locations. For holy places, the unconstrained distribution of service points is not practically possible due to physical obstacles in these places, like mountains and restricted zones. For example, we could not place an ambulance car above Alrahma mountain or inside Alkhaif mosque. Therefore, constrained distribution of service points is only considered in this paper.

The distribution of service points in any field is usually customized with respect to certain performance metrics. For holy places, one of the most important metrics, which needs to be minimized, is the distance [3]. For any location within the field, this metric represents the distance from this location to the nearest service point. Minimizing this metric not only reduces the distance that should be traversed to acquire the service, but it also increases the coverage metric. The coverage metric represents the total number of service points, which serve that location. In the literature, distributing service points in any field is a variant of the discrete facilities location problem, which is known to be an NP-hard one [4, 5]. Therefore, heuristics, approximation algorithms, and optimization-based techniques should

be used to solve it [6]. In this paper, we present a Genetic Algorithm (GA)-based methodology that aims at optimally distributing service points in any field, specially holy places, to minimize the distance that should be traversed to acquire these services. Our methodology could be used to minimize one of two distance metrics. The first is the average distance, which is the mean of distances from all locations within the field to their nearest service points. The second metric is the maximum distance, which represents the farthest location from a service point. As a proof of concept, the distribution of ambulance cars in Arafat is considered. The obtained results prove that our methodology could significantly enhance the performance of these service points.

The rest of this paper is organized as follow. Sections II reviews the related work. Section III surveys GA as an optimization technique. Formulation of the problem and models of the two distance metrics are presented in Section IV. Section V discusses our GA-based methodology for the optimal distribution of service points. Section VI gives experimental results of our case study to validate our work. We draw conclusions and give directions for future work in Section VII. Finally, Section VIII summarizes our recommendations to enhance the performance of the current system of services.

## II. Related Work

The distribution of service points in any field, which we target in this paper, is a variant of the discrete facility location problem [7]. The discrete facility location problem is studied with respect to many metrics. Out of these metrics, distance is the most considered one. Consequently, many previous research work aim at deciding the proper locations of service points, such that the distance to different locations within the field is minimized. Both the average and the maximum distances are considered for minimization. First, minimizing the average distance is named the p-median problem [8] or the minisum problem [9]. This problem aims at minimizing the mean of all distances from service points to different locations within the field. Therefore, it represents the average-case performance of a distribution. Second, minimizing the maximum distance is named the p-center problem [10] or the minimax problem [11]. This problem aims at minimizing the maximum distance from service points to the farthest locations from them. Therefore, it represents the worst-case performance.

Neither of the p-median nor the p-center problems is considered to optimally distribute service points in holy places. However, they are used for many other fields. Moreover,

different techniques are used to solve the two problems. For example, the p-median problem is solved using GAs in [12]. An algorithm to speed up the solution of the p-center problem is presented in [13]. The case of uncertain distances for the p-center problem is targeted in [14]. In summary, a thorough survey about different formulations of the two problems and algorithms used to solve them is given in [15]. Finally, for holy places, a slightly related problem of distributing camps in Mina could be found in [16].

## III. Genetic Algorithms (GA) optimization

GA is used to solve complex optimization problems, which could not be solved by conventional methods. It is a global optimization technique that mimics the evolution of human genes [17]. GA optimization starts by a set of chromosomes, which is named a generation. Each chromosome represents a possible solution of the optimization problem. All chromosomes within a generation are evaluated according to the optimization function. Continually, the optimization engine evolves new generations from the preceding ones until a certain stopping criterion terminates the execution. Famous stopping criteria are exceeding a maximum number of generations or a maximum allowable execution time. The evolution of one generation from the preceding one is done through three genetic operators: elitism, crossover, and mutation. In elitism, the best chromosome, or chromosomes, survive to represent the first portion of the new generation. In the crossover, two chromosomes mate together to generate two new ones. The resultant children from mating multiple pairs of chromosomes represent the second portion of the new generation. In the mutation, some chromosomes are slightly modified to prevent the optimization engine from being trapped in local minima or maxima. These modified chromosomes represent the last portion of the new generation.

## IV. Problem formulation

In this section, we present the models of the two distance metrics, which we use in this paper. In Section IV, our GA-based methodology would minimize one of these two models to generate the optimal distribution of service points in any field of interest. In order to ensure covering the whole area of that field, a grid sampling strategy, similar to the one presented in [18], is employed. Accordingly, the field is partitioned into horizontal and vertical slices of infinitesimal $\delta x$ and $\delta y$. This results in a grid of small rectangles. Points at the corners of these rectangles are uniformly distributed throughout the field with very small distances in between. Therefore, we name them sampling points and only consider them in our distance calculations. The distance metrics abstract the effort, the time, or the energy that are needed

by a service point to reach a sampling point and vice versa. We start our modeling by finding the distance from each sampling point to its nearest service point. Consider S and P to represent the two sets of service points and sampling points, respectively. For any arbitrary sampling point, pi, the distance from that point, dij, to each service point, sj, is first calculated. The minimum of these distances, which represents the shortest path from that sampling point to a service point, is then found. This minimum constitutes the distance metric, di, of the arbitrary sampling point, pi, and could consequently be represented by

$$d_i = \min(d_{ij}) \qquad ,\forall s_j \in S \qquad (1)$$

After finding the shortest path of every sampling point to a service point, we calculate our average and maximum distance metrics for any candidate distribution of service points. Any of these metrics could be used as an objective function, which would be minimized by our GA-based methodology. As the name implies, the average distance is the mean of all sampling points distance, as expressed by (1). The average distance metric, $d_{avg}$, therefore captures the overall performance of any distribution and could be represented by

$$d_{avg} = \text{mean}(d_i) \qquad ,\forall p_i \in P \qquad (2)$$

The maximum distance, in turn, is the maximum of all sampling points distance, as expressed by (1). It represents the farthest sampling point from a service point. The maximum distance metric, $d_{max}$, therefore captures the worst-case performance of any distribution and could be represented by

$$d_{max} = \max(d_i) \qquad ,\forall p_i \in P \qquad (3)$$

## V. Proposed methodology

This section discusses our GA-based methodology for optimal distribution of service points in any field. As explained in Section II, applying GA requires representing possible distributions of service points in the form of chromosomes. In this paper, our GA-based methodology employs binary chromosome representation. The length of any chromosome is equal to the number of candidate locations of service points. Each gene within a chromosome is either 1 or 0 to indicate whether a service point is actually distributed to its corresponding location or not, respectively. The total number of 1's of any chromosome should be equal to the number of actual service points. This is ensured by using special creation, crossover, and mutation functions. First, in our creation function, random genes, whose number is equal to that of actual service points, are set to 1. Second, in our crossover function, a single point crossover is regularly used. Thereafter, the legality of generated

children is checked. According to the outcome of this check, random genes might be flipped to guarantee that the total number of ones is equal to that of actual service points. Third, in our mutation function, half of the chromosomes are generated completely random. This is done to introduce new distributions to the GA engine and prevent it from being trapped in a local optimum. For the second half of mutation chromosomes, arbitrary 1 and 0 in the most fitted chromosome are randomly selected and flipped. This is done to introduce minor changes to the best achieved distribution, in a hope to further enhance it.

Fig. 1 shows our methodology for optimal distribution of service points using GA. The GA optimization starts, in the first step, by reading the inputs required by the engine. These inputs are the description of the field, the candidate locations to which service points could be distributed, and the required number of service points that should be actually distributed. In the second step, grid sampling is carried out to ensure covering the whole area of the field, as discussed in Section III. Thereafter, the GA engine runs iteratively to find the best distribution of service points with respect to one of the two distance metrics. In the third step, a new generation of chromosomes is formed. For our initial population, random chromosomes are generated using our creation function. For all subsequent generations, elitism, crossover, and mutation are used to form them. Every chromosome within the generation is then evaluated by steps 4-6 of our methodology. In the fourth step, the distance metric of each sampling point is found, according to (1). Thereafter, in the fifth step, the metric for which optimization should be carried out is decided. In the sixth step, according to the required metric, either the average distance, over all sampling points, or the maximum distance is calculated, according to (2) or (3), respectively. The calculated distance is used to evaluate the fitness of each chromosome within the generation. Chromosomes are consequently ranked according to their fitness score. The rank of each chromosome decides if it would survive to the subsequent generation, through elitism, or be considered for crossover and mutation. In the seventh step, the exit criterion is checked. In the eighth step, if the exit criterion is satisfied, the GA engine finally generates the optimal distribution of service points within the field.

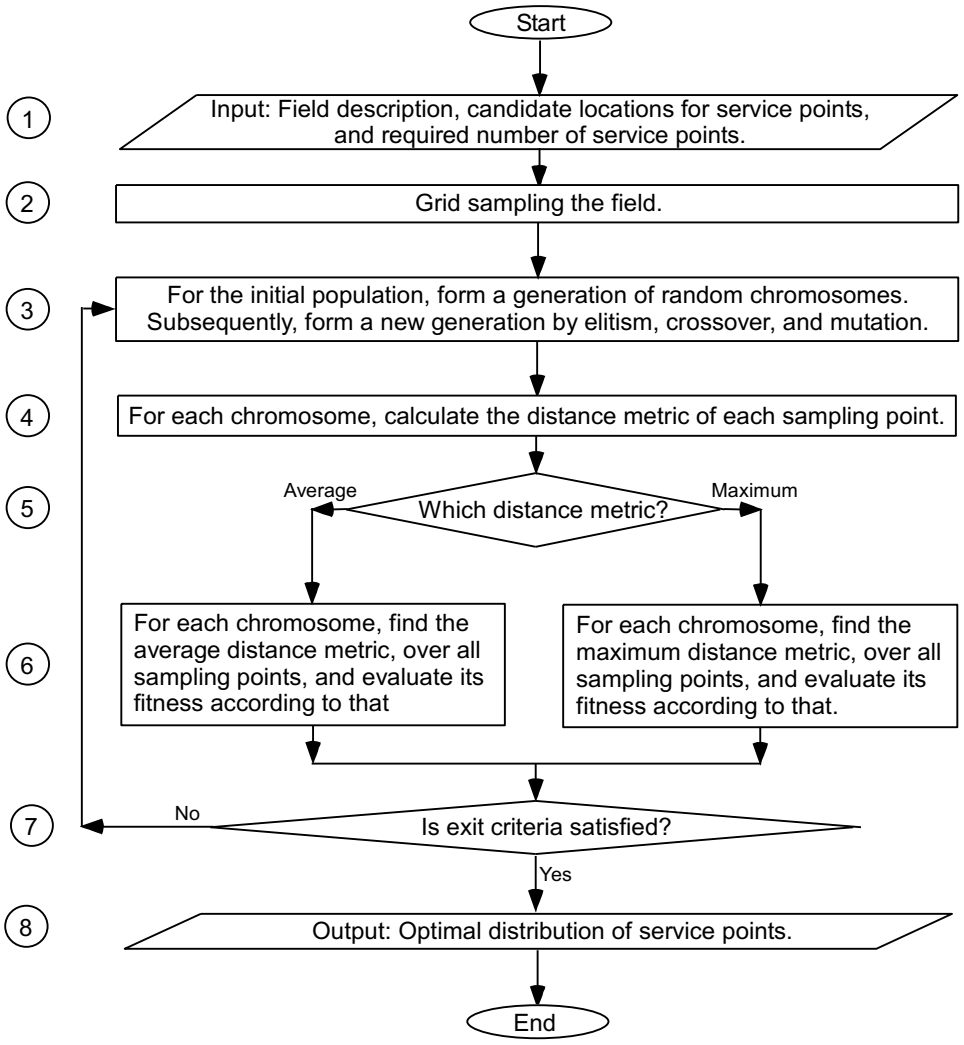



Fig. 1. GA-based methodology for optimal distribution of service points.

## VI. Experimental results

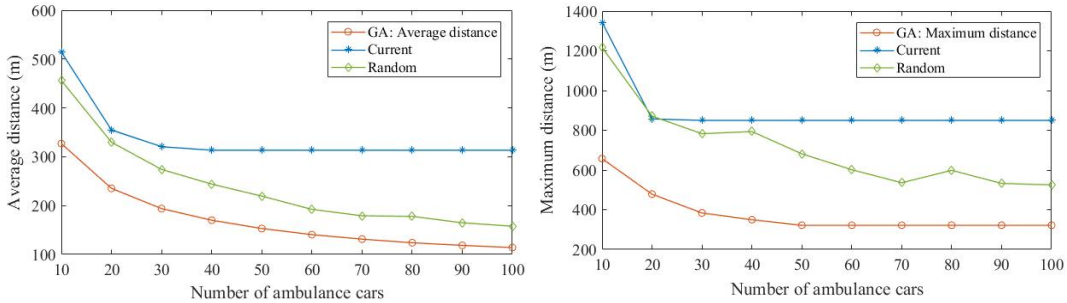
In order to verify the efficiency of our GA-based methodology, we consider a case study of distributing ambulance cars in Arafat. Our selection of the case study is motivated by the fact that the Hajj is moving toward the summer. Indeed, the day during the summer is long and very hot. More pilgrims would be affected by the direct sunlight and the high temperature. Therefore, ambulance cars should optimally cover the whole area of Arafat and quickly move to provide immediate medical help.

Before presenting and discussing our results, we herein summarize the tool, assumptions, and parameters used in getting these results. First, for the tool, the Matlab® global

optimization toolbox [19] is used in solving the optimization problem in this paper. Each generation consists of 10 different chromosomes, representing 10 different distributions. Two chromosomes of the best fitness are allowed to survive from one generation to the next through elitism. Furthermore, crossover and mutation generate 4 chromosomes each. For our methodology, different numbers of chromosomes could be used for the generation size, the elitism, the crossover, and the mutation. However, the used values are found by experimentation to give the best convergence time. Those values also agree with the ones suggested in [20]. Second, for the candidate locations of service points, ambulance cars could only be distributed to the intersection of any two paved roads. This results in a total of 330 candidate locations for ambulance cars. This restriction aims at facilitating the movement of any car and helping it to reach the desired location quickly.

The two distance metrics presented in Section III are considered for comparison in this section. Accordingly, for each metric, we change the number of ambulance cars from 10 to 100 and compare the results of our methodology to those of the random as well as the currently employed distribution strategies. In the random distribution strategy, some of the aforementioned candidate road intersections are randomly selected as locations for ambulance cars. In the current distribution strategy, ambulance cars are only restricted to fixed locations. These are the locations of hospitals, medical centers, and red crescent centers. Fig. 2 shows the results of the three distribution strategies with respect to the two distance metrics. The results of our GA-based methodology are averages over 10 runs. In each subfigure, our GA-based methodology, the current distribution strategy, and the random distribution strategy are represented by a red line with circle markers, a blue line with star markers, and a green line with diamond markers, respectively.

The average distances resulted from the three distribution strategies are shown in Fig. 2(a). From this figure, we first notice the superiority of our methodology over the two other strategies. Depending on the number of ambulance cars, our GA-based methodology reduces the average distance by 33.7% to 63.6%, with respect to the current distribution strategy, and by 26.7% to 30.4%, with respect to the random distribution strategy. Second, the figure shows that the average distance of the current distribution strategy remains constant beyond 30 ambulance cars. As that strategy restricts the distribution of ambulance cars to fixed locations, it could not benefit from increasing the number of cars or even achieve an average distance as small as that of the random distribution strategy. From these results, we finally conclude that keeping services centralized in fixed locations prevents them from attaining the maximum possible performance.




(a) Average distance (b) Maximum distance

Fig. 2. Comparison of our GA-based methodology to random and current distribution strategies with respect to different distance metrics.

The maximum distances resulted from the four distribution strategies are shown in Fig. 2(b). As mentioned in Section III, the maximum distance represents the farthest sampling location from an ambulance car. The figure first re-emphasizes the superiority of our methodology over the two other distribution strategies. Depending on the number of ambulance cars, our GA-based methodology reduces the maximum distance by 44.2% to 62.2%, with respect to the current distribution strategy, and by 38.7% to 56%, with respect to the random distribution strategy. Second, the figure again shows that the current distribution strategy could not even outperform the random distribution one with respect to the maximum distance metric. Furthermore, it could not benefit from increasing the number of ambulance cars and its maximum distance sticks beyond 20 cars.

## VII. Conclusion and future work

In this paper, we present a methodology to optimize the distribution of service points in any field. The methodology is suitable for distributing services in holy places. The optimization process is carried out using Genetic Algorithms with binary chromosome representation. Our methodology considers two distance metrics, average and maximum distances. A case study of distributing ambulance cars within Arafat is given to validate the efficiency of our methodology. Results show that the proposed methodology could significantly reduce the distance compared to current as well as random distribution strategies.

Our work could be extended into different directions. First, more metrics could be considered. Second, the methodology could be modified to combine between stationary and movable service points. Finally, for any required level of performance, the methodology could be adapted to decide the minimum number of service points that are needed to achieve this target performance.

## VIII. Recommendations

From the experience we got throughout our work and depending on the results we obtained in our case study, we give the following recommendations

1) There is a significant unused performance that should be better utilized from the current system of services. Therefore, for different types and aspects of already available services, optimization techniques should be employed to exploit the maximum performance from them.
2) The more we transform from centralized to de-centralized distribution of services, the higher the performance we get from these services. Accordingly, enhanced and high performance strategies, which properly distribute these services, are of great importance.
3) The distances between service points and different locations within holy places should be minimized. The benefits of this minimization are not only to save time, effort, and energy in acquiring these services, but also to increase their coverage. For emergency services, like ambulance cars and fire trucks, the benefits further extend to save pilgrims life.

## References


[1] Vision 2030, Kingdom of Saudi Arabia, http://vision2030.gov.sa/en, Last accessed: Feb. 2018.

[2] D. Yang, S. Misra, X. Fang, G. Xue, and J. Zhang, “Two-tiered constrained relay node placement in wireless sensor networks: Computational complexity and efficient approximations,” IEEE Transactions on Mobile Computing, 11(8), pp. 1399–1411, 2012.

[3] R. Hwang, R. Lee, and R. Chang, “The slab dividing approach to solve the euclidean p-center problem,” Algorithmica, 1(9), pp. 1–22, 1993.

[4] R. Fowler, M. Paterson, and S. Tanimoto, “Optimal packing and covering in the plane are NP-complete,” Information Processing Letters, 3(12), pp. 133–137, 1981.

[5] C. Chang, C. Chen, and C. Liu, “A novel approximation algorithm for minimum geometric disk cover problem with hexagon tessellation,” in Advances in Intelligent Systems and Applications - Volume 1, R. Chang, L. Jain, and S. Peng (Eds), Springer, Berlin, Heidelberg, pp. 157–166, 2013.

[6] T. Cormen, C. Leiserson, R. Rivest, and C. Stein, “Introduction to Algorithms,” 3rd ed. The MIT Press, 2009.

[7] R. Farahani, M. Hekmatfar (Eds.), “Facility Location: Concepts, Models, Algorithms and Case Studies,” Springer-Verlag Heidelberg, 2009.

[8] C. ReVelle, R. Swain, “Central facilities location,” Geographical Analysis, 2(1), pp. 30–42, 1970.

[9] C. ReVelle, H. Eiselt, “Location analysis: A synthesis and survey,” European Journal of Operational Research, 165(1), pp. 1–19, 2005.

[10] S. Hakimi, “Optimum locations of switching centers and the absolute centers and medians of a graph,” Operations Research, 12(3), pp. 450–459, 1964.

[11] O. Berman, Z. Drezner, G. Wesolowsky, “The collection depots location problem on networks,” Naval Research Logistics (NRL), 49(1), pp. 15–24, 2002.

[12] O. Alp, E. Erkut, Z. Drezner, “An efficient genetic algorithm for the p-median problem,” Annals of Operations Research, 122(1–4), pp. 21–42, 2003.

[13] B. Callaghan, S. Salhi, G. Nagy, “Speeding up the optimal method of Drezner for the p-centre problem in the plane,” European Journal of Operational Research, 257(3), pp. 722–734, 2017.

[14] J. Nematian, M. Sadati, “New methods for solving a vertex p-center problem with uncertain demand-weighted distance: A real case study,” International Journal of Industrial Engineering Computations, 6(2), pp. 253–266, 2015.

[15] C. ReVelle, H. Eiselt, M. Daskin, “A bibliography for some fundamental problem categories in discrete location science,” European Journal of Operational Research, 184(3), pp. 817–848, 2008.

[16] M. Shambour, E. Khan, A. Alsalibi, “Distribute Mina camps automatically to increase the capacity and efficiency,” in Proceedings of the 17th Scientific Meeting of Hajj, Umrah, and Visit Research, AlMadinah AlMunawara, Saudi Arabia, May 2017.

[17] W. J. Tang and Q. H. Wu, “Biologically inspired optimization: A review,” Transactions of the Institute of Measurement and Control, 31(6), pp. 495–515, 2009.

[18] M. Franceschetti, M. Cook, and J. Bruck, “A geometric theorem for approximate disk covering algorithms,” California Institute of Technology, Pasadena, CA, USA, Tech. Rep. ETR035, 2001.

[19] MATLAB® R2017a, “Global optimization toolbox,” The MathWorks Inc., https://www.mathworks.com/products/globaloptimization.html, Last accessed: Feb. 2018.

[20] A. Morgan, H. Elmiligi, M. El-Kharashi, F. Gebali, “Unified multi-objective mapping and architecture

# Third Theme:
# Environmental and Health Studies

# Assessment of Ebola disease outbreak emergency response among Healthcare Providers in Mena Emergency Hospital during Hajj Season 1435

Hassan Kasim Haridi[1], Abdulellah Al-Fatani[2], Ayman Esam Yamani[3]
1- General Directorate of Health Affairs, Hail Region
2- Maternity and Children's Hospital, Jeddah
3- Al-Noor Hospital, Makkah

## Abstract

Background: During Ebola virus disease (EVD) outbreak, 1435 there have been concerns pilgrims may spread the contagious diseases Ebola. Ministry of Health have been instituted all precautions to prevent the spread of Ebola during the hajj.

Objectives: To document healthcare emergency response towards the potential of facing Ebola virus outbreak during Hajj season 1435.

Methods: This work was a cross-sectional study, carried out among healthcare providers (HCPs) in Mena Emergency Hospital. All HCPs were invited to participate and voluntary respond to a self-administrated, structured, anonymous questionnaire during the period 1-5 /12/1435. The questionnaire included questions and statements covering: bio-demographic data of the participants, perception of the outbreak, knowledge, attitude, risk acceptance.

Results: Overall, 157 completed questionnaires was received, of them 85 physicians and 72 nurses, representing 54.1% and 45.9% of the sample respectively.

An overall, 90.7% of the respondents reported receiving infection control instructions/guidelines about Ebola virus infection/outbreak; 85.9% received/read MOH circulars updating them with the outbreak and providing guidelines for dealing with confirmed or suspected cases of EVD; 83.1% received Ebola alert SMS from the MOH Command and Control Center; 66.9% attended CME programs for Ebola virus infection/outbreak; and 52.9% visited MOH internet site concerned with EVD. The vast majority of the participants (89.8%) attained >50% scores on the knowledge scale, of them 41.4% attained >75% score, while 48.4% attained 50-75% scores.

The adjusted multivariate logistic regression analysis, revealed that: being a physician, original work of the participant is hospital setting and reading MOH circulars regard EVD guidelines were independently associated with good knowledge.

Attending CME training concerned with Ebola virus infection/outbreak, seeking information from MOH internet site about Ebola virus infection/outbreak, being a nurse, and married marital status, were factors independently predicted the risk acceptance among the participants.

Meanwhile, having good knowledge about Ebola virus infection/outbreak, concern that may get sick with Ebola virus and being married as marital status, were factors that independently associated with the reported self-efficacy about dealing with Ebola virus infection/outbreak.

Conclusion: Emergency response of healthcare providers to Ebola virus infection/outbreak 1435 in Mena Emergency hospital was adequate. Staff with good exposure to the official sources of knowledge (CME programs, Ministry of Health (MOH) circulars & guidelines, MOH internet site, exhibited better knowledge, risk acceptance and self-efficacy. Despite, most of the participants attended training programs for preparedness; still, about one third of the participants felt insufficient knowledge and skills, which imply the need to review these programs in terms of coverage and content to satisfy their training needs.

## 1. Introduction

Ebola virus disease (EVD), previously known as Ebola hemorrhagic fever is a deadly disease caused by infection with one of the Ebola virus species. Ebola virus causes severe viral hemorrhagic fever with a high fatality rate [1]. The 2014 outbreak of EVD in West Africa, caused by Ebola virus, was the largest and most complex Ebola outbreak in history. There were more cases and deaths in this outbreak than all others combined [2]. Ebola virus is highly contagious, can be transmitted by direct contact with blood, body fluids, or skin of EVD patients or persons who have died of EVD; the virus has an incubation period of 2-21 days (average 3-13days); symptoms range from, firstly, fever and fatigue before descending into headaches, vomiting, violent diarrhea, then multiple organ failure and massive internal bleeding [1-3]. EVD outbreaks have a case fatality rate of 50-90%, yet no specific drug or vaccine is available for people and/or animals hosts [2].

Health care providers (HCPs) are at a greater risk of contracting EVD and may promote its transmission by occupational exposures [3]. Transmission in health care settings has been associated frequently with EVD outbreaks in Africa. If cases of the disease do appear,

prompt actions including strict infection control measures should be applied to avoid the spread of the disease within health-care facilities. Patients must be isolated from contact with any unprotected people and hospital workers must wear protective clothing, such as masks, gloves, gowns and goggles [3].

Being a highly contagious disease Ebola HF can spread to other parts of the world because of continuous movement of people in different parts of the world so it becomes necessary for the HCPs to be, aware of this fatal disease. Saudi Arabia, being a place for the largest mass gathering in the world during Hajj, with Muslims coming from every place in the globe have a specific concern regard outbreaks of infectious diseases.

## 2. Research aims:

The objectives of this work were to assess emergency response of HCPs towards the potential dealing with Ebola virus infections during Hajj season 1435H (2014G), their risk perception, level of concern, acceptance of risk and basic knowledge about the disease and outbreak.

## 3. Research Methodology:

### 3.1 Study design and Setting

This work was a descriptive cross-sectional study, conducted in Mena Emergency Hospital, during 1-5/12/1435H (26-30 September 2016). The hospital is well equipped, of 214 beds capacity, operating seasonally during Hajj. The hospital run by more than 450 personnel; of them ~100 physicians, ~200 nurses and ~50 other HCWs directly involved in patient care. Hospital staff are recruited from all health regions of the country for this temporary period of the year. The hospital experience severe congestion with patients during operation, receiving large number of emergences and outpatients with full bed-capacity patient's admissions.

### 3.2 Participants and Sampling

Physicians and nurses of the hospital staff were the sampling frame of the study. The eligible participants were those who are directly involved in patient care. To receive an adequate number of responses, all eligible physicians and nurses available at the time of the survey were invited to participate, with two hundred questionnaires distributed.

### 3.3 Survey instrument and administration

An anonymous structured questionnaire was constructed based on the literature review and previous research findings [1-3]. The questionnaire included 40 items in four parts: First part,

included nine questions/statements to describe demographic, professional and work practice characteristics of the respondents; the second part included eight questions/statements to explore awareness regard Ebola virus infection/outbreak, concern about possibility to face Ebola virus infection cases. The third part included questions to assess preparedness: the participant, being oriented with guidelines regard Ebola virus infection/outbreak, attended CME training programs, being instructed with infection control standard procedures, receiving SMS from MOH, visiting MOH internet site for Ebola virus infection/outbreak orientation. The forth part of the questionnaire included 15 questions to assess participant's knowledge about the disease and sources of his/her knowledge. Reliability Statistics for the knowledge items of the questionnaire was high (Cronbach's Alpha= 0.792).

Healthcare workers were invited to participate in the study at the time of their arrival to embark on their mission in the hospital and before commencing the hospital orientation programs. Participation was voluntary. The agreed subjects self-completed the questionnaire with a briefing for the study objectives by a trained coordinator who did not have medical or administrative responsibilities in the hospital during the study.

### 3.4 Pilot study

The questionnaire was pre-tested and piloted with a convenience sample of 10 HCPs (5 physicians and 5 nurses) with similar demographic characteristics to the study population to ensure clarity and ease of administration. Based on respondents' recommendations, some changes were done to improve the final questionnaire.

### 3.5 Ethics

Participation was voluntary for the agreed staff. Filling and returning back the questionnaire was considered a consent for participation. A written approval from the hospital authority was taken to conduct the study. The study was a tool to explore preparedness of the staff and to assess the instructive needs to be addressed in the orientation sessions before commencing the hospital operation.

### 3.6 Statistical analysis

Statistical analysis was carried out using EpiInfo 7 program and SPSS Version 23. We generated descriptive statistics for all survey items. A bivariate analysis with Chi-square test was done to explore associations between respondent's characteristics with different levels of knowledge about Ebola virus infection/outbreak.

Knowledge scale was created, composed of 37 knowledge items, which revealed high reliability (Cronbach's Alpha= 0.792). Knowledge scale was dichotomized into binary dependent outcome variable to classify respondent into two groups; “knowledgeable” respondents, who attained 75% knowledge score and “less knowledgeable” with scores < 75% on the knowledge scale.

A multivariate logistic regression models with backward selection and cutoff point of <0.2 were developed to capture predictors independently associated with three outcome variables, namely: knowledge, risk acceptance and self-efficacy. Odds ratios (ORs) and their 95% confidence intervals (CIs) were reported as measures of association between predictors and outcome of interest. All statistical tests were two-tailed and p-values of 0.05 or less were considered statistically significant.

## 4. Results and discussion:

### 4.1 RESULTS

In total, 200 questionnaires were distributed and 157 were returned complete, with response rate of 78·5%. The respondents of HCPs were made of 88 (56.1%) males and 69 (43.9%) females of which physicians constituted 85 (54.1%) and nurses 72 (45.9%). Detailed characteristics of the respondents are summarized in Table 1.

Table 2, give details about risk perception and concern regard Ebola virus infection among Healthcare Providers (HCPs) their beliefs in self-efficacy and institutional preparedness in dealing with the potential EVD threat during Hajj season 1435H (2014). About ninety percent (89.9%) thought that Ebola virus outbreak is a major global threat and 89.7% agreed that HCPs who care for Ebola patients are at higher risk of getting infection with the virus. Most of the participants (83.2%) were accepting the risk of might getting infection, because it is a part of their job.

Participants expressed their concern that an outbreak might occur during Hajj; 33.1% were extremely concerned/highly concerned, 25.3% somewhat concerned, while 41.6% were slightly or not concerned at all. Among participants, 36.4% was extremely concerned/highly concerned of might get thick with Ebola being a patient’s caregiver, and 27.3% were extremely concerned/highly concerned of transferring the infection to their families. Overall, 33.1% of the participants perceived a high risk for acquiring Ebola.

A good knowledge scores was attained by the participants, with median (mean ±SD) score of 26 (25.42±5.42) on a scale of 37 points (Table 3). In total, 89.8% the participants attained

50% or higher on the knowledge score; of them 41.4% attained ≥75% score and 48.4% attained 50-74% of the score (Table 5, Figure 1). Most participants (89.8%) knew that Ebola is transmitted by contact with body fluids of infected persons and 88.5% of them know that the virus can enter the body through broken skin or unprotected mucus membranes. However, lower percentage of the participants (24.2%) realize the that the incubation period is as short as two days and as long as 21 days (39.5%). Only 62.4% exactly identified the operational case definition of patient under investigation. More than ninety percent (94.3%), recognized that fever 38.6°C and 80.3% of them recognized that unexplained hemorrhage (bleeding or bruising) are cardinal symptoms/signs of the Ebola infected patients (Table 3). However, only 46.5%, 62.4%42.7%54.1% recognized that leucopenia, thrombocytopenia, elevated serum AST & ALT and coagulation abnormality are important findings in laboratory investigation for a case of Ebola virus infection respectively (Table 3). Most of the participants (79.0%) reported that there is a specific laboratory test for Ebola virus detection, (83.4%) there is no specific treatment, and 84.7% that there is no preventive vaccine available (Table 3).

Sources of participant's knowledge mostly reported were MOH internet site (52.2%), CME training programs (44.6%), general internet sites (33.8%), colleagues (31.2%), WHO and CDC internet sites (30.6%), media TV/newspapers (24.2%) and official MOH circulars including guidelines (22.3%) (Table 4).

The adjusted multivariate logistic regression analysis controlling for confounders and other independent variables, revealed that: being a physician (OR, 4.55; 95% CI 1.58-13.05; P=0.005), original work of the participant is a hospital setting (OR, 4.25; 95% CI, 1.45-15.79; P=0.031), and reading MOH circulars regard DVD guidelines (OR, 10.25, 95% CI 1.45-15.79; P=0.021) were independently associated with good knowledge. Being a nurse (OR, 10.22; 95% CI, 1.79-58.37; p=0.009), being married as marital status (OR, 7.28; 95% CI 1.30-40.81; P=0.021), attending CME training concerned with Ebola virus infection/outbreak (OR, 3.61; 95% CI, 1.18-10.97; P=0.023) and seeking information from MOH internet site about Ebola virus infection/outbreak (Odds Ratio, 4.19; 95% CI, 1.34-13.10; P=0.014) were factors that independently predicted risk acceptance among the participants. Meanwhile, being married as marital status (OR, 2.52; 95% CI, 1.05-6.05; P=0.039), concern that may get sick with Ebola virus (OR, 1.91; 95% CI, 1.24-2.93; P=0.007) and having good knowledge about Ebola virus infection/outbreak (OR, 1.12; 95% CI, 1.03-1.22; P=0.007),

were factors that independently associated with reported self-efficacy about dealing with Ebola virus infection/outbreak (Table 6).

### 4.2 DISCUSSION

On 8 August, it was formally designated by WHO that Ebola virus infection outbreak is a public health emergency of international concern [4] This declaration coincided with Muslims' largest gathering in Hajj season 2014, with Muslims coming from all countries of the world. This raised the concern that pilgrims may spread the diseases, so that Saudi Arabia played down fears, having banned pilgrims from the affected African countries with the outbreak, namely, Sierra Leone, Guinea and Liberia. Ministry of Health (MOH) have been instituted all precautions to prevent entry and spread of EVD during the hajj [5].

As serving mass gathering, healthcare facilities during Hajj, receive high load of patients that make work environment vulnerable for transmission of infections, unless infection control measures are strictly applied and HCPs are properly prepared. Prevention and dealing with conceivable undetected cases of Ebola virus infection among pilgrim coming from unbanned counties was a real concern for healthcare facilities.

This work was a cross-sectional survey among HCPs in Mena Emergency Hospital, a seasonally operating institution, providing care to pilgrims during their stay in the holy place Mena. The objectives of the study were to assess the emergency response of HCPs in facing a potential EVD cases, as well as exploring their risk perception, concern and risk acceptance.

The study underlined a good emergency response and adequate preparedness among the participants. An overall, 90.7% of the respondents reported receiving infection control instructions/guidelines about Ebola virus infection/outbreak; 85.9% received/read MOH circulars updating them with the outbreak and providing guidelines for dealing with confirmed or suspected cases of EVD; 83.1% received Ebola alert SMS from the MOH Command and Control Center; 66.9% attended CME programs for Ebola virus infection/outbreak; and 52.9% visited MOH internet site concerned with EVD. The vast majority of the participants (89.8%) attained >50% scores on the knowledge scale, of them 41.4% attained >75% score, while 48.4% attained 50-75% scores. This situation denote the effort spent in preparation of HCPs to ensure competence in providing better care for pilgrims within safe Hajj healthcare facilities. However, still one third (33.1%) of HCPs were not covered by CME training for EVD, the most formal way to ensure proper staff preparation, capacity building and

reassurance. This gap was fixed through the confirmatory staff training carried out during hospital preparation period before commencing hospital operation.

Engagement of various preparedness activities such as revision of protocols, training of HCPs proved effective in other studies. Healthcare associated cases of EVD due to contact to the cross-bordered cases to US and Spain have demonstrated the importance of training of HCPs in personal protective equipment regimens [6-7]. Having been trained on EVD showed positive association with acceptable knowledge in Italian hospitals [8].

Attending CME training programs in this study proved also effective for staff assurance. Staff who attended CME programs for EVD/outbreak, have near four times (OR, 3.61; 95% CI, 1.18-10.97; P=0.023) probability for accepting the risk for dealing with EVD cases than CME non-attending staff.

Outstandingly effective, the study demonstrated an important role of reviewing MOH circulars with guidelines in enhancing HCPs knowledge about the disease and outbreak. Staff who were acquainted themselves with MOH circulars devoted to enhance staff awareness and providing guidelines regarding EVD/outbreak were independently have ten times probability of achieving good knowledge scores (OR, 10.25; 95% CI1.42-74.31) than their counterparts.

Physicians were independently more knowledgeable than nurses were (OR, 4.55; 95% CI, (1.58-13.05; p=0.005). This is, not only may be logically explained by the different education level; but also could be attributed to the better opportunity of the physicians to receive more training than nurses could.

Despite that, the participants expressed higher perception (89.7%) about EVD/outbreak with agreement that HCPs caring for Ebola patients are at highest risk of getting infection, yet, less concern expressed by them. Participants in the study, expressed less concern (33.1% were extremely/highly concerned) that there will be a large EVD outbreak will occur during Hajj and 36.4% were extremely/highly concerned that they may get sick with EVD during their duty in Hajj. This could be attributed in part by their convenience with the decision taken by authorities in Saudi Arabia of banning pilgrims from the affected African countries with the outbreak and may also reflect their satisfaction with the institutional measures directed for prevention and control of the disease. Their prior preparation by training, better communication and providing sufficient resources needed for standard infection prevention & control may be also considered.

The role of exposure to relevant sources of knowledge for risk acceptance was obvious in our study. Participants who participated in CME training programs (OR, 3.61; 95% CI, 1.18-10.97; P=0.023) and those who were seeking information from the official MOH site regard EVD/outbreak (OR, 4.19; 95% CI, 1.34-13.10; P=0.014), both were independently associated with risk acceptance.

The present study highlighted that self-efficacy of the participants was independently affected by participants' knowledge, which comes in agreement finding of other researchers [9]. Higher concern that participants' may getting infection with EVD being a HCP was independently associated with also with self-efficacy. This may be explained by actively seeking behavior of the highly concerned person to get more knowledge about the disease, get training to have better skills in infection prevention/control to protect self and others.

Some limitations may encounter our study to generalize results and conclusions. First of all, although Mena Emergency Hospital nearly have similar Healthcare manpower compared to other hospitals in the holy places in Makkah, the study results may not be fully representative of medical professionals and hospitals serving pilgrims during Hajj season. Secondly, the sample size was smaller than to bring a narrower confidence intervals for estimates or to capture other, may be important independent factors associated with the outcome variables of interest. Furthermore, the response rate among nurses (~ 40%) was lower than physicians (~ 80%) which may not proportionally representing the nursing staff. Thirdly, other HCPs other than physicians and nurses who might be in direct contact with patients or biological samples were not included, so generalizing results to all HCPs should be taken with caution. Despite these several limitations, the study succeeded to give insights about the emergency response among HCPs about EVD/outbreak and their knowledge gaps, which were subsequently taken into consideration while providing the orientation training courses in the preparation period, before commencing the hospital operation.

## 5. Summary:

Emergency response of healthcare providers to Ebola virus infection/outbreak (2014) in Mena Emergency hospital was adequate. The hospital is an example for other hospitals serving Hajj pilgrims. Staff with good exposure to official sources of knowledge (CME programs, Ministry of Health (MOH) circulars & guidelines, MOH internet site, possessed better knowledge, risk acceptance and self-efficacy. Despite, most of the participants attended training programs for preparedness; still, about one third of them felt insufficiency

in knowledge and skills, which highlights the need to review these programs in terms of coverage and content to satisfy their training needs.

## 6. Recommendations:

In spite of the emergency response of healthcare providers to Ebola virus infection/outbreak (2014) in Mena Emergency hospital was adequate as an example for other hospitals serving Hajj pilgrims and most of the participants attended training programs for preparedness; still, about one third of them felt insufficiency in knowledge and skills, which highlights the need to review these programs in terms of coverage and content to satisfy their training needs.

## 7. References:


[1] U.S. Centers for Disease Control and Prevention. Ebola Hemorrhagic Fever Information Packet. 2009; Ebola Fact sheet (Accessed Sep 17, 2017). Available at: https://www.cdc.gov/vhf/ebola/pdf/ebola-factsheet.pdf

[2] World Health Organization: Ebola virus disease Fact Sheet. (Accessed Sep 17, 2017) Available at: http://www.who.int/mediacentre/factsheets/fs103/en/

[3] World Health Organization: Infection prevention and control guidance for care of patients in health-care settings, with focus on Ebola: Interim guidance. (Accessed December 30, 2017). Available at: http://www.who.int/csr/resources/publications/ebola/filovirus_infection_control/en/

[4] World Health Organization: Statement on the 1st meeting of the IHR Emergency Committee on the 2014 Ebola outbreak in West Africa. (Accessed 22 October 2014). Available at: http://www.who.int/mediacentre/news/statements/2014/ebola-20140808/en/

[5] Saudi MoH. Health Regulations for Travelers to Saudi Arabia for Umrah& Pilgrimage (Hajj)-1435 (2014) 2014 (Accessed 25 September 2014). Available at: http://www.moh.gov.sa/en/Hajj/HealthGuidelines/HealthGuidelinesDur- ingHajj/Pages/HealthRegulations1435.aspx.

[6] WHO. Ebolavirus disease – Spain. Geneva: World Health Organization, 2014. Available at: http//://www.who.int/csr/don/09-october-2014-ebola/en/ (accessed 30 December 2014).

[7] McCarthy M. Texas healthcare workers is diagnosed with Ebola. BMJ. 2014; 349 (oct13 6):g6200. Available at: hhtp://dx.doi.org/10.1136/bmj. G6200 PMID:25313199.

[8] Sodano L, Radici F, Rossini A, D'Alessandro D. Cross-sectional study on knowledge of health care workers about Ebola Virus Disease and its Prevention: a pilot study in two hospitals in Rome (Italy). Ann Ig. 2015;27(6):814-23. Doi: 10.7416/ai.2015.2075.

[9] Carlos C1, Capistrano R1, Tobora CF1, delos Reyes MR1, Lupisan S1, Corpuz A2, et al. Hospital preparedness for Ebola virus disease: a training course in the Philippines. Western Pac Surveill Response J. 2015 Jan 27;6(1):33-43. doi: 10.2471/WPSAR.2014.5.4.008. eCollection 2015 Jan-Mar.

## 8. Figures & Tables:

Table (1): Characteristics of the studied healthcare Providers (HCPs) in Mena Emergency Hospital during Hajj season 2014, Saudi Arabia. (n=157)

| Characteristics | Number | (%) |
|---|---|---|
| **Gender** | | |
| • Male | 88 | 56.1 |
| • Female | 69 | 43.9 |
| **Age in years *** | | |
| • <30 | 47 | 31.1 |
| • 30-39 | 50 | 33.1 |
| • 40+ | 54 | 35.8 |
| Median (Mean ± Standard Deviation) | 35 (36.66±9.94) | |
| **Nationality** | | |
| • Saudi | 58 | 36.9 |
| • Non Saudi | 99 | 63.1 |
| **Marital Status*** | | |
| • Married | 113 | 72.4 |
| • Single/Others | 43 | 27.6 |
| **Job category** | | |
| • Physician | 85 | 54.1 |
| • Nurse | 72 | 45.9 |
| **Education attainment (last degree)*** | | |
| • Less than Bachelor | 45 | 28.8 |
| • Bachelor | 65 | 41.7 |
| • Diploma/Master | 35 | 22.4 |
| • MD/PhD/Fellowship | 11 | 7.1 |
| **Original Workplace*** | | |
| • Hospital Setting | 122 | 79.7 |
| • PHC center/ Others | 31 | 20.3 |
| **Duration of Experience in years*** | | |
| • <5 | 44 | 29.9 |
| • 5-10 | 51 | 34.7 |
| • >10 | 52 | 35.4 |
| **Health Profiles** | | |
| • Have any chronic Disease | 29 | 18.5 |
| **Exposure to institutional and self-resources of updated knowledge and practices** | | |
| • Read MOH circulars and guidelines as regard Ebola. | 133 | 85.9 |
| • Visited MOH internet Site for Ebola awareness. | 82 | 52.9 |
| • Attended any CME program for Ebola. | 105 | 66.9 |
| • Received Ebola alert SMS messages from MOH. | 128 | 83.1 |
| • Read/instructed Ebola infection control guideline. | 137 | 90.7 |

*Total number in some categories may be less than 157, due to missed responses.

Table 2: Risk perception and Concern regard Ebola virus infection and Beliefs in self and institutional efficacy in dealing with a potential Ebola virus Disease (EVD) infection among Healthcare providers (HCPs) in Mena Emergency Hospital, Saudi Arabia during Hajj season 1435H (2014).

| **Risk Perception about Ebola Outbreak** | | |
|---|---|---|
| Do you think that EVD Outbreak is a major global threat? | **Number** | **%** |
| -Agree | 133 | 89.9 |
| -Uncertain | 8 | 5.4 |
| -Disagree | 7 | 4.7 |
| Do you agree that HCPs who care for Ebola patients are at highest risk of getting infection? | | |
| -Agree | 139 | 89.7 |
| -Uncertain | 13 | 8.4 |
| -Disagree | 3 | 1.9 |
| Do you accept the Risk of might getting the infection, because it is a part of your job? | | |
| -Yes | 104 | 83.2 |
| -No | 21 | 16.8 |
| **Concern about Ebola Outbreak:** | | |
| Are you concerned that there will be a large outbreak the recent Hajj Season 1435H? | | |
| -Not at all concerned | 30 | (19.5) |
| -Slightly concerned | 34 | (22.1) |
| -Somewhat concerned | 39 | (25.3) |
| -Highly concerned | 27 | (17.5) |
| -Extremely concerned | 24 | (15.6) |
| Are you concerned that you may get sick with Ebola being a Health Care worker? | | |
| -Not at all concerned | 29 | 18.8 |
| -Slightly concerned | 32 | 20.8 |
| -Somewhat concerned | 37 | 24.0 |
| - Highly concerned | 30 | 19.5 |
| -Extremely concerned | 26 | 16.9 |
| Are you concerned that someone in his/her family may get sick with Ebola? | | |
| -Not at all concerned | 61 | 39.6 |
| -Slightly concerned | 35 | 22.7 |
| -Somewhat concerned | 16 | 10.4 |
| - Highly concerned | 26 | 16.9 |
| -Extremely concerned | 16 | 10.4 |
| **Belief in self and institutional efficacy in dealing with possible situation suggest Ebola cases.** | | |
| - Do you feel that your knowledge/skills are sufficient to deal with any suspect case of EVD? | 90 | 64.3 |
| -Do you think that the institutional preparedness is sufficient for dealing with any possible situation suggest EVD cases? | 133 | 75.3 |

*Total number in some categories may be less than 157, due to missed responses.

Table 3: Frequency of correct answers regard Ebola virus infection 2014 outbreak, among health care Providers (HCPs) in Mena Emergency Hospital during Hajj season 1435H (2014), Saudi Arabia.

| Item of knowledge | Number | (%) |
|---|---|---|
| ***Knowledge about the Outbreak and Agent Characteristics** | | |
| • Geographic distribution: Mostly affected countries. | 147 | 93.6 |
| • One of the hemorrhagic fevers. | 148 | 94.3 |
| • An infectious disease. | 143 | 91.1 |
| • Mortality: Severe and often fatal. | 125 | 79.6 |
| • Causative agent is virus. | 149 | 94.9 |
| **Knowledge of Transmission** | | |
| • **Easy transmission. | 101 | 64.3 |
| • *Period of infectivity is related to the duration of symptoms. | 116 | 73.9 |
| *Most confirmed human transmission occur through | | |
| • Infected body fluids | 141 | 89.8 |
| • Infected objects | 92 | 80.7 |
| • Infected animals | 98 | 72.6 |
| • Airborne | 38 | 34.5 |
| • The virus can enter the body through broken skin or unprotected mucus membranes e.g. eyes, nose or mouth | 139 | 88.5 |
| **Knowledge of Incubation Period** | | |
| • As short as: From 2 days | 38 | 24.2 |
| • As long as: To 21 days | 62 | 39.5 |
| **#Knowledge of Clinical Picture of Cardinal Symptoms and Signs, Diagnosis and Case definition** | | |
| • Fever 38.6°C. | 148 | 94.3 |
| • Severe headache. | 126 | 80.3 |
| • Muscle pain. | 121 | 77.1 |
| • Weakness. | 121 | 77.1 |
| • Diarrhea. | 127 | 80.9 |
| • Vomiting. | 105 | 66.9 |
| • Abdominal (stomach) pain. | 110 | 70.1 |
| • Unexplained hemorrhage (bleeding or bruising). | 126 | 80.3 |
| • Cough. | 76 | 48.4 |
| • Expectoration. | 115 | 73.2 |
| • Leucopenia. | 73 | 46.5 |
| • Thrombocytopenia | 98 | 62.4 |
| • Elevated serum AST and ALT. | 67 | 42.7 |
| • Coagulation abnormalities. | 85 | 54.1 |
| • There is a specific Laboratory Test/s. | 124 | 79.0 |
| ****Knowledge of the Case Definition of Person Under Investigation?** | | |
| • Case Definition of Person under Investigation is based on both Clinical Picture and epidemiological Risk Factors. | 98 | 62.4 |
| ***Knowledge of treatment and prevention** | | |
| • There is a specific effective Medication. | 131 | 83.4 |

| | | |
|---|---|---|
| • There is a preventive vaccination. | 133 | 84.7 |
| ***Knowledge of Infection Prevention/Control measures against Ebola virus infection** | | |
| • Wear protective clothing, including masks, gloves, gowns, and eye protection. | 130 | 96.3 |
| • Ensure sterilization measures. | 117 | 88.0 |
| • Isolate patients with Ebola from other patients. | 120 | 93.8 |
| • Avoid direct contact with the bodies of people who have died from Ebola virus infection. | 110 | 90.9 |
| • Ebola pathogen can be eliminated with heat (heating for 30 to 60 minutes at 60 °C or boiling for 5 minutes). | 50 | 48.6 |
| • Lipid solvents as alcohol-based products, detergents, hypochlorites can be used as disinfectants. | 68 | 63.5 |
| **Knowledge Score with maximum score of 37 points:**<br>• Mean ± SD<br>• Median<br>• Range | 25.42±5.42<br>26<br>4-37 | |

*Yes/No.
**Selection from multiple choices.
***Selection any of the choices: highly effective or effective.
#Check Boxes.

Table 4: Source* of Knowledge of the Participants regarding Ebola infection.

| Source of knowledge | Number | (%) |
|---|---|---|
| • Colleagues | 49 | 31.2 |
| • Medical Journals | 22 | 14.0 |
| • WHO/CDC Internet sites | 48 | 30.6 |
| • General Internet Sites | 53 | 33.8 |
| • Ministry of Health Site | 82 | 52.2 |
| • Official Circulars and guidelines | 35 | 22.3 |
| • CME Program/Lecture(s) | 70 | 44.6 |
| • Media TV/Newspapers | 38 | 24.2 |
| • Other Sources | 9 | 5.7 |

∗Multiple responses

Table 5: Association between respondents' characteristics and knowledge Levels of Ebola Virus Disease (EVD)/Outbreak.

| Characteristics | Percentage Score Attained | | | Significance | |
|---|---|---|---|---|---|
| | <50 | 50-74 | ≥75 | $X^2$ | *P* value |
| **Total Score of knowledge** | 16 (10.2) | 76 (48.4) | 65 (41.4) | | |
| **Gender** | | | | 11.54 | 0.003 |
| • Male | 4 (4.5) | 39 (44.3) | 45 (51.1) | | |
| • Female | 12 (17.4) | 37 (53.6) | 20 (29.0) | | |
| **Age in years** | | | | 10.99 | 0.027 |

| | | | | | |
|---|---|---|---|---|---|
| • <30 | 7 (14.9) | 30 (63.8) | 10 (21.3) | | |
| • 30-39 | 4 (8.0) | 23 (46.0) | 23 (46.0) | | |
| • 40+ | 4 (26.7) | 22 (40.7) | 28 (51.9) | | |
| **Nationality** | | | | 19.19 | <0.001 |
| • Saudi | 11 (19.0) | 35 (60.3) | 12 (20.7) | | |
| • Non Saudi | 5 (5.1) | 41 (41.4) | 53 (53.5) | | |
| **Marital Status** | | | | 7.96 | 0.019 |
| • Married | 11 (9.7) | 48 (42.5) | 54 (47.8) | | |
| • Single/others | 5 (11.6) | 28 (65.1) | 10 (23.3) | | |
| **Job category** | | | | 19.16 | <0.001 |
| • Physician | 4 (4.6) | 33 (38.8) | 48 (56.5) | | |
| • Nurse | 12 (16.7) | 43 (59.7) | 17 (23.6) | | |
| **Education last degree** | | | | 33.19 | <0.001 |
| • Less than Bachelor | 10 (22.2) | 29 (64.4) | 6 (13.3) | | |
| • Bachelor | 4 (6.2) | 27 (41.5) | 34 (52.3) | | |
| • Diploma/Master | 0 (0.0) | 19 (54.3) | 16 (45.7) | | |
| • MD/PhD/Fellowship | 1 (9.1) | 1 (9.1) | 9 (81.8) | | |
| **Original Workplace** | | | | 3.13 | 0.209 |
| • Hospital Setting | 11 (9.0) | 56 (45.9) | 55 (45.1) | | |
| • PHC center | 5 (16.1) | 17 (54.8) | 9 (29.0) | | |
| **Experience in years** | | | | 11.05 | 0.026 |
| • <5 | 8 (18.2) | 23 (52.3) | 13 (29.5) | | |
| • 5-10 | 2 (3.9) | 27 (52.9) | 22 (43.1) | | |
| • >10 | 2 (3.8) | 23 (44.2) | 27 (51.9) | | |
| **Have Chronic Disease** | | | | 1.71 | 0.425 |
| • Yes | 4 (13.8) | 16 (55.2) | 9 (31.0) | | |
| • No | 12 (9.4) | 60 (46.9) | 56 (43.8) | | |

Table 6: Adjusted Multivariate Logistic Regression analyses of Factors Associated with Good Knowledge, Risk Acceptance and Self-Efficacy among Healthcare Providers (HCPs) as regard dealing with Ebola Virus Decease (EVD)/Outbreak in Mena Emergency Hospital, during Hajj season 1435 H (2014) (n=157)

| | Good Knowledge[a] | | Risk Acceptance[b] | | Self-efficacy[c] | |
|---|---|---|---|---|---|---|
| | aOR (95% CI) | *p-Value* | aOR (95% CI) | *p-Value* | aOR (95% CI) | *p-Value** |
| **Assignment.** | | | | | | |
| - Physician | 4.55 (1.58-13.05) | | 1 | | | |
| - Nurse | ١ | 0.005 | 10.22 (1.79-58.37) | 0.009 | | |
| **Marital Status** | | | | | | |
| - Single | | | 1 | | 1 | |
| - Married | | | 7.28 (1.30-40.81) | 0.021 | 2.52 (1.05-6.05) | 0.039 |
| **Original Workplace.** | | | | | | |
| - PHC Setting | 1 | | | | | |
| - Hospital setting | 4.25 (1.45-15.79) | 0.031 | | | | |
| **Did you read Ministry of Health Circulars and Guidelines as regard Ebola virus disease/outbreak?** | | | | | | |
| - No | 1 | | | | | |
| - Yes | 10.25 (1.42-74.31) | 0.021 | | | | |
| **Did you attend any CME program for Ebola virus infection/outbreak?** | | | | | | |
| - No | | | 1 | | | |
| - Yes | | | 3.61 (1.18-10.97) | 0.023 | | |
| **Did you visit Ministry of Health internet site for Ebola virus infection/outbreak awareness?** | | | | | | |
| - No | | | 1 | | | |
| - Yes | | | 4.19 (1.34-13.10) | 0.014 | | |
| **Knowledge Score[†].** | | | | | | |
| - per 1-point increase | | | | | 1.12 (1.03-1.22) | 0.007 |
| **Are you concerned that you may get sick with Ebola virus being a healthcare worker?** | | | | | | |
| - No | | | | | 1 | |
| - Yes | | | | | 1.91 (1.24-2.93) | 0.003 |

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval.
[a]Final -2*Log-Likelihood: 116.90; Likelihood Ratio: 32.48; Model *P*-Value: 0.002;
[b]Final -2*Log-Likelihood: 89.83; Likelihood Ratio: 18.67; Model *P*-Value: 0.002;
[c]Final -2*Log-Likelihood: 150.55; Likelihood Ratio: 26.32; Model *P*-Value: <0.001;
*wald test.
[†] Maximum score with 37 points.

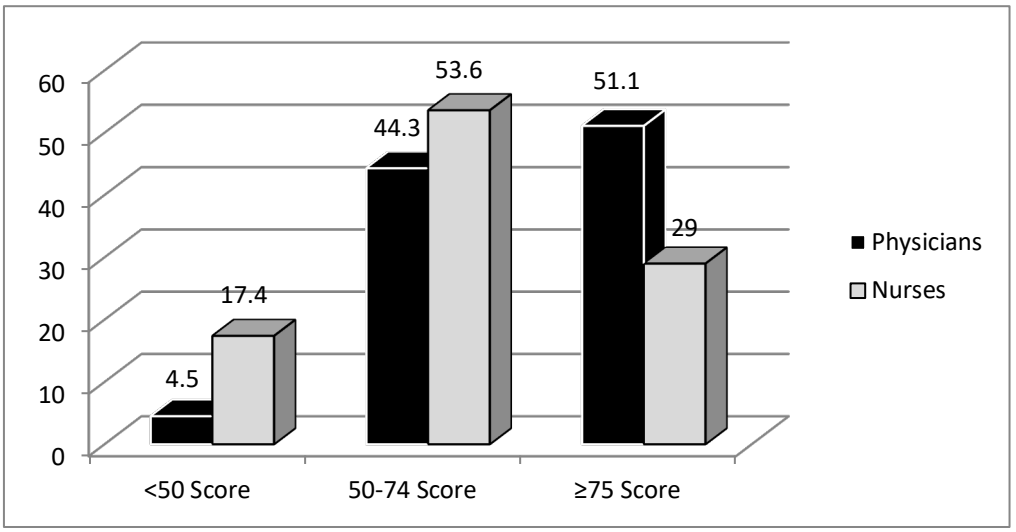



Figure 1: Percentage attainment on knowledge Score for Physicians and Nurses

# Determination of vectors' reproduction spots in Makkah using GIS and remote sensing techniques

Waleed Abou El-Saoud, Safwat S. Gabr, Ibrahim H Abdel-Rahim, Essam Morsy
The Custodian of the Two Holy Mosques Institute of Hajj and Umrah Research, Umm Al-Qura University

## Abstract

The Holy City of Makkah receives millions of pilgrims every year. The natural environment in the adjacent areas of Makkah is a suitable environment for the growth of many vectors. This environment is characterized by high temperature, high humidity, and is usually located away from direct air currents, a good environment for the growth of such vectors. Recent statistics from the World Health Organization (WHO) indicate that vector-borne diseases account for 17% of all infectious diseases worldwide. The Kingdom of Saudi Arabia is exerting great efforts and developing intensive programs to control the spreading of these vectors to maintain a healthy community, mainly for pilgrims. Early detection of the growth locations of these vectors and determining their spreading patterns is very important for its control. The main aim of this study is to identify the high-risk zones of the vectors using remote sensing and GIS through modeling and analyzing the available climatic, rainfall, wind, land surface temperature (LST), normalized vegetation index (NDVI), temperature, and population density data to identify the most critical areas in Makkah for vector growth. The primary results from this study indicate that the areas with high population density, a relatively low topography, and a high surface temperature (ranges between 25-35 °C) are the most suitable areas for vectors growth and/or spreading. No significant impact of the NDVI on the presence of these vectors. The study also showed that the most susceptible areas to vectors growth in Makkah are; Al-Zhra, Hendawyiah, Khadyiah, Masfalah, Utabyiah, Hegon, and Tandbawy respectively, and some locations in Al-Awalyi & Waly El-Ahad planned districts. Accordingly, the study recommends the need to rely on satellite imagery and geographic information systems in vector control programs to identify areas vulnerable to vectors reproduction.

## 1. Introduction:

Worldwide, there are about three hundred species of mosquitoes, which transmit several infectious diseases to humans and animals. *Culex*, *Anopheles* and *Aedes* are the most common species. *Aedes albopictus* is known as Asian tiger mosquito. *Aedes agypti* is known as yellow fever mosquito and it transmit also dengue fever virus. Table 1 shows infectious diseases transmitted by various species of mosquitoes [1].

Table 1: Infectious diseases transmitted by various species of mosquitoes [1].

| **Vectors** (Mosquitoes) | **Infectious Diseases** |
|---|---|
| Anopheles | Malaria, Lymphatic filariasis |
| Culex | Lymphatic filariasis, Japanese encephalitis, Other viral diseases |
| Aedes | Yellow fever, dengue fever, dengue haemorrhagic fever, other viral diseases and Lymphatic filariasis |
| Mansonia | Lymphatic filariasis |

The female of *Aedes aegypti* (*Ae. Aegypti*) is considered the principal vector of dengue fever [2]. *Ae. aegypti* is a peridomestic mosquito which lives around human dwellings, it is active during the day time, mainly consumes human blood, and goes through a complete life cycle (from egg stage to larval and to adulthood stage). Meteorological parameters such as air temperature play a vital role in controlling the various life stages *Ae. Aegypti* [3]. The Aedes mosquitoes have four life stages: eggs, larva, pupa and adult. Mosquitoes can life and reproduce inside and outside the home. The entire life cycle, from egg to an adult, takes approximately 8-10 days. Larvae are aquatic and develop into pupae in as little as five days (Figure 1) [4].

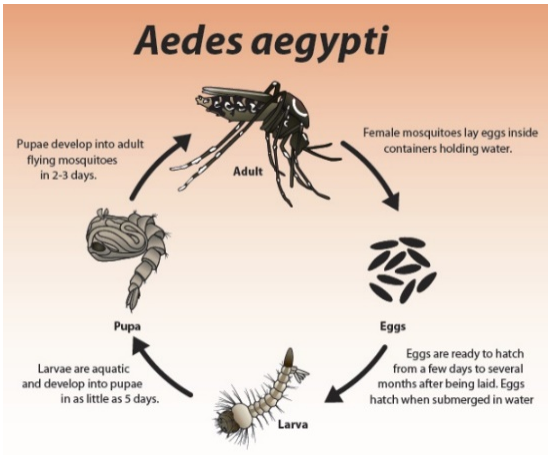



Figure 1. Life cycle of Aedes Aegypti, [4].

The close association of the vector of dengue viruses (*Ae. Aegypti*) with humans and the environment allows this mosquito species to persist in regions that may otherwise be non-suitable depending on the climatic variables alone [5]. The relationship between the *Ae. aegypti* flight performance and the temperature as well as relative humidity was studied by [6]. Generally, below 27°C, the flight performance was greater. Best flight performance was demonstrated at 21°C temperature, however the temperature ranged from 15 to 32°C at which the mosquitos were able to fly. In concerning to the relative humidity, mosquitos' flight was not affected within 30 to 90 % relative humidity range, regardless of the air temperature, except at 32°C, where 30 % relative humidity had a significant effect on mosquitos' flight. Several researchers [7] determined the development, growth, and survival of *Ae. aegypti* at several temperature levels ranging from 15 to 34$^{o}$C. The results indicated that survival of adult mosquitos was low at 15°C temperature and 3% relative humidity, better at 27°C (90%) and highest at 20 °C (92%).

Geographic information systems (GIS), global positioning systems (GPS), remote sensing, and spatial statistics are tools to analyze and integrate the spatial component in epidemiology of vector-borne disease into research, surveillance, and control programs based on a landscape ecology approach [8]. Over the past twenty-five years, the use of remote sensing techniques for mapping of the vector-borne infectious diseases has evolved significantly. Worldwide, epidemiologists are used the new remote sensing techniques to study the epidemiology of a variety of insects-borne diseases [9].

Multispectral satellite data can be used to predict arthropod-borne disease trouble spots. This is dependent on clear understandings of environmental factors that determine the presence of disease vectors [10]. Several health studies and researches have used remotely sensed data for monitoring, surveillance, or risk mapping, particularly of vector-borne diseases [11]. Vector habitats were identified and characterized through using of the association between satellite-derived environmental changes such as temperature, humidity, and land cover types and vector density [9].

In Southern Chiapas, Mexico, remote sensing was used as a landscape epidemiologic tool for identification villages at high risk for malaria transmission, as defined by adult *Anopheles albimanus* abundance [12].

In the Republic of Korea, it was suggested that the classified remotely sensed data could potentially be used to estimate the distributions of larval and adult mosquito populations [13].

In African highlands, landuse change has been hypothesized to be one of the mechanisms for malaria epidemics because it can alter the physical and chemical characteristics of mosquito breeding habitats [14].

In western Kenya highlands, it was shown that one meter spatial IKONOS images combined with computer modelling based on topographic land-cover features were useful tools for demonstration of the larval habitat of the anopheles mosquitos, which could assist to control of malaria spreading [15]. Also, In Kenya, Rift Valley fever viral activity was detected by satellite remote sensing imagery [16].

In Jeddah, Saudi Arabia, geographical information system (GIS) was applied to analyze the presence of dengue fever in various seasons of the year. It was shown that the central areas in Jeddah are the main hotspots for dengue fever; however, its intensity varied both in space and time [17].

It was shown that the Geographic Information Systems, combined with remote sensing analysis, have the potential to assist in minimizing disease risk. Examples are used from subtropical Queensland, Australia, where the salt marsh mosquito, *Aedes vigilax*, and the freshwater species, *Culex annulirostris*, are vectors of human arbovirus diseases such as Ross River and Barmah Forest virus disease. *Culex annulirostris* is also implicated in the transmission of Japanese Encephalitis. Mapping the breeding habitats of the species facilitates assessment of the risk of contracting the diseases and also assists in control of the vectors [18].

Other Researchers [19] applied the global environmental data for mapping infectious diseases distribution. Others [20] had seen great potential for the use of new technologies and approaches, such as GIS and decision support systems for the predication, prevention and control of the vector-borne and other infectious diseases.

The aim of the current study is; (1) to identify the environmental factors, which contributes to vector reproduction using Landsat 8 data analysis, (2) to correlate the extracted factors with vector occurrence pattern from the data collected from the municipality of Makkah reports (from 2013-2017), and (3) to predict potential high-risk zones for a vector reproduction.

## 2. Materials and Methods:

***2.1. Study Area***. This ecological study was conducted in the city of Makkah districts, western region of kingdom of Saudi Arabia. Makkah occupies a total area of 1200 km², 105,037 $km^2$ of which 7 million inhabitants occupies, 2016 [21]. Situated at altitudes ranging from 277 to 350 meters, Makkah is open for visitors from the entire world, particularly during the religious occasions of Hajj and Umrah. The total number of Muslims who visited the holy city of Makkah for Hajj during 2016 was 1.862.909 [21]. This mass gathering in a small spatial region during a short period of time represent a big challenge to the country.

In the current study, Landsat 8 data acquired in October 29, 2016 (after the rainfall event of October, 24) as well as the SRTM digital elevation model have been analyzed using ERDAS imaging 2016 software package. ArcGIS 10.4 is used for GIS spatial and geostatistical analysis of the data as well as map production.

***2.2. larvae vectors***. eggs foci data reported and collected in ovitraps from 2013 to 2016 were used in this study. The data was obtained from the municipality vector reporting system, which contains the address for each larva focus and ovitrap and the dates of the survey. The collected data contains larvae known to be harmful; *Aedes agypti*, *Culex antennatus*, *Culex pipiens*, *Culex quinquefasciatus*, *Culex tritaeniorhynchus*, *Culex zombaensis* and other unharmful larvae (Figure 2).

***2.3. Climatic Data***. Generally, climate of Makkah district can be described as arid weather during the year. Hajj Research Institute (HRI) has its meteorological monitoring network, which consists of eight meteorological monitoring stations are distributed allover Makkah. The data are gathered and analyzed for the 2016, to get the updated image about the weather conditions of Makkah districts. The discussed meteorological parameters for the study area can be summarized as following:

#### *2.3.1. Temperature.*

The temperature of Makkah district ranges between 14.99 to 47.66 °C all over the year, where the western and southeastern regions of Makkah is characterized by high temperature compared with the central region (Figure 3).

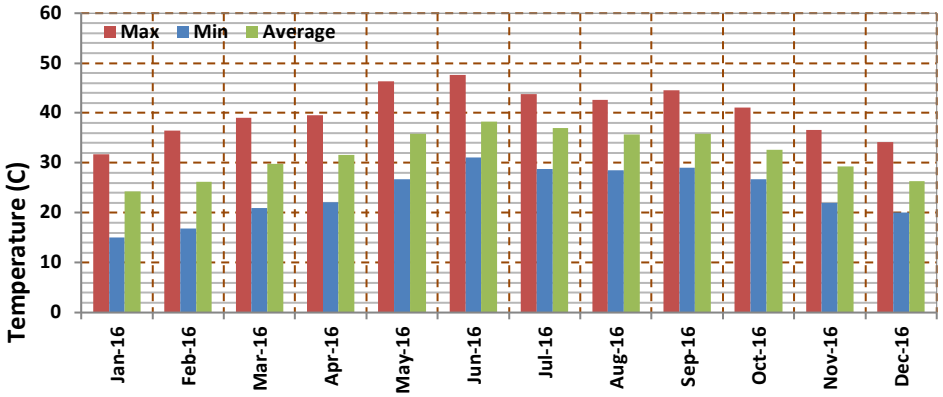



Figure 3: Average monthly variation of temperature in Makkah during 2016 (Kudy).

### *2.3.2. Relative Humidity.*

The spatial distribution of relative humidity is shown on (Figure 4), where the central region of Makkah was characterized by low relative humidity (35%) and increased gradually in the directions of eastern and western regions of Makkah. Generally, the relative humidity ranged between 35-41% allover Makkah, whereas in the month of November, the range lying between 10.34 to 75.19%.

### *2.3.3. Rainfall*

The complexity in the topography was reflected clearly on the spatial distribution of rainfall in Makkah (Figure 5), where the central region of Makkah was characterized by high rainfall compared with the north and southwest regions of Makkah. Generally, the rainfall ranged between 21.59-86.61 mm allover Makkah.

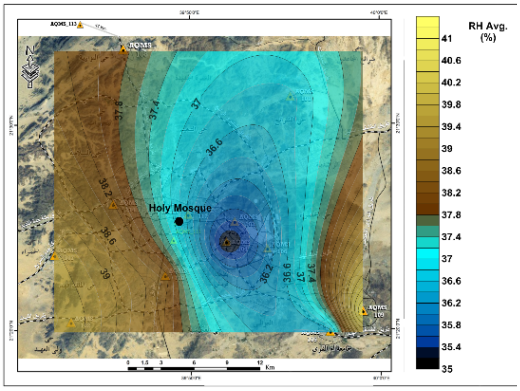



Figure 4: Contour map of relative humidity (%) in Makkah during 2016.

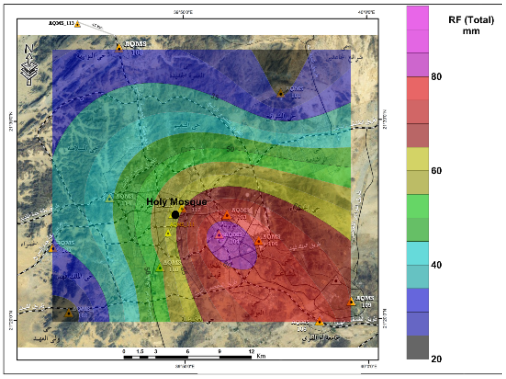



Figure 5: Contour map of rainfall (mm) in Makkah during 2016.

According to the World Health Organization (WHO) the interactions between temperature and rainfall are important as determinants in a dengue transmission, as cooler temperatures affect the survival of adult mosquitoes, thus influencing transmission rates [22]. Furthermore, rainfall and temperature may affect patterns of mosquitoes feeding and reproduction, and hence the population density of vector mosquitoes.

### *2.4. Spatial Diffusion Pattern*

All reported locations of larvae foci building and the locations of the ovitraps were geocoded using the location addresses. Spatial statistical techniques used in this study included Kernel's density in order to determine the dens and specific patterns of distribution on the study area in square kilometers.

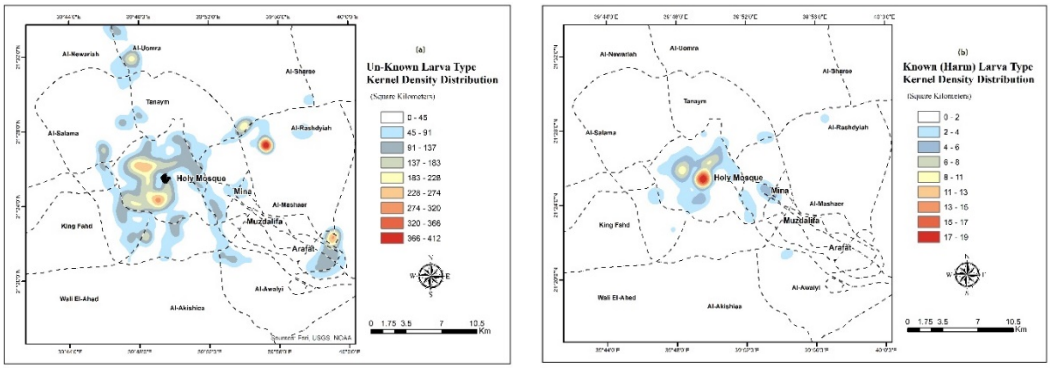



Figure 2. Spatial distribution of (a) the unharmful larva (b) the harmful larva in the study area.

### *2.5. Environmental parameters affecting Vectors' reproduction:*

The major phase of the data collection was to identify the environmental factors, which had significantly influenced the larva distribution pattern. All the environmental data was collected from remote sensing data; this technique has been tested successfully by [23]. Four environmental parameters were extracted from Landsat 8 data (landuse, NDVI of vegetated and non-vegetated areas, land surface temperature, LST) in addition to the population density.

#### *2.5.1. Image Classification (Land use / land cover map):*

Image classification is the process of assigning land cover classes to pixels, Landsat 8 Operational Land Imager (OLI) imagery of Makkah using the Maximum Likelihood Classification tools.

Six classes were established as mountains, green areas and water bodies, Urban areas, Wadis, construction areas, and open (cleared) areas. Descriptions of these land cover classes are presented in (Table 2).

Table 2: Land cover classification scheme.

| | |
|---|---|
| Mountain | Hill, large rock, rugged terrain |
| Urban Area | Residential, commercial services, industrial, mixed urban or built-up land |
| Green Area-Water Body | Trees, agriculture area, vegetated area, water body |
| Wadis | Soil types related to Wadi deposits and sand dunes |
| Construction Area | New areas undergoing planning for future development |
| Open (cleared) class | Bare soil, sandy soil, desert, open land |

### *2.5.2. Calculation of Land Surface Temperature (LST) and Normal Difference Vegetation Index (NDVI):*

Land surface temperature (LST) is defined as the temperature felt when the land surface is touched with the hands or the skin temperature of the ground [24]. As one of the most important aspects of the land surface, LST has been a main topic for developing methodologies to be measured from space. Calculating LST from remote sensed images is needed since it is an important factor controlling most physical, chemical, and biological processes of the Earth [25]. There is a growing awareness among environmental scientists that remote sensing can play a role in providing the data needed to assess ecosystems conditions and to monitor change at all special scales [26].

In the present study, the Land Surface Temperature (LST) and NDVI can be retrieved from Landsat 8 satellite image following the steps of (Figure 3), where the Thermal Infrared Sensor (TIRS) band 10 was used to estimate brightness temperature and bands 4 and 5 were used for calculating the NDVI. The metadata of the satellite images used in the algorithm is presented in (Table 3).

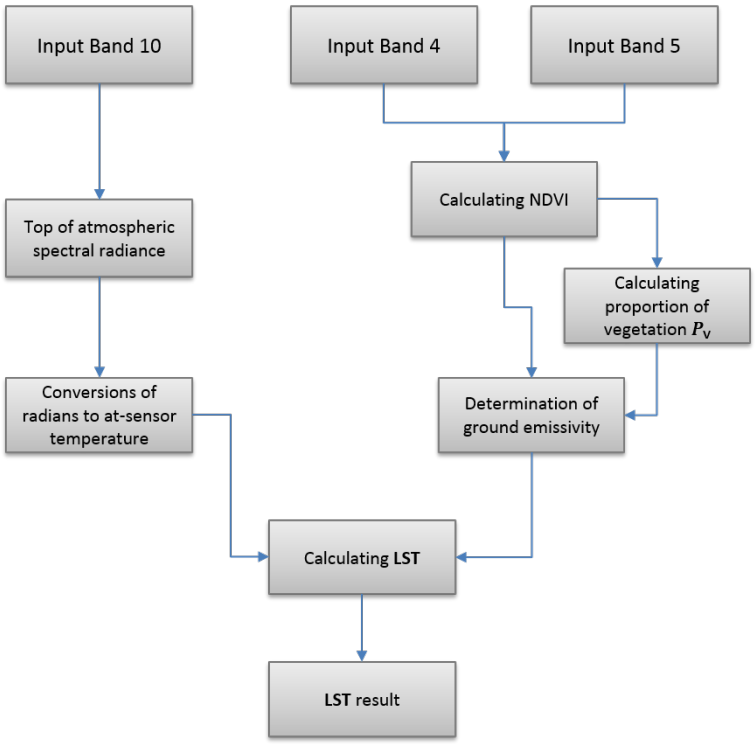



Figure 3: Flowchart for LST retrieval

Table 3: Metadata of the Landsat 8 satellite image.

| Thermal constant, Band 10 | |
|---|---|
| K1 | 774.8853 |
| K2 | 1321.0789 |
| Rescaling factor, Band 10 | |
| $M_L$ | 0.000342 |
| $A_L$ | 0.29 |
| Correction, Band 10 | |
| $O_i$ | 0.29 |

### *2.5.2.1. Top of Atmospheric Spectral Radiance:*

Landsat 8 consist of quantized and calibrated scaled Digital Numbers (DN) representing multispectral image data acquired by both the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The products are delivered in 16-bit unsigned integer format and

can be rescaled to the Top of Atmosphere (TOA) reflectance and/or radiance using radiometric rescaling coefficients provided in the product metadata file.

The first step of the algorithm is converted the TIRS bands data to the TOA spectral radiance ($L_\lambda$) using the formulas taken from the USGS webpage [27]:

$$L_\lambda = M_L * Q_{\text{cal}} + A_L$$

Where;
$L_\lambda$ = TOA spectral radiance (Watts/ (m2 * srad * μm))
$M_L$= Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
$A_L$ = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
$Q_{cal}$= Quantized and calibrated standard product pixel values (DN)

#### *2.5.2.2. Conversion of Radiance to At-Satellite Brightness Temperature:*

After the digital numbers ($DN_s$) are converted to radiance, the TIRS band data should be converted from spectral radiance to brightness temperature (BT) using the thermal constants provided in the metadata file. The following equation is used in the tool's algorithm to convert radiance to BT [27]:

$$BT = \frac{K_2}{\ln[(K_1 / L_\lambda) + 1]} - 273.15$$

Where;
BT = At-satellite brightness temperature (K)
$L_\lambda$ = TOA spectral radiance (Watts/( m2 * srad * μm))
$K_1$ = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the thermal band number)
$K_2$ = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the thermal band number)

For obtaining the results in Celsius, the radiant temperature is revised by adding the absolute zero (approx. −273.15°C) [28].

#### *2.5.2.3. Calculate the Normal Difference Vegetation Index (NDVI):*

Landsat visible and near-infrared bands were used for calculating the Normal Difference Vegetation Index (NDVI). The importance of estimating the NDVI is essential since the amount of vegetation can be used as a factor for vectors distribution. The calculation of the NDVI is important because, afterward, the proportion of the vegetation ($P_V$) should be calculated, and they are highly related with the NDVI, and emissivity ($\varepsilon$) should be calculated, which is related to the $P_V$:

$$NDVI = NIR(band\ 5) - R(band\ 4) \ / \ NIR(band\ 5) - R(band\ 4)$$

Where; NIR represents the near-infrared band (Band 5) and $R$ represents the red band (Band 4).

#### *2.5.2.4. Calculating the Proportion of Vegetation ($P_V$):*

A method for calculating $P_V$ suggests using the NDVI values for vegetation and soil ($NDVI_V$ = 0.5 and $NDVI_S$ = 0.2) to apply in global conditions [29]:

$$Pv = (NDVI - NDVIs \,/\, NDVIv - NDVIs)2$$

Where; $NDVI_S$ and $NDVI_V$ Represent the minimum and maximum values of the NDVI image, respectively, which, provided that the area is large enough, will correspond with areas with no vegetation (bare soil) and with full vegetation coverage.

#### *2.5.2.5. Calculating Land Surface Emissivity (LSE):*

The land surface emissivity (LSE ($\varepsilon$)) must be known in order to estimate LST, since the LSE is a proportionality factor that scales blackbody radiance (Planck's law) to predict emitted radiance, and it is the efficiency of transmitting thermal energy across the surface into the atmosphere [30]. The determination of the ground emissivity is calculated conditionally as suggested in [29]:

$$\varepsilon_\lambda = \varepsilon_{V\lambda} P_V + \varepsilon_{s\lambda} (1 - P_V) + C_\lambda$$

Where; $\varepsilon_V$ and $\varepsilon_s$ are the vegetation and soil emissivity respectively, and $C$ represents the surface roughness ($C$ = 0 for homogenous and flat surfaces) taken as a constant value of 0.005 [31].

When the NDVI is less than 0, it is classified as water, values between 0 and 0.2, it is considered that the land is covered with soil or rocks, values between 0.2 and 0.5 are considered mixtures of soil and vegetation cover and is applied to retrieve the emissivity. In the last case, when the NDVI value is greater than 0.5, it is considered to be covered with vegetation, and the value of 0.973 is assigned. The last step of retrieving the LST or the emissivity corrected land surface temperature $T_s$ is computed as follows [32]:

$$T_s = \frac{\mathrm{BT}}{\{1 + [(\lambda \mathrm{BT}/\rho) \ln \varepsilon_\lambda]\}},$$

Where; $T_s$ is the LST in Celsius (◦C, (2)), BT is at-sensor BT (◦C), $\lambda$ is the wavelength of emitted radiance (for which the peak response and the average of the limiting wavelength ($\lambda$ = 10.895) [15] will be used), $\varepsilon_\lambda$ is the emissivity calculated, and

$$\rho = h\frac{c}{\sigma} = 1.438 \times 10^{-2}\ \mathrm{m\ K},$$

Where; $\sigma$ is the Boltzmann constant ($1.38 \times 10^{-23}$ J/K), $h$ is Planck's constant ($6.626 \times 10^{-34}$ J s), and $c$ is the velocity of light ($2.998 \times 10^{8}$ m/s) [33].

### *2.5.3 Population Density:*

Population density in any urban area is another factor that has to be taken into account in preventing an outbreak of diseases. The data of population density for Makkah districts have been collected from the database of Makkah Region Development Authority and The Census data of the General Authority for Statistics (2010). In our study, we removed the mountainous areas from our calculation to better calculate the actual locations for population density. These locations have their own unique characteristics that are easily identifiable and can be located visually. Population data was also used to verify the result. A densely populated area stands a higher chance of experiencing a disease even if the mosquito house index in that area is low. This is because mosquitoes do not have to travel far to search for its victims. Therefore, an outbreak of infectious diseases can and will be able to spread rapidly in such an area.

## 3. Results and discussion:

This study found that areas at a high risk for vectors reproduction could be identified through the integration of environmental factors derived from remote sensing with other data from GIS analysis and modeling. The weighted overlay function was chosen to create the risk area map. The following sections provide a detailed analysis of the impact of each variable:

### *3.1. Land cover and land use classification*

The land cover and land use information of Makkah districts obtained from the Landsat 8 image is highlighted in Figure 4. From the classification result, it was found that most larvae location found in urban areas, followed by horticulture areas especially at Arafat area. Just a few locations were reported in the construction areas. The reason why mosquito larvae location found mostly in urban areas can be explained by a number of factors. For an urban area, proper infrastructure such as a good drainage system is very important. A poor drainage system will create pools of stagnant water, which are suitable breeding grounds for mosquitoes. The same problem occurs in construction areas. In areas with a high population density, vector disease transmission can and will occur rapidly. Other areas that also have a record of larvae are areas that are not cleanly maintained, areas that have been left idle, areas with rapid development and areas having temporary structures.

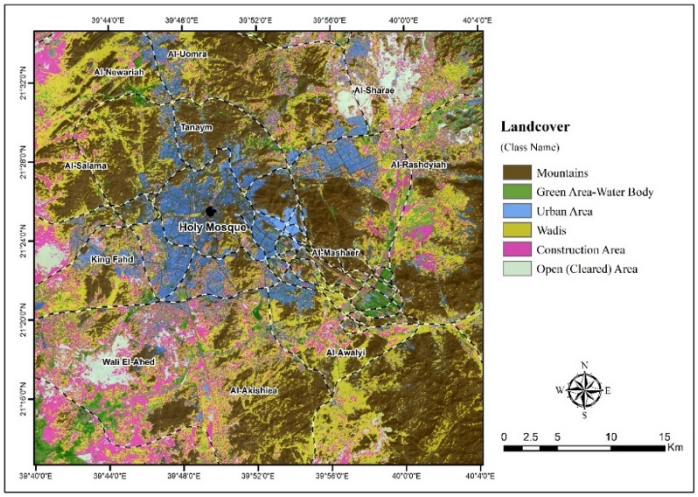



Figure 4. Unsupervised classification of the study area.

### *3.2. Land surface temperature (LST)*

The temperature profile of the land surface over the study area is shown on the LST map in (Figure 5) which was derived from the Landsat-8 thermal infrared (TIRS) band. The areas with high levels of LST (in red) can be correlated to Wadies and construction areas, while the blue area equate to either an urban area or a vegetated area. The LST map shows that the temperature ranges from 23°C to 45.82°C. Most of the reported mosquito larvae occurred in the areas with a temperature range from between 25.0°C to 35.0°C. This temperature range is very conducive to the mosquito breeding cycle as an increase in the number of times that the mosquito breeds will also increase the likelihood of the emergence of the diseases outbreak.

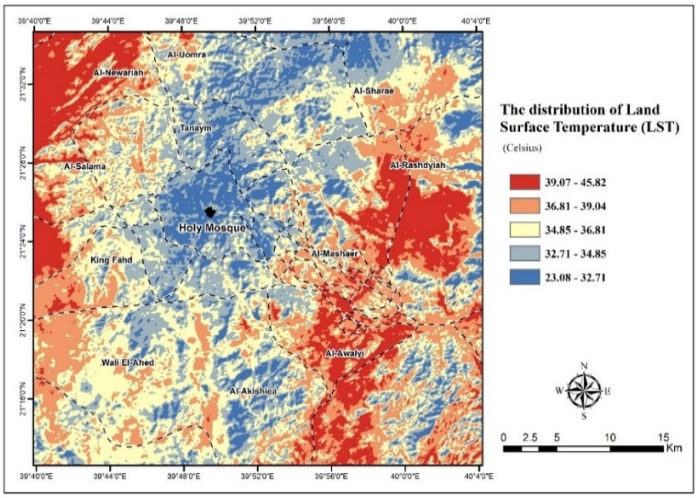



Figure 5. The distribution of Land Surface Temperature from Landsat 8 satellite image.

### *3.3. Normalised Difference Vegetation Index (NDVI):*

NDVI is usually used to derive the vegetation index from satellite images. For this study, it was used to identify the green areas over the study area, in which; NDVI values range from −1 to +1, where negative values correspond to an absence of vegetation [34]. Figure 6 shows that the range of NDVI values in the study area is between -0.101 and 0.457. Built-up areas and other land use class are shown in white, while the dark colored (black) areas refer to the vegetation density of an area. This study found that the vegetation density of an area was not a major factor in influencing the number of mosquito larvae occurred.

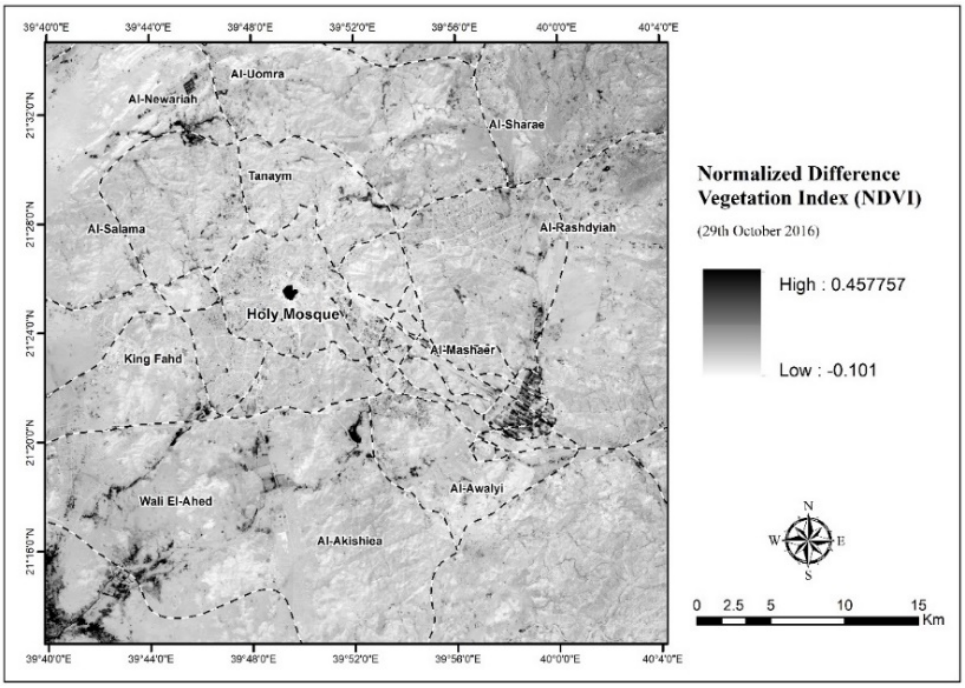



Figure 6. NDVI image of Makkah districts on 29th October 2016.

### *3.4. Population Density:*

Using the data collected from Makkah Region Development Authority and The Census data of the General Authority for Statistics (2010), and by excluding the mountainous regions, the population density for each of Makkah districts can be summarized in (Figure 7). This figure show that most of the high density districts are located close to the Haram area. Al-Zahra, Hindawia, Khalidiya, Masfalah, Hujun, Otaibia, Khansa, Mabda, Al-Gamia, Al-Adel and Aziziah respectively.

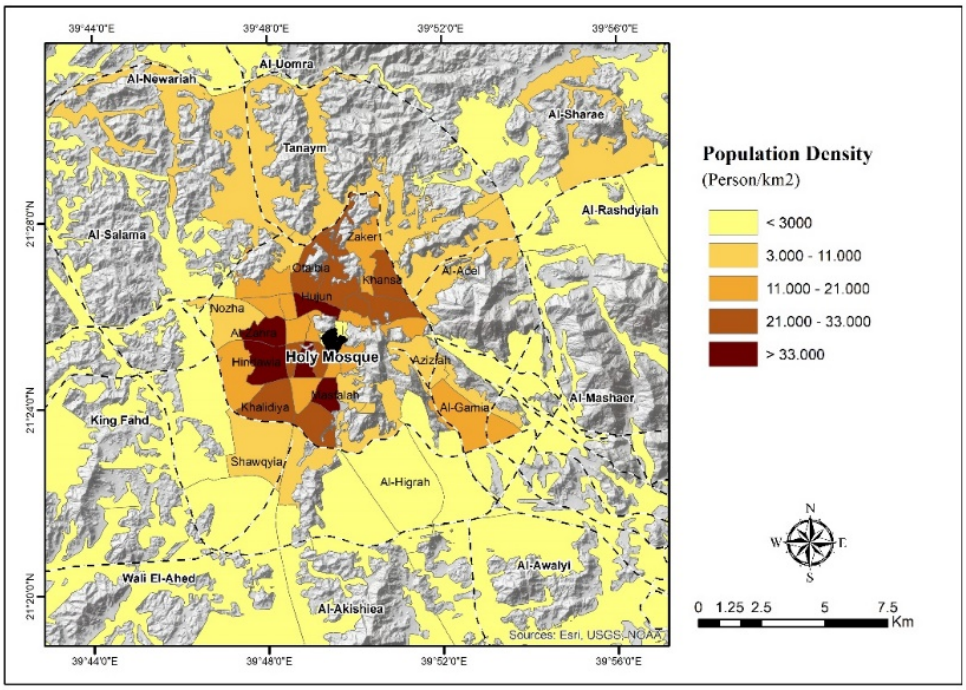



Figure 7. Population density map of Makkah district.

### *Identification of Vectors' Propagation Risk Areas in Makkah districts*

Each of the four variables was tested using the weighted overlay function technique in the ArcGIS software. This technique is usually used for applying a common measurement scale of values to diverse and dissimilar inputs in order to create an integrated analysis in (Figure 8). The priority value was ranked as low, medium and high (1 to 3) for each variable. A low value means the sub variable had a low intensity influence; a medium value equated to a greater risk influence to the spreading and a high value equated to a very significant influence on the vectors spreading pattern. The detailed weighting values for all four environmental variables that were identified as an indicator factor of vectors spreading are presented in (Table 4). For the information obtained, the following algorithm was used to develop the vectors spreading zone from each environmental indicator as shown below.

*(Land cover) + (Population Density) + (NDVI) + (LST)*

Identification of areas with a high risk of having a disease outbreak requires the input of the above stated parameters for this analysis. The analysis results of the parameters were then given a specific priority value based on the requirements of this study. The priority values were ranked as 'low', 'medium" and 'high'. The contribution of these values in every spatial

layer were given a value between 1 (low) to 3 (high), where a value of 1 means a very low contribution while a value of 3 means a high contribution to a disease outbreak. Areas with the highest score can then be identified as being areas with a very high risk of having a disease outbreak.

The potentially high-risk areas for the occurrence of a disease incidences over the study area are shown in (Figure 9), which is concentrated mainly within; Al-Zhra, Al-Hendawyiah, Al-Khadyiah, Al-Masfalah, Al-Utabyiah, Al-Hegon, Al-Tandbawy, Al-Maabd, Al-Andlus and some locations in Al-Awalyi & Waly El-Ahad planned districts. Reported larva data obtained from the municipality vector reporting system was used to verify the above result.

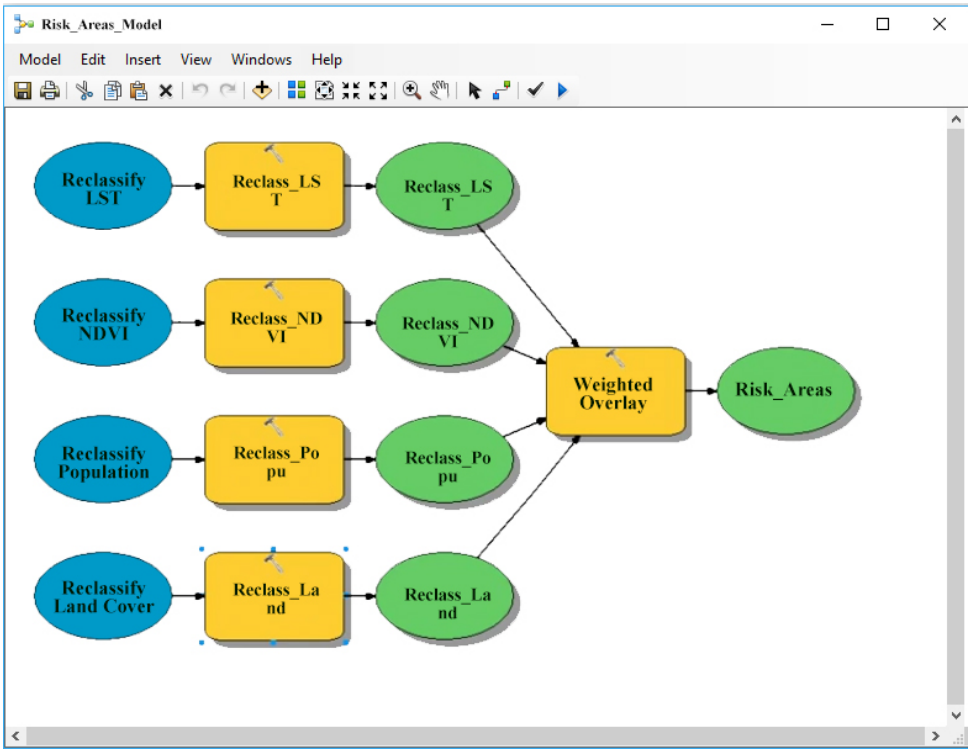



Figure 8. A model workflow for locating of the areas which are likely to be affected by vector reproduction.

Table 4. The weighted overlay value for environmental risk indicator.

| No. | Environmental Factors | | Risk Value |
|---|---|---|---|
| | Raster | Field | |
| 1 | Land Cover | Mountain | 1 |
| | | Green Area-Water Body | 2 |
| | | Urban Area | 3 |
| | | Wadis | 1 |
| | | Construction Area | 3 |
| | | Open (Cleared) Area | 1 |
| 2 | NDVI | Vegetation area | 2 |
| | | Non-vegetation area | 1 |
| 3 | LST | Low | 3 |
| | | Medium | 2 |
| | | High | 1 |
| 4 | Population density | Very low | 1 |
| | | Low | 1 |
| | | Medium | 2 |
| | | High | 3 |
| | | Very high | 3 |

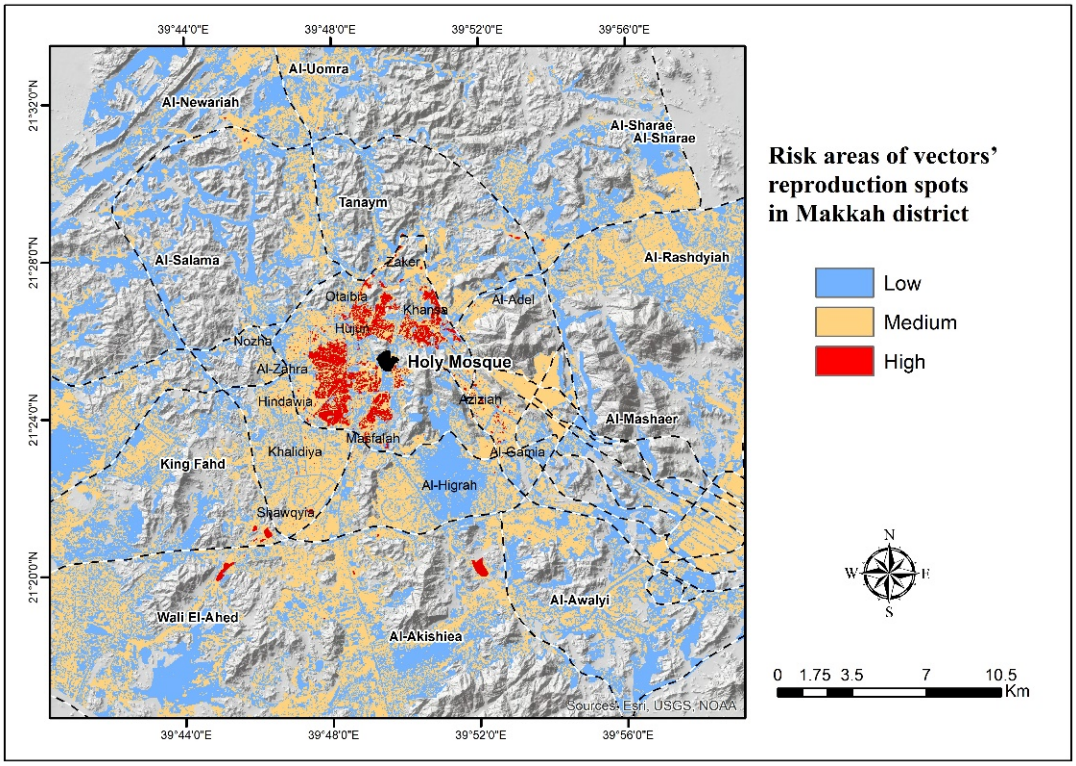



Figure 9. Risk areas of vectors' reproduction in Makkah districts.

## 4. Conclusions

Remote sensing satellite data such as Landsat 8 is capable of providing information on the environmental factors: land cover/use, land surface temperature (LST), NDVI and topography, which are influential to a vectors' reproduction. The high-risk areas for a larva occurrence are significantly correlated with environmental factors obtained from remote sensing data, which are then integrated with rainfall, temperature, humidity and population density data. The present study showed the main factors suitable for larva locations. These locations are mostly of densely population, near construction sites, have a low land topographically with surrounding high values of land surface temperature (LST). Such areas represent an ideal habitat area types may affect by epidemic outbreak after days of heavy rainfall followed by high temperature. Results from this research indicate that the identified 'high risk' areas are located within Al-Zhra, Al-Hendawyiah, Al-Khadyiah, Al-Masfalah, Al-Utabyiah, Al-Hegon, Al-Tandbawy, Al-Maabd, Al-Andlus and some locations in Al-Awalyi & Waly El-Ahad planned districts. The result also shows a strong correlation between locations of reported harm locations with the potential high-risk area map, which was created based on environmental factors used to identify the risk areas. Remote sensing and GIS technologies are important tools for the effective surveillance and prediction of the vector born disease in order to reduce the number of outbreak cases. GIS analysis has the ability to model a risk map of vector born disease distribution through the use of the weighted overlay function, which enabled the users to easily identify high risk areas in a short time period. Results from this study indicate that both remote sensing and GIS data analysis is potential for various applications oriented towards improving the monitoring and control of potential future vector born disease outbreaks.

## 5. Recommendation

In the current study we highly recommend the use of remote sensing data (e.g. Landsat 8) in the standard procedures of vector control since it has proven to be able to determine the environmental factors and conditions controlling the reproduction and growth of such vectors. Our results can be useful for public health professionals responsible for vector control in Makkah region since the city if vulnerable to be affected by infectious diseases, which can be easily transmitted through such vectors during the Hajj and Umrah seasons.

## 5. References:


[1]. World health organization (WHO) (2006): Mosquitos and other biting Diptera. Available from: http://www.who.int/water_sanitation_health/resources/vector007to28.pdf (Last accessed on 2018 Feb 5).

[2]. Hopp, M.J. and Foley, J.A., 2001. Global-scale relationships between climate and the dengue fever vector, *Aedes aegypti*. Clim Change 48: 441-463.

[3]. Bliss, A.R. and Gill, J.M., 1993. The effects of freezing on the larvae of Aedes aegypti. Amer J Trop Med Hyg 13: 583-588.

[4]. Center for Disease Control (CDC): Mosquito Life cycle (Aedes aegypti). Available at: https://www.cdc.gov/dengue/resources/factSheets/MosquitoLifecycleFINAL.pdf.

[5]. J ansen, C.C., Beebe, N.W., 2010. The dengue vector *Aedes aegypti*: what comes next. Microbes Infect. 12, 272–279.

[6]. Rowley, W.A., Graham, C.L., 1968. The effect of temperature and relative humidityon the flight performance of female *Aedes aegypti*. J. Insect Physiol. 14,1251–1257.

[7]. Rueda, L.M., Patel, K.J., Axtell, R.C., Stinner, R.E., 1990. Temperature-dependent development and survival rates of *Culex quinquefasciatus* and *Aedes aegypti* (Diptera: Culicidae). J. Med. Entomol. 27, 892–898.

[8]. Kitron U. (1998): Landscape ecology and epidemiology of vector-borne diseases: tools for spatial analysis. J Med Entomol.; 35(4):435-45.

[9]. Kalluri S, Gilruth P, Rogers D, Szczur M (2007): Surveillance of arthropod vector-borne infectious diseases using remote sensing techniques: a review- PLoS pathogens, (3) 10, 1361-1371.

[10]. Roberts DR, Paris JF, Manguin S, Harbach RE, Woodruff R, Rejmankova E, Polanco J, Wullschleger B, Legters LJ. (1996): Predictions of malaria vector distribution in Belize based on multispectral satellite data. Am J Trop Med Hyg.; 54(3):304-8.

[11]. Beck LR, Lobitz BM, Wood BL (2000): Remote sensing and human health: new sensors and new opportunities. Emerging infectious diseases, 6 (3), 217-227.

[12]. Beck LR, Rodriguez MH, Dister SW, Rodriguez AD, Rejmankova E, Ulloa A, Meza RA, Roberts DR, Paris JF, Spanner MA, et al. (1994): Remote sensing as a landscape epidemiologic tool to identify villages at high risk for malaria transmission. Am J Trop Med Hyg.; 51(3):271-80.

[13]. Sithiprasasna R, Lee WJ., Ugsang DM. and Linthicum K. (2005): Identification and characterization of larval and adult anopheline mosquito habitats in the Republic of Korea: potential use of remotely sensed data to estimate mosquito distributions. International Journal of Health geographics, 4-17

[14]. Tuno N, Okeka W, Minakawa N, Takagi M, Yan G (2005): Survivorship of Anopheles gambiae sensu stricto (Diptera: Culicidae) larvae in western Kenya highland forest. J Med Entomol.; 42(3):270-277.

[15]. Mushinzimana, Emmanuel; Munga, Stephen; Minakawa, Noboru; Li, Li; Feng, Chen-chieh; Bian, Ling; Kitron, Uriel; Schmidt, Cindy; Beck, Louisa; Zhou, Guofa; Githeko, Andrew K; Yan, Guiyun (2006): Landscape determinants and remote sensing of anopheline mosquito larval habitats in the western Kenya highlands. Malaria Journal,5:13. doi:10.1186/1475-2875-5-13

[16]. Linthicum KJ, Bailey CL, Davies FG, Tucker CJ. (1987): Detection of Rift Valley fever viral activity in Kenya by satellite remote sensing imagery. Science.; 235(4796):1656-1659.

[17]. Al-Ghamdi, K., Khan M.A., & Mahyoub, J., 2009. Role of climatic factors in the seasonal abundance of Aedes aegypti L. and dengue fever cases in Jeddah province of Saudi Arabia. Curr. World Environ. 4, 307–312.

[18]. Dale PE, Ritchie SA, Territo BM, Morris CD, Muhar A, Kay BH. (1008): An overview of remote sensing and GIS for surveillance of mosquito vector habitats and risk assessment. J Vector Ecol.; 23(1):54-61.

[19]. Hay SI, Tatem AJ, Graham AJ, Goetz SJ (2006): Global environmental data for mapping infectious disease distribution. Advances in Parasitology. 62, 37-77.

[20]. Eisen L and Eisen RJ (2011): Using Geographic Information Systems and Decision Support Systems for the Prediction, Prevention, and Control of Vector-Borne Diseases. Annual Review of Entomology, Vol. 56:41-61

[21]. General Authority for Statistics in Saudi Arabia 2017, Available online at: https://www.stats.gov.sa/en

[22]. WHO. Dengue: guidelines for diagnosis, treatment, prevention and control. Geneva 2009. Available from: http://www.who.int/tdr/publications/documents/dengue-diagnosis.pdf

[23]. S. J. Connor, M. C. Thomson, P. J. Milligan, and S. P. Flasse. 1996. “The ecology of malaria as seen from Erth observation satellites. Annals of Tropical Medicine and Parasitology 90(3): 243-264.

[24]. A. Rajeshwari and N. Mani, “Estimation of land surface temperature of dindigul district using landsat 8 data,” International Journal of Research in Engineering and Technology, vol. 3, no. 5, pp. 122–126, 2014.

[25]. F. Becker and Z.-L. Li, “Towards a local split window method over land surfaces,” International Journal of Remote Sensing, vol. 11, no. 3, pp. 369–393, 1990.

[26]. S. Ustin, Manual of Remote Sensing: Remote Sensing for Natural Resource Management and Environmental Monitoring, John Wiley & Sons, Hoboken, NJ, USA, 2004.

[27]. Using the USGS Landsat 8 Product, Available from: https://landsat.usgs.gov/using-usgs-landsat-8-product (Last accessed on 2018 Jan12).

[28]. H.-Q. Xu and B.-Q. Chen, “Remote sensing of the urban heat island and its changes in Xiamen City of SE China,” Journal of Environmental Sciences, vol. 16, no. 2, pp. 276–281, 2004.

[29]. J. A. Sobrino, J. C. Jiménez-Muñoz, and L. Paolini, “Land surface temperature retrieval from LANDSAT TM 5,” Remote Sensing of Environment, vol. 90, no. 4, pp. 434–440, 2004.

[30]. J. C. Jimenez-Munoz, J. A. Sobrino, A. Gillespie, D. Sabol, and W. T. Gustafson, “Improved land surface emissivities over agricultural areas using ASTER NDVI,” Remote Sensing of Environment, vol. 103, no. 4, pp. 474–487, 2006.

[31]. M. Stathopoulou and C. Cartalis, “Daytime urban heat islands from Landsat ETM+ and Corine land cover data: an application to major cities in Greece,” Solar Energy, vol. 81, no. 3, pp. 358–368, 2007. View at Publisher ·

[32]. M. Stathopoulou and C. Cartalis, “Daytime urban heat islands from Landsat ETM+ and Corine land cover data: an application to major cities in Greece,” Solar Energy, vol. 81, no. 3, pp. 358–368, 2007.

[33]. Q. H. Weng, D. S. Lu, and J. Schubring, “Estimation of land surface temperature-vegetation abundance relationship for urban heat island studies,” Remote Sensing of Environment, vol. 89, no. 4, pp. 467–483, 2004.

[34]. (Pettorelli et al., 2005): Pettorelli, N., Vik, J.O., Mysterud, A., Gaillard, J.M., Tucker, C. J. & Stenseth, N.C., (2005), Using the satellite-derived NDVI to assess ecological responses to environmental change, Trends in ecology & evolution,20(9), pp. 503-510.

# Pilgrims attitude and believes towards medications use during Hajj 2013

Abdul Haseeb[1], Hani Saleh Faidah[2], Mahmoud Essamuddin Elrajjal[1]
1-College of Pharmacy, 2- Faculty of Medicine, Umm Al-Qura University

## Abstract

Millions of Muslims are visiting Makkah, Saudi Arabia, on yearly basis to perform religious pilgrimage known as Hajj. They come from various nations and belong to many ethnic subgroups. Most of them bring their medications with them from their countries to use them accordingly. Inappropriate use and handling of their drugs can result in exacerbation of their disorders and can lead to severe outcomes. To date, there is no study exploring pilgrim's attitude regarding quality use of medicines during Hajj. This study seeks to explore current knowledge and attitudes of pilgrims from South Asian nationalities about medications use and handling during Hajj. This cross-sectional study was carried out by South Asian pilgrims attending outpatient settings of respective Hajj mission hospitals and emergency settings around Masjid Al Haram, Makkah, Saudi Arabia. Among total of 601 respondents 55 % were females and 45 % were males. Majority of interviewees (63 %) were from Pakistan, India (18%), and Bangladesh (12 %) respectively. Majority of them visited emergency care for acute hypertension (49 %), Ischemic heart diseases (38 %), uncontrolled diabetes Mellitus (34 %) and asthma (11 %). Cough was the most common symptom among patients (77 %). We found that the majority of the patients (97 %) received their medications from Hajj mission due to the ease in a communication process. Only 14 % of the respondents were satisfied with the community pharmacy services and claimed language barrier in communication. Interestingly 87 % of the pilgrims claimed that they share medications during the Hajj days. This can serve as baseline data and provide further insight into planning and development of pilgrim's health education.

## Introduction :

Millions of Muslims used to visit Makkah, Saudi Arabia, on yearly basis to perform religious pilgrimage known as the Hajj(1). They come from various nations and belong to many ethnic subgroups(2, 3). Most of them bring their medications with them from their countries and or obtain medications from surrounding medical centres or pharmacies accordingly(4, 5). Inappropriate use and handling of their drugs can result in exacerbation of their disorders and can lead to severe outcomes. There are few studies explaining poor level of knowledge among pilgrims towards common health conditions and their prevention measures which necessitate to study their attitude towards medication use for common illnesses during Hajj and pilgrimage(6-8).Based on assumption of language variation and different knowledge level of pilgrims, there is strong need to have patients information leaflets in different languages to guide them about judicial use of medications during their stay in Hajj (9).

To date, there is no study exploring pilgrim's attitude regarding quality use medicines during Hajj. Therefore, we studied common medication use among pilgrims and their common source during Hajj. In addition, pilgrims' satisfaction level towards pharmaceutical services offered by hajj mission hospitals, Ministry of Health medical centres and community pharmacies nearby pilgrims accommodations.

## Research aims:

This study aims to explore current knowledge and attitudes of pilgrims from South Asian nationalities about medications use and handling during Hajj.

## Research Methodology:

**Study Design & Settings:** In order to formally investigate this issue, we conducted a cross-sectional study of South Asian origin pilgrims during the 2013 Hajj season. Pilgrims were asked to complete a structured anonymous questionnaire on their views towards antibiotics use. South Asian pilgrims attending outpatient settings of Pakistani Hajj mission hospital and emergency settings around the Grand Mosque (Masjid Al Haram) of Makkah Saudi Arabia.

**Sample Size:** Based on the 95% confidence interval, a response distribution of 50% and a 5% margin of error, 601 participants were targeted for the study based on calculation by Roasoft ® sample size calculator (10). Patients were approached conveniently to be included in the current study.

**Ethical approval:** This study was initially approved by Ajyad Emergency Hospital. Later it was approved by Directorate General Health of Makkah Region by approval number M47/300/32512. In addition, study was approved by Pakistan Hajj Mission Hospital, Al – Azziziya Main office to access patients in Pakistan Hajj mission hospital.

## Results and discussion:

A total of N=601 responses were collected for quality use of medications by pilgrims during Hajj. The majority of the respondents (55.4%) were females. Majority of the respondents (28.6%) were from age group 45-54 Years, followed by (24.5 %) of age group 55-64 Years. Among the participated respondents, Pakistani were highest (63.3%), followed by Indian (18.6%) and Bengali (12.4%).Most of the respondent (34.3%) education status was secondary school and (28.1%) primary school. Urdu language was the most proficient language among the respondents with 81.2% had full command while 10.3% reported little command, while English was the second proficient language with (12.5%) full command and (14.8%) little command on English. However, other languages reported had no marked proficiency like Bengali, Afghani and Arabic. About (50.1%) reported had accompanied with family to perform Hajj and about economic status while brought were SR 2001 – 3000 (535 - 802 $) among (30.8%); shown in table 1 .

The pattern of medicine use results by chi-square test, the results indicates that respondents (54.9%) were currently using medication for chronic diseases and shows statistically significant association between age and education status. About general use of medicine analgesics were highly consumed (88.4%) and have statistically significant association with age and education status, however antihypertensive drugs were second most used medicine (48.9%) having significant association age and education status. Regarding specific medication use Azithromycin is mostly use (76.7%) by respondents showing statistically significant association with age and education status, while β-blockers, warfarin and Primolut N has showed significant association with age, gender and education status shown in table 3 .

The access to medicine results by chi-square test, the results indicate that respondents first point in order to consult for health problem appeared to be statistically associated with gender and educational status respectively. This showed that there was an association of gender as well as education status with consulting nearby medical center, consulting private clinic nearby participant's accommodation, consulting pharmacist at pharmacy outlet,

consulting a friend in group to take his/her medications, and self-medication. The results also revealed that participants usually obtained medicines from private medical centers and it appeared to be statistically associated with educational status but not with gender. In the same way, results revealed that apart from private medical centers, there was no statistically significant association of other places, from where medicines could be bought with educational status or gender respectively. Over all, the results showed that there were significant differences by gender and education status, respectively, when the participants endorsed other places to show how participants usually obtained medicines shown in table 4.

Evaluation of patient's perception and awareness on the use of medicines toward Perception towards medicine labelling results reveals that (16.6%) reported of having adequate information given on label having statistically significant association with gender and education status respectively and (54.2%) read information on label before using medicine. Trouble reading labels for medicines supplied from government hospitals, medical centers of my country Hajj mission, private medical centers/clinics and community pharmacy reported high (53.6%) in government hospital having significant association with education status, however; community pharmacy reported low (22%) and having statistically significant with gender and education status. Regarding satisfied with the information written on the labels given by government hospitals, medical centers of my country Hajj mission, private medical centers/clinics and community pharmacy; (41.8%) responded having satisfied with the information written on the labels from government hospital. Awareness toward appropriate

use of medicines, (64.2%) responded about aware that all medicines have expiry date. About the correct way of medicines storage (38.6%) respond of knowing it shown in table 5. The linear regression results revealed that gender have no significant association having (OR 0.025 CI -0.078 - 0.147) understanding the proper use of your medicines in term of dose, frequency, method of administration, side effect monitoring and interaction while education level also have no significant association having (OR -0.277 CI -0.101–0.002) shown in table 5 .

The assessment of medicine information resources results by chi-square test, the results indicate that respondent's first person to consult for medicine information appeared to be statistically associated with education status but not gender. This also showed that there was an association of education status with doctor, pharmacist, nurse, medical assistant,

friend in group, family member shown in table 6. Responses regarding easy to obtain medicine information from government hospital doctor (76.9%) responded to it, while (73.4%) responded to country Hajj mission doctors/medical staff for easy to obtain medicine information and is statistically associated with education level shown in table6 .

About medicines information obtained from media/printed materials (magazines, newspapers), internet, common information and entertainment channels (TV, radio), modern healthcare professionals (doctors, pharmacists, nurses), traditional and complimentary practitioners (Hakim, etc.), friends, family and neighbors. About (47.4%) reported of never obtained medicine information from media/printed materials (magazines, newspapers), similarly about (48.8%) never form common information and entertainment channels (TV, radio). The linear regression analysis revealed that gender was not associated while education status was associated with Media / Printed materials like magazines and newspapers (OR -0.081 CI -0.561– -0.044) and common information and entertainment channels like TV, radio (OR 0.081 CI 0.003–0.559) shown in table 7.

## Summary:

This can serve as baseline data and provide further insight into planning and development of pilgrim's health education

## Recommendations:

This study has highlighted the substantial misuse of medications in pilgrims of South Asian-origin. The Saudi authorities should consider issuing directives to relevant embassies with a view to discouraging pilgrims from bringing their own supplies of medications. Furthermore, the leaders of pilgrim caravans should be trained to educate the pilgrims to seek appropriate medical care in the context of suspected infection and self-care and to avoid self-directed use of all medications.

## Reference:

1.Forde AM. The Hajj. Influenza Other Respir Viruses. 2012;6(6): e72-3.

2.Baharoon S, Al-Jahdali H, Al Hashmi J, Memish ZA, Ahmed QA. Severe sepsis and septic shock at the Hajj: etiologies and outcomes. Travel Med Infect Dis. 2009;7(4):247-52.

3.Deris ZZ, Hasan H, Sulaiman SA, Wahab MS, Naing NN, Othman NH. Preference of treatment facilities among Malaysian Hajj pilgrims for acute respiratory symptoms. Saudi Med J. 2009;30(8):1103-4.

4.Azeem M, Tashani M, Barasheed O, Heron L, A Hill-Cawthorne G, Haworth E, et al. Knowledge, attitude and practice (KAP) survey concerning antimicrobial use among Australian Hajj pilgrims. Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders). 2014;14(2):125-32.

5.Alzahrani AG, Choudhry AJ, Al Mazroa MA, Turkistani AH, Nouman GS, Memish ZA. Pattern of diseases among visitors to Mina health centers during the Hajj season, 1429 H (2008 G). J Infect Public Health. 2012;5(1):22-34.

6.Sahin MK, Aker S, Tuncel EK. Knowledge, attitudes and practices concerning Middle East respiratory syndrome among Umrah and Hajj pilgrims in Samsun, Turkey, 2015. Eurosurveillance. 2015;20(38).

7.Gautret P, Benkouiten S, Salaheddine I, Belhouchat K, Drali T, Parola P, et al. Hajj pilgrims' knowledge about Middle East respiratory syndrome coronavirus, August to September 2013. Eurosurveillance. 2013;18(41):20604.

8.Gautret P. Middle East Respiratory Syndrome (MERS) coronavirus. What travel health advice should be given to Hajj pilgrims? Travel Med Infect Dis. 2013;11(5):263-5.

9.Greenhalgh T. Time for patient leaflets on the Hajj. BMJ. 2011;343: d6609.

10.Raosoft I. Sample size calculator. Available from: ww raosoft com/samplesize. 2004.

Table 1: Demographic characteristic of pilgrims N=601

| **Demographics** | **N (%)** |
|---|---|
| **Gender** | |
| Male | 268 (44.6) |
| Female | 333 (55.4) |
| **Age** | |
| 18-24 Years | 38 (6.3) |
| 25-34 Years | 57 (9.5) |
| 35-44 Years | 104 (17.3) |
| 45-54 Years | 172 (28.6) |
| 55-64 Years | 147 (24.5) |
| >65 Years | 83 (13.8) |
| **Nationality** | |
| Pakistani | 381 (63.3) |
| Indian | 112 (18.6) |
| Bengali | 75 (12.4) |
| Afghani | 4 (0.7) |
| Egyptian | 4 (0.7) |
| Indonesian | 3 (0.4) |
| Nigerian | 2 (0.3) |
| UAE | 2 (0.3) |
| Morocon | 2 (0.3) |
| Chinese | 2 (0.3) |
| Malaysian | 1 (0.2) |
| Saudi | 1 (0.2) |
| Others | 12 (2.0) |
| **Education level** | |

| | |
|---|---|
| Primary school | 169 (28.1) |
| Secondary school | 206 (34.3) |
| College/University | 107 (17.8) |
| No formal education | 119 (19.8) |
| **Language proficiency** | |
| ***Urdu*** | |
| Full command | 488 (81.2) |
| Little command | 62 (10.3) |
| ***English*** | |
| Full command | 75 (12.5) |
| Little command | 89 (14.8) |
| ***Bengali*** | |
| Full command | 65 (10.5) |
| Little command | 5 (0.8) |
| ***Arabic*** | |
| Full command | 15 (2.5) |
| Little command | 13 (2.2) |
| ***Afghani*** | |
| Full command | 29 (4.8) |
| Little command | 9 (1.5) |
| **Living status** (Coming along) for Hajj | |
| Alone | 33 (5.5) |
| With family | 301 (50.1) |
| With group | 267 (44.4) |
| **Economic Status** (Money brings for Hajj) | |
| SR 1000 & Below (260 $ & Below) | 25 (4.2) |
| SR 1001 – SR 2000 (267 $ - 534 $) | 172 (28.6) |
| SR 2001 – SR 3000 (535 $ - 802 $) | 185 (30.8) |
| SR 3001 – SR 4000 (803 $ - 1069 $) | 119 (19.8) |
| SR 4001 & Above (1069 $ - above) | 100 (16.6) |

Table 2: Pattern of diseases by respondents

| **Disease** | **N (%)** |
|---|---|
| Hypertension | 291 (48.4) |
| Heart diseases (MI, Angina etc.) | 242 (40.2) |
| Hyperlipidemia | 127 (12.1) |
| Diabetes Mellitus | 202 (33.6) |
| Respiratory diseases (Asthma, COPD) | 84 (14) |
| Thyroid disorder | 7 (1.2) |
| Peptic ulcer | 21 (3.5) |
| Hepatitis B | 8 (1.3) |
| HIV/AIDS | 0 (0) |
| Cough | 461 (76.7) |
| Diarrhea (Before Arrival) | 32 (5.3) |
| Nausea & Vomiting | 47 (7.8) |
| Diarrhea (After Arrival) | 133 (22.1) |
| Kidney disease/problems | 3 (0.5) |
| Fever | 33 (5.5) |
| Shoulder pain | 2 (0.3) |
| Stomach pain | 2 (0.3) |
| Arthritis surgery | 2 (0.3) |
| Chest infection | 2 (0.3) |
| Throat infection | 2 (0.3) |
| Fracture in hand | 2 (0.3) |
| Gas problem | 2 (0.3) |

| | |
|---|---|
| Pulmonary embolism | 2 (0.3) |
| Uric acid | 2 (0.3) |

** Chi-square test, ** Fisher exact Test, † statistically significant p<0.05*

Table 3: Pattern of medicine use responses by respondents

| **Statement** | **N (%)** | **Age** | **Gender** ($\chi^2$) | **Education level** ($\chi^2$) |
|---|---|---|---|---|
| Currently taking any medicine for chronic diseases | 330 (54.9) | <0.001*† | 0.889* | <0.001*† |
| Duration for taking the medicines | 1–220 Months | | | |
| **General use of medicines** | | | | |
| *Antihypertensive medications* | 294 (48.9) | <0.001*† | 0.402* | <0.001*† |
| *Anti - diabetic medications* | 238 (39.6) | <0.001*† | 0.304* | <0.001*† |
| *Anti-infective drugs* | 279 (46.4) | 0.183* | <0.001*† | <0.001*† |
| *Hormonal therapy* | 51 (8.5) | 0.425* | 0.419* | <0.001*† |
| *Vitamins* | 196 (32.6) | 0.080* | 0.141* | <0.001*† |
| *Herbal drugs* | 256 (42.6) | <0.001*† | 0.235* | <0.001*† |
| *Analgesics* | 531 (88.4) | 0.160* | 0.046*† | <0.001*† |
| *Blood Thinning Agents* | 245 (40.8) | <0.001*† | 0.478* | <0.001*† |
| **Specific Medication Use** | | | | |
| *Azithromycin* | 461 (76.7) | 0.005*† | 0.063* | <0.001*† |
| *β. blocker* | 207 (34.4) | <0.001*† | 0.005*† | <0.001*† |
| *Warfarin* | 79 (13.1) | <0.001*† | 0.025*† | <0.001*† |
| *Diuretics* | 30 (5) | 0.026*† | 0.099* | 0.114* |
| *Primolut N* | 55 (9.2) | <0.001*† | <0.001*† | <0.001*† |
| *Others* | 12 (2) | 0.178** | 0.428* | 0.699** |

Table 4: Access to medicine responses

| **Statement** | **N (%)** | **Gender** ($\chi^2$) | **Educational status** ($\chi^2$) |
|---|---|---|---|
| **First point to consult for health Problem** | | | |
| *Consult nearby medical center* | 375 (62.4) | <0.001*† | <0.001*† |
| *Consult private clinic nearby my accommodation* | 45 (7.3) | | |
| *Consult pharmacist at pharmacy outlet* | 50 (8.3) | | |
| *Consult my friend in group to take his medications* | 25 (4.2) | | |
| *Self-medication* | 106 (17.6) | | |
| **Usually obtain your medicines from** | | | |
| *Governmental Hospitals around Haram and my residence* | 564 (31.6) | 0.060* | 0.720* |
| *Medical center of my country hajj mission* | 563 (31.5) | 0.3038 | 0.061* |
| *Private medical centers* | 394 (22.1) | 0.051* | 0.014*† |

| | | | |
|---|---|---|---|
| *Community pharmacy* | 109 (6.1) | 0.579* | 0.193 |
| *Grocery shop (Biqala/store)* | 77 (4.3) | 0.743* | 0.065 |
| *Other* | 78 (4.3) | 0.083** | 0.501** |

*Medicine obtained responses varies in total N=601, as multiple responses (3 options) have to be selected. *chi-square test used, ** Fisher exact test, † statistically significant p<0.0*

Table 5: Evaluation of patient's perception and awareness on the use of medicines

| **Statement** | **N (%)** | **Gender** ($\chi^2$) | **Education** ($\chi^2$) |
|---|---|---|---|
| **Perception towards medicine labelling** | | | |
| Adequate information given on label | 100 (16.6) | 0.022 *† | <0.001*† |
| Read information on label before using medicine | 326 (54.2) | 0.409* | 0.074* |
| **Trouble reading labels for medicines supplied from** | | | |
| *Government hospitals* | 322 (53.6) | 0.912* | <0.001*† |
| *Medical centers of my country Hajj mission* | 246 (40.9) | 0.959* | <0.001*† |
| *Private medical centers/clinics* | 164 (27.3) | 0.114* | <0.001*† |
| *Community pharmacy* | 132 (22) | 0.019*† | <0.001*† |
| **Satisfied with the information written on the labels given by** | | | |
| *Government hospitals* | 251 (41.8) | 0.697* | <0.001*† |
| *Medical centers of my country Hajj mission* | 221 (36.8) | 0.815* | <0.001*† |
| *Private medical centers/clinics* | 116 (19.3) | 0.062* | 0.009*† |
| *Community pharmacy* | 88 (14.6) | 0.126* | <0.001*† |
| **Awareness toward appropriate use of medicines** | | | |
| Medicine name (Active ingredient name/Brand name) | 203 (33.8) | 0.105* | 0.002*† |
| Aware of the side effects of your medicines | 118 (19.6) | 0.365* | <0.001*† |
| Aware that all medicines have expiry date | 386 (64.2) | 0.380* | <0.001*† |
| Aware that other medicines/ food that should not been taken together | 112 (18.6) | <0.001*† | <0.001*† |
| Aware that there are some of modern and traditional medicines should not to be taken together | 92 (15.3) | 0.815* | <0.001*† |
| Know the correct way of medicines storage | 232 (38.6) | 0.130* | <0.001*† |
| Know that all medicines have to keep in specific temperature | 72 (12) | 0.465* | <0.001*† |

| **Understand the proper use of your medicines in term of dose, frequency, method of administration, side effect monitoring and interaction** | | **OR** | |
|---|---|---|---|
| | | **Gender [CI 95%]** | **Education [CI 95%]** |
| *Understand* | 252 (41.9) | | |
| *Partially understand* | 263 (43.8) | | |
| *Not understand* | 86 (14.3) | | |

| | | |
|---|---|---|
| | 0.025 [-0.078-0.147] ** | -0.277 [-0.101-0.002] ** |

** Chi-square test, ** linear Regression, † statistically significant p<0.05*

Table 7: Medicines information obtained

| Statement | Often N (%) | Seldom N (%) | Never N (%) | OR | |
|---|---|---|---|---|---|
| | | | | Gender [CI 95%] | Education [CI 95%] |
| Media / Printed materials (magazines, newspapers) | 153 (25.5) | 163 (27.1) | 285 (47.4) | 0.020 [-0.452-0.758] | -0.081* [-0.561- -0.044] |
| Internet | 50 (8.3) | 352 (58.6) | 199 (33.1) | -0.038 [-0.797-0.289] | 0.047 [-0.104-0.396] |
| Common information and entertainment channels (TV, radio) | 145 (24.1) | 163 (27.1) | 293 (48.8) | -0.064 [-1.085-0.122] | 0.081 * [0.003-0.559] |
| Modern healthcare professionals (doctors, pharmacists, nurses) | 119 (19.8) | 256 (42.6) | 226 (37.6) | 0.034 [0.322-0.819] | 0.032 [0.159-0.372] |
| Traditional and complimentary practitioners (Hakim, etc) | 122 (20.3) | 278 (45.8) | 204 (33.9) | 0.002 [-0.551-0.572] | 0.079 [-0.005-0.512] |
| Friends, family and neighbors | 140 (23.3) | 237 (39.4) | 224 (37.3) | 0.040 [-0.287-0.871] | 0.029 [-0.172-0.362] |

*Linear Regression, * statistically significant p <0.05*

# Evaluation of water quality supplied in pilgrims and Umrah visitors buildings

Omar B Ahmed[(1)], Atif A Asghar[(1)], Ibrahim H Abdel-Rahim[(1)], Mahmoud Y Lubbad[(2)], Abeer A Barhameen[(3)], Ali A Saygal[(4)], Mahir H Mashat[(1)], Ahmed Alsihli[(1)],

1- The Custodian of the Two Holy Mosques Institute of Hajj and Umrah Research, Umm Al-Qura University 2- Ministry of Health 3- Faculty of Medicine 4- Faculty of Applied Science

## Abstract

The present study was undertaken in order to determine the chemical and microbial quality of water supplied in pilgrims' and Umrah visitors' buildings. Faucets in 73 hotels at Makkah during Ramadan and Hajj seasons 1438 h (2017) have been examined. The samples were chemically analyzed for free chlorine, pH, TDS while microbiological analysis were coliform count, *E. coli* count, heterotrophilic Plate count (HPC) and *Legionella* using advanced microbiologic and molecular methods. The result showed that of the 73 samples tested, the PH was ranged between (5.15-7.3), the TDS were ranged between (84-195) PPM while chlorine was not adequate in all samples. The fecal coliform count was detected in 5 (6.8%) water samples, the MPN was very high in three of them. The *Pseudomonas aeruginosa* was not detected in any sample. The HPC was detected in 7 samples (9.6%), three of them were very high. Neither Legionella nor *E.coli* was detected in water supplies in pilgrims and Umra visitors buildings. It was concluded that the water supplied in pilgrims buildings were of good chemical quality, free of contamination with: *legionella*, *Pseudomonas aeruginosa* and fecal *E.coli* while few of them were contaminated with fecal coliforms. Efforts to enforce effective water treatment, periodic inspection and testing of the water in hotels' or pilgrims and Umra visitors buildings are recommended.

## 1. Introduction:

The World Water Day (22nd March ) is an international annually held day which was recommended at the 1992 United Nations Conference on Environment and Development (UNCED) (1). The day aims to focus attention on the importance of freshwater and advocating for the sustainable management of freshwater resources. In Makkah the main sources of drinking water are the desalination plants, the average consumption per capita of

potable water about 260 L per day (2). The pilgrims buildings should be comfortable, convenient and have all necessary safety equipment and in a continuous challenge to protect pilgrims from water illness. Water has to be clean, clear and meet regulatory standards and/or WHO guidelines (2006) (3). 'Water quality' is a term used here to express the suitability of water to sustain various uses or processes and involves the routine testing of water quality to ensure compliance with national standards. Health risks for unhealthy water include physical, chemical and microbial. The pH and total dissolved solids (TDS) are two ways to measure water quality and are two very important aspects of buildings. TDS is made up of inorganic salts, as well as a small amount of organic matter. The pH value of a water source is a measure of its acidity or alkalinity. Pure water would have a pH of 7.0, but water sources and precipitation tends to be slightly acidic, due to contaminants that are in the water (4). Chlorination, one of water treatment processes, creates water that is safe for public consumption. A large amount of research and many studies have been conducted to ensure success in new treatment plants using chlorine as a disinfectant. A large variety of bacterial, viral and protozoan pathogens are capable of initiating waterborne infections. The enteric bacterial pathogens include Salmonella spp., Shigella spp., Campylobacter jejuni, enterohaemorrhagic Escherichia coli. Environmental pathogens include Legionella, Mycobacterium spp and Pseudomonas aeruginosa. (5). In addition, viruses such as Hepatitis A and E viruses, rotavirus, calicivirus and enteric protozoa associated with waterborne disease such as Giardia lamblia emerging as opportunistic pathogens (6). After disinfection, numbers would be expected to be low; In some cases chemical hazards may also be introduced from water delivered to buildings from external sources. Chemicals from environmental and industrial sources, agriculture, water treatment, and materials in contact with water can contaminate building systems. The impacts on health of inadequate management of water in buildings is considerable and has in turn significant direct and indirect economic and social impacts. WHO has identified that the benefits of all interventions to reduce risks from unsafe water outweigh costs by substantial margins (7). The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria. Total coliform counts give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. Fecal coliforms are the group of the total coliforms that are considered to be present specifically in the gut and feces of warm-blooded animals. Because the origins of fecal coliforms are more specific than the

origins of the more general total coliform group of bacteria, fecal coliforms are considered a more accurate indication of animal or human waste than the total coliforms (8). *E. coli* is considered to be the species of coliform bacteria that is the best indicator of fecal pollution and the possible presence of pathogens (5). The present study was undertaken in order to determine the chemical and microbial quality of water supplied in pilgrims buildings.

## 2. Research aims:

The present study was undertaken in order to determine the chemical and microbial quality of water supplied in pilgrim's buildings.

## 3. Research Methodology:

Seventy-three bottles representing 73 buildings from randomly selected hotels and pilgrims' buildings in Makkah during Ramdan season 1438 (2017), and were tested for chemical and bacteriological quality .Samples were collected in 1-litre sterile bottles directly from the outlet .Collected samples were transferred in an ice box to the Microbiology Laboratory in Department of Environmental and Health Research the Custodian of the Two Holy Mosques Institute of Hajj and Umrah Research, Umm Al Qura University. Samples were stored at 4°C till further investigation of water-quality parameters to be carried out. The pH is measured by advanced electrochemical meter orion thermo scientific wide range of TDS/conductivity meters, which gives direct value of pH and EC according to manufacturer's instructions. The heterotrophic plate count (HPC) Sampler (EMD Millipore), consisting of a removable dip paddle contained in a plastic sampler. (According to manufacturer instructions). *Escherichia coli (E. coli)* and Coliforms count were determined in the samples, in additional to most probable number (MPN) of coliform bacteria. The number of Total coliforms and *E. coli* per 100 ml, based on the number of positive wells counted, was determined by referring to a 97-well MPN table (IDEXX) (according to manufacturer instructions). Identification of *Pseudomonas aeruginosa* (*P. aeruginosa)* was done using standard methods. All other growths on MacConkey agar were also subjected to identification. For Legionella identification, One liter of samples was filtered through 0.22 µm mixed cellulose ester membrane filters (Schleicher & Schuell) in a stainless-steel filter holder with a water aspirator. Total DNA was extracted from concentrated water samples using two classic manual methods: freeze & thaw and phenol-chloroform. Amplification reactions were preformed according to what has been described earlier by Hsu et al., 2006; Rafiee M, et al 2014 (9,10). The PCR primers LEG 225 (5'AAGATTAGCCTGCGTCCGAT-3') and LEG 858

(5' GTCAACTTATCGCGTTTGCT-3') were used to amplify a 650 bp fragment of the 16SrRNA gene of *Legionella* species. Fifty µl PCR mixture containing 8 µl of DNA template, 1 µl (100 pmol) of each primer and a 25 µl of Taq PCR Master (Promega Company) was prepared. Amplification was performed using Mastercycler PCR machine (Eppendorf, Germany). The thermal cycling conditions were as follows: an initial denaturation step at 94ºC for 5 min, followed by 35cycles of denaturation at 95ºC for 30 s, annealing at 64 ºC for 30 s and extension at 74ºC for 20 s. 1 cycle of 72ºC for 5 min. The PCR products were analyzed by electrophoresis in 1.5% agarose gels, 100 bp DNA ladder was included in each run and DNA bands were viewed under UVP BioDoct It Imaging System after staining with ethidium bromide (2 g/ml). Data was presented as average of replicates. In order to determine the significance relationships between variables Chi-square and Wilcoxon test were used and P-values less than 0.05 were considered statistically significant. All the available data were analyzed by a computer program (IBM SPSS statistics 20).

## 4. Results and discussion:

The result showed that in the tested 73 samples, the PH was ranged between (5.15-7.3), the TDS were ranged between (84-195) PPM and adequate chlorine in all samples (table1). The fecal coliform count was detected in 5 (6.8%) water samples, the MPN was very high (135.5) in three of them while the other two samples showed very low MPN of 2 and 4 values (table 2, figures1,3,4). The HPC was detected in 7 samples (9.6%), three of them were very high, two are moderate, two were very low (table3 and figure2). No *P. aeruginosa* was detected in the samples. Neither *Legionella* nor *E. coli* was detected in water supplies in pilgrims and Umra visitors buildings (figures 5,6). There was significant correlation between coliform with heterotrophic bacteria ($P \leq 0.05$) as in table 4. In Makkah, the water supply system functions with water supplied after treatment with rapid filtration and chlorine disinfection. Following that, the tap water passes through the building's internal water supply system and is distributed to users. All water supply systems of the hotels investigated in this study used an elevated water tank system. According to the previous studies (2) with design businesses, the majority utilize the elevated water tank system. According to legislation on water systems in Saudi Arabia, the residual active chlorine concentration of water supplied from the faucet is required to be above 0.1 mg/L. A leading advantage of chlorination is that it has proven effective against bacteria and viruses; however, it cannot inactivate all microbes. In the United States, pH is, like TDS, a secondary standard; the Secondary Maximum Contaminant Level for pH is between 6.5 and 8.5. A large variety of bacterial

pathogens are capable of initiating waterborne infections. For legionella, no band was detected using PCR technique i.e. the water samples were free for Legionella species (figure 3). Travel and hotel stays are recognized as risk factors for legionellosis (11). In Europe, approximately 20% of detected legionellosis cases are considered to be travel associated (11,12). In most countries like Japan, measures against *Legionella* are taken so as to reduce the risk of disease from *Legionella* for the whole of society (13). *Legionella* bacteria cannot grow in temperatures above 55 ºC. the extensive-piping systems may result in variability of temperature and encourage biofilm accumulation, such factors may favour the growth and proliferation of Legionella spp. (14,15). Different studies have shown that large buildings provide a rich environment for Legionella than small facilities. (15, 16). The negative results may be attributed to different factors such as the water supply system functions treatment with chlorine disinfectant. However, significant particulate contamination of the water was observed in one sample. Microbial pathogens represent the greatest risk associated with building water supplies. Recent surveillance data indicate that a substantial proportion of outbreaks in recreational water and drinking water were associated with buildings and hotels and other places such as hospital and schools. HPC serves as an indicator of general microbial population and thereby as indirect indicators of water safety. Clark et al., reported that the common bacterial species occurring in all types of water samples were *E. coli*, *Enterobacter aerogenes*, *Aeromonas hydrophila*, *Klebsiella pneumoniae*, and *Citrobacter freundii* (17). Total coliforms are not useful as an indicator of faecal pathogens, but they can be used to assess the cleanliness and integrity of distribution systems and the potential presence of biofilms. It has been proposed that total coliforms could be used as a disinfection indicator. However, the test for total coliforms is far slower and less reliable than direct measurement of disinfectant residual. In addition, total coliforms are far more sensitive to disinfection than are enteric viruses and protozoa. HPC measurements detect a wider range of microorganisms and are generally considered a better indicator of distribution system integrity and cleanliness (18). However, in the present study, coliforms bacteria were detected in (9.6%) of the samples. Water pollution caused by fecal contamination is a serious problem due to the potential for contracting diseases from pathogens (disease causing organisms). Proportion of water-borne disease is associated with contamination within buildings. This arises from direct contamination through faults in water systems (e.g. bird and small animal droppings into storage tanks) (5). Water in pilgrims building should be monitored so as to protect them from infections or other health problems due to unhealthy

water. It can be concluded that the water supplied in pilgrims buildings were of good chemical quality, free of *legionella*, *P. aeruginosa* and fecal *E. coli* contamination while few of them were contaminated with fecal coliforms. Efforts to enforce effective water treatment in pilgrims and Umra visitors' buildings by the are recommended. There should be periodic inspection and testing of hotels' water systems.

## 5. Summary:

It can be concluded that the water supplied in the pilgrims' buildings were of good chemical quality, free of *legionella*, *P. aeruginosa* and fecal *E. coli* contamination while few of them were contaminated with fecal coliforms.

## 6. Recommendations:

Efforts to enforce effective water treatment in pilgrims and Umrah visitors' buildings by the are recommended. There should be periodic inspection and testing of hotels' water systems.

## 7. References:


1-http://www.greenhotelier.org/know-how-guides/water-management-and-responsibility-in-hotels/

**٢- امل صلاح جمبي :مصادر مياه الشرب ومشكلاتها في مدينة مكة المكرمة دراسة في جغرافية الموارد المائية" رسالة ماجستير جامعة م القرى , كلية العلوم الاجتماعية قسم الجغرافيا ١٤٣٢-١٤٣٣**

**3-**World Health Organization (WHO) (2006) Guidelines for the safe use of wastewater, excreta and greywater. World Health Organization, Geneva.

4-SDWF (2008) TDS & pH. Safe Drinking Water Foundation: 6 pp.

5-World Health Organization (WHO) (2010) Water safety in buildings. World Health Organization, Geneva

6-*H. Leclerc*, Relationships between common water bacteria and pathogens in drinking-water in" *Heterotrophic Plate Counts and Drinking-water Safety*. Edited by J. Bartram, J. Cotruvo, M. Exner, C. Fricker, A. Glasmacher. Published by IWA Publishing, London, UK. ISBN: 1 84339 025 6.2003 World Health Organization (WHO).

7- Hutton G, and Haller L. (2004). Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level. World Health Organization, Geneva http://www.who.int/water_sanitation_health/wsh0404.pdf.

8- x- Pandey PK, Kass PH, Soupir ML, Biswas S, Singh VP. (2014). Contamination of water resources by pathogenic bacteria. *AMB Express*.;4:51. doi:10.1186/s13568-014-0051-x.

9- Hsu et al. (2006) Legionella prevalence in hot spring recreation areas of Taiwan. Water Res, 40(17):3267–3273.

10- Rafiee M, et al. Detection and identification of Legionella species in hospital water supplies through Polymerase Chain Reaction (16S rRNA). Journal of Environmental Health Science & Engineering 2014, 12:83.

11-Bartram J, Chartier Y, Lee JV, Pond K and Surman-Lee S (Eds) (2007) Legionella and the prevention of legionellosis. World Health Organization, Geneva.

12-Joseph C (2002) The risk of suffering from Legionnaires' disease whilst abroad. Journal of the Royal Society of Health 122: 6-7

13-Toyosada K, Otani T, Shimizu Y, Managi S. (2017) Water Quality Study on the Hot and ColdWater Supply Systems at Vietnamese Hotels. Water, 9, 251; doi:10.3390/w9040251

14-Yu, V.L. (2002) Legionella surveillance: political and social implications – a little knowledge is a dangerous thing. J Infect Dis 185, 259–261.

15- Borella, P., Montagna, M.T., Stampi, S., Stancanelli, G., Romano-Spica, V., Triassi, M., Marchesi, I., Barghellini, A. et al. (2005) Legionella contamination in hot water of Italian hotels. Appl Environ Microbiol 61, 5805–5813.

16-Leoni, E. and Legnani, P.P. (2001) Comparison of selective procedures for isolation and enumeration of Legionella

species from hot water systems. J Appl Microbiol 90, 27–33.

17-Clark, J.A., Burger, C.A. and Sabanatinos, L.E. (1982) Characterization of indicator bacteria in municipal raw water, drinking water and new main water supplies. Can. J. Microbiol. 28, 1002–1013.

18-WHO (2017) Guidelines for drinking-water quality: 4th edition. Geneva. World Health Organization, , ISBN 978-92-4-154995-0.

Table1: chemical analysis of the water

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| PH | 73 | 5.15 | 7.30 | 6.3499 | .36337 |
| TDS(ppm) | 73 | 84.60 | 195.00 | 112.4808 | 28.58775 |

Table2: coliform count of the water

| MPN/100 ml | | Frequency | Percent |
|---|---|---|---|
| Low | 2.00 | 1 | 1.4 |
| | 4.00 | 1 | 1.4 |
| High | 135.50 | 3 | 4.1 |
| Negative | NEG | 68 | 93.2 |
| | Total | 73 | 100.0 |

Table3: HPC of the water

| | CFM/ 100 ml | Frequency | Percent |
|---|---|---|---|
| low | 200.00 | 1 | 1.4 |
| | 300.00 | 1 | 1.4 |
| Intermediate | 2500.00 | 1 | 1.4 |
| | 14500.00 | 1 | 1.4 |
| High | 285400.00 | 1 | 1.4 |
| | 314500.00 | 1 | 1.4 |
| | 325200.00 | 1 | 1.4 |
| Negative | NEG | 66 | 90.4 |
| | Total | 73 | 100.0 |

Table4: Correlation between heterotrophic bacteria and fecal coliforms.

| | Variable | P value (Pearson Chi-Square) | P value (Wilcoxon) |
|---|---|---|---|
| HPC bacteria | Fecal coliform | 0.000 | 0.018 |

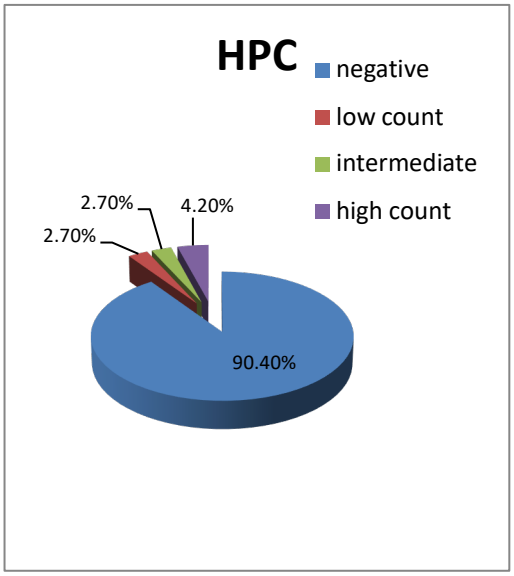



Figure2: **HPC of the water**

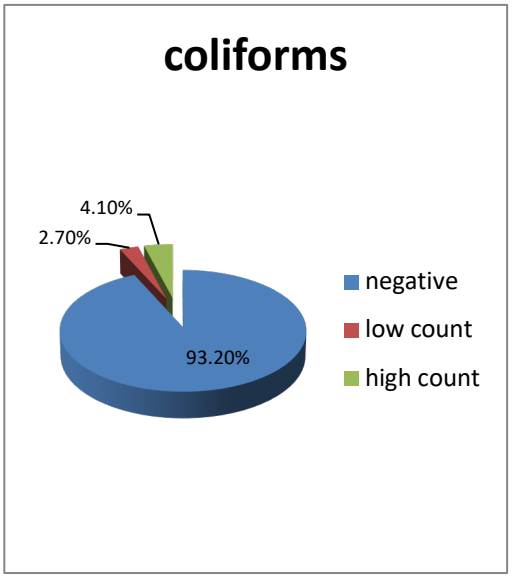



Figure1: **coliform count of the water**

Figure3: **Negative coli form result by Colilert**

Figure4: **Positive coli form result by Colilert**

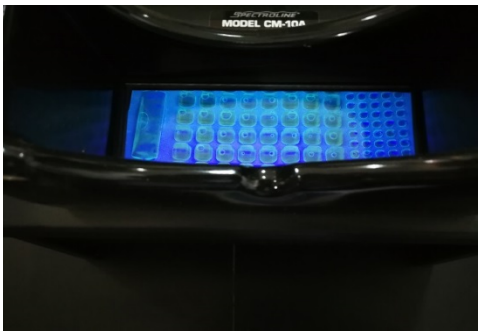



Figure5: **Negative E. coli result by Colilert (UV)**

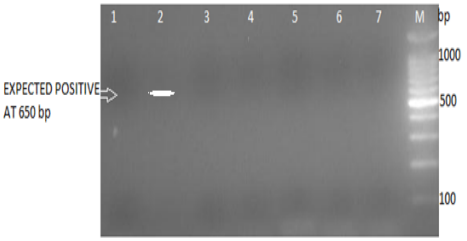



Figure 6. **No band detected in 1% agarose gel electrophoresis after PCR reaction, Band 2: positive control**

# Fourth Theme:
# Engineering Studies

# Seat belt use on transportation buses for hajj 1438 – (2017)

Wadie Abdullah Hassan Alsaeed[(1)], Sami Saeed Almudraa[(1)], Joanna Gaines[(2)]
1- Field Epidemiology Training Program, King Saud University, Ministry of Health
2- CDC & Prevention, Atlanta, USA

## Abstract

Background: In Saudi Arabia, there were approximately 526,000 vehicle crashes in 2016 causing 39,000 injuries, with up to 17 deaths per day [8]. In Islam all Hajj pilgrims must enter Makkah by road [1]. Tour buses are the most used method of transportation, with more than 24,000 tour buses carrying pilgrims to Makkah. Passengers are assigned to buses based on country of residence. Seat belt use is mandatory in Saudi Arabia by law, but little is known about compliance during Hajj.

Methods: During the 2017 Hajj we completed an observational study on seat belt use among pilgrims and bus drivers. We also observed police behavior at check points for enforcing seat belt use on bus drivers and passengers. To describe and identify any differences in seat belt use, we sought a diverse sample of buses with passengers of different socioeconomic status and from different countries.

Results: We observed seat belt use on 40 buses carrying 41- 49 passengers each. Five (12.5%) buses out of 40 had at least one passenger using seat belt. Females (54%) had higher seat belt use than males (47.9%). All 40 (100%) bus drivers were observed to wear seat belts. No drivers or police were observed to encourage passengers to use seat belts. We found no difference in seat belt use between Saudi national passengers of different socioeconomic status: none wore seat belt. Seat belt use among developed countries (51.1%) was higher than underdeveloped countries (0%) and still developing countries (0%).

Conclusion: Despite mandatory seat belt use in Saudi Arabia, seat belt use among Hajj pilgrims was low. Saudi Arabia has a high rate of injuries due to vehicle crashes, and seat belts are an effective way to reduce injuries. Public awareness of the benefits of seat belts and strong enforcement of seat belt use will reduce injuries from vehicle crashes.

## 1. Introduction:

The Annual Islamic event, Hajj, takes place in Makkah (the most holy city for all Muslims). Hajj is the fifth pillar of Islam [1]. On average over 2 million pilgrims travel to perform Hajj every year [2]. This year the number of pilgrims is expected to reach 3 million. The majority of Hajj pilgrims arrive to Saudi Arabia by air (94%), by land (5%), and by sea (1%), as seen in Figure 1 [11]. Despite the method of transportation used by pilgrims to arrive to Saudi Arabia, in Islamic rules all Hajj pilgrims must enter Makkah by road. Therefore, the majority of pilgrims will travel on a tour bus for at least a portion of their journey. Tour buses equipped with safety belts are the safest design for long distance travel, and highway travel at high speeds. School buses, usually not equipped with safety belts are made for short distance, and slower speed travel. Unfortunately, both types of buses have been used previously for transportation of pilgrims.

## 2. Research Aims:

A. To assess the availability of tour buses with seat belts.
B. To assess the usage of seat belts among pilgrims riding buses into and out of Makkah.
C. To assess the police enforcement of seat belt laws.

## 3. Research Methodology:

An observational study was conducted to identify seat belt use by pilgrims on buses. Observations will also be noted as to police enforcement at checkpoints and the drivers' or group leaders' encouragement of seat belt usage. The study conductor walked the aisle of each bus and observed each pilgrim to determine seatbelt usage. The observational study on 40 buses was conducted. 10 buses were observed in the Eastern Province at specific bus stations belonging to specific Hajj agencies. These observations began from their start point on day 5 and day 6 of Dhu al-Hajjah specifically on buses carrying pilgrims traveling to Makkah. The study continued with observations on 15 buses in Makkah at the bus station (Tafweej Center), during day 12 and day 13 of Dhu al-Hajjah for pilgrims traveling to Madinah. The study concludes after observations were conducted on 15 busses in Makkah at the bus station during day 14 to day 15 of Dhu al-Hajjah for pilgrims traveling to Jeddah Airport.

The study consisted of three different groups. **Group 1** contained local Saudi national pilgrims who were traveling from the Eastern Province to Makkah. 10 randomized buses were selected, selection was based on obtaining data from three types of socioeconomics;

high socioeconomic class AKA VIP class, average socioeconomic class AKA Average class, and low socioeconomic class AKA Low Income class. **Group 2** consisted of International pilgrims who completed Hajj and were visiting the second holy city, Madinah. The observations were conducted on 15 randomized buses. **Group 3** was also consisted of International pilgrims who completed Hajj and were ready to go back to their countries from Jeddah Airport. Targeted observation of 15 selectively randomized buses based on the following criteria; developed countries, developing countries, and underdeveloped countries. The total sample size for this study was 1896 pilgrims.

The primary investigator collected all data points for each bus, data points collected were seat belt usage on buses by pilgrims, driver seat belt usage, directions to passengers, and traffic police enforcement of seat belt laws. All data was documented in details.

After the observation period was complete, all data was entered into the Epi Info 7 software and Microsoft Excel for analysis.

This study was conducted under the supervision of Dr. Sami Almudarra, Director of FETP, and Dr. Joanna Gaines from USA C.D.C.

**4. Results and Discussion:**

**Results:** Forty buses carrying 41- 49 passengers each were observed. Five (12.5%) buses out of 40 had at least one passenger using a seat belt. Females (54%) had higher seat belt use than males (47.9%). All 40 (100%) bus drivers were observed to wear seat belts. No driver or police were observed to encourage passengers to use seat belts. There was no difference in seat belt use between Saudi national passengers of different socioeconomic status: none wore seat belts. Seat belt use among developed countries (51.1%) was higher than underdeveloped countries (0%) and still developing countries (0%).

Figure 2 shows the breakdown of the two groups in the observational study. Group 1 is the Saudi national pilgrims differentiated by socioeconomic status, and group 2 is the non- Saudi pilgrims by their country's developmental status.

Group 1 contained local Saudi national pilgrims who were traveling from the Eastern Province to Makkah. Ten buses carrying a total of 469 passengers were selected. These passengers were observed based on their socioeconomic class. In all classes the percentage of seat belt use was 0%. This data is shown in Table 1. Group 2 was 15 randomized buses of 675 international pilgrims who completed Hajj and were visiting the second holy city, Madinah. The observed seat belt rate for this group was 0 %. This data is

shown in Table 3. Group 3 was made up of international pilgrims who completed Hajj and were traveling to the Jeddah Airport; 15 buses with a total of 752 pilgrims were observed. The total seat belt use on these buses was 12% as is shown in Table 3. This group was broken down by the developmental status of their countries of origin. Figure 4 illustrates the findings that only the pilgrims from developed countries utilized the seat belts at the rate of 51.1% as seem in Figure 3. Females (54.1%) from developed countries were slightly more likely to wear seat belts than their male (49.6%) counterparts as shown in Figure 4. In Table 2 there is highly significance relation between social level and sex in using seat belt among piligrims

Table 4 shows the results for all the passengers in the study (1896). The percentage of seat belt use for the total passengers was 4.8%. When grouping all passengers together, males (5.1%) have a slightly higher percentage of seatbelt use than females (4.4%) it is worth note to observe the number of males observed was much higher than the number of females observed.

The results for the drivers of the buses seat belt use was 100%. Every driver was using a seatbelt, and at the checkpoints the traffic police were enforcing this law, but there was no enforcement of seatbelts use to passengers. The conductor of the study also observed the bus driver or group leader gave no encouragement to passengers to wear seatbelts.

**Discussion:** Although there was no variation among Saudi national social classes regarding safety belt use on the transportation buses for Hajj, some variation did occur with regards to the safety belt use amongst non-Saudi national. The overall associated seat belt use with regards to Saudi pilgrims and pilgrims from underdeveloped and still developing nations was at 0%. While in developed countries, countries there is more public awareness, and laws enforcement around seatbelt use, there was 51.1% usage. The numbers in this study are consistent with the WHO Global Status Report on Road Safety in 2015, which states that underdeveloped and still developing countries have the highest risk of dying on a road traffic crash [9].

There is also a direct link between the enforcement of seatbelt laws and seatbelt usage. Every driver in this study was wearing his seat belt, and at every checkpoint it was checked by the traffic officers. However, the passenger seat belt use was neither checked nor enforced by the same traffic officers. In addition there was no encouragement or safety awareness that was given to passenger to ensure seatbelt usage.

There were some limitations to this study. The observer was not allowed on all buses he selected to observe, but was able to complete the needed sample size. Another limitation was that the observer was male, and it was sometimes difficult to judge by observation if the female passengers were utilizing their seat belts. Since this study was limited to tour buses, more information might be shown if all types of passenger vehicles were observed.

**5. Conclusion:**

What accounts for the lack of seat belt use by passengers? This study shows clearly that although seat belts are proven to decrease serious injury and fatalities in road vehicle crashes [5], only 4.8% of passengers used them. The 4.8% of passengers who utilized seat belts were from developed countries. The lack of seat belt use among passengers is endemic to passengers for all economic backgrounds. There is serious work that needs to be done to help prevent injury and death by increasing passenger seat belt use.

According to this study, passenger seat belt laws, although in effect are not properly enforced. Enforcement has been shown to have positive effect on seat belt use in developed countries around the world [10].

**6. Recommendations:**

1. Make an awareness campaign during Hajj that requires all bus drivers to encourage seat belt use among their passengers.

2. Traffic police enforce seat belt laws for passengers making the bus companies responsible for citations.

3. Increase more of the surveillance system known as (SAHER), to enforce speed and seat belt use.

**7. References:**


1. "Saudi Arabia - Pilgrimage." *Au.af.mil*. 4 Jan. 2012. Web. 7 Aug. 2017.
2. "Saudi Arabia plans 19,000 buses for 1.4m hajj pilgrims." *English.alarabiya.net*. 19 Aug. 2014. Web. 7 Aug. 2017.
3. "Saudi Arabia: Hajj/Umrah Pilgrimage - Chapter 4 - 2018 Yellow Book | Travelers' Health |CDC." *Wwwnc.cdc.gov* Web. 7 Aug. 2017.
4. "Health risk at the Hajj *ResearchGate*. 1 Apr. 2006. Web. 7 Aug. 2017.
5. Olumuyiwa Joshua Ogundele. "The impact of seat-belts in limiting the severity of injuries in patients presenting to a university hospital in the developing world Ogundele

OJ, Ifesanya AO, Adeyanju SA, Ogunlade SO - Niger Med J." *Nigeriamedj.com*. Medknow Publications and Media Pvt. Ltd., n.d. Web. 7 Aug. 2017.

6. Alaa K Abbas. "Seat belts and road traffic collision injuries." *World Journal of Emergency Surgery*. 28 May 2011. Web. 7 Aug. 2017.
   "About MOI." *Moi.gov.sa*. n.d. Web. 7 Aug. 2017.
7. "Seat belt utilization in Saudi Arabia and its impact on road accident injuries - ScienceDirect." *Sciencedirect.com*. n.d. Web. 6 Aug. 2017.
8. "Global status report on road safety: time for action." Geneva, World Health Organization, 2015. (www.who.int/violence_injury_prevention/road_safety_status/2015).
9. Julia F. Costich, Svetla S. Slavova."Using Enforcement and Adjudication Data to Assess the Impact of a Primary Safety Belt Law" *Traffic Injury Prevention* Vol. 16 , Iss. 7,2015.
10. "Hajj Statistics 1437 H (2016)." Saudi Arabia, General Authority for Statistics, 2017 (https://www.stats.gov.sa/sites/default/files/hajj_1437_en.pdf).
11. *Regulations to extend compulsory seat belt wearing to bus and coach passengers*. (n.d.). Retrieved 1 26, 2018, from Department for Transport: http://www.dft.gov.uk/consultations/aboutia/ria/regulationstoextendcompulsor5561?page=2
12. Ruhai, G., Manjiang, H., & Dong, X. (2010). *Simulation Study of Bus Occupant Restraint System in Emergency Brake*. Retrieved 1 26, 2018, from http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.ieee-000005663075
13. *Seat Belts - How Effective? - Road Safety Observatory*. (n.d.). Retrieved 1 26, 2018, from http://www.roadsafetyobservatory.com/HowEffective/vehicles/seat-belts

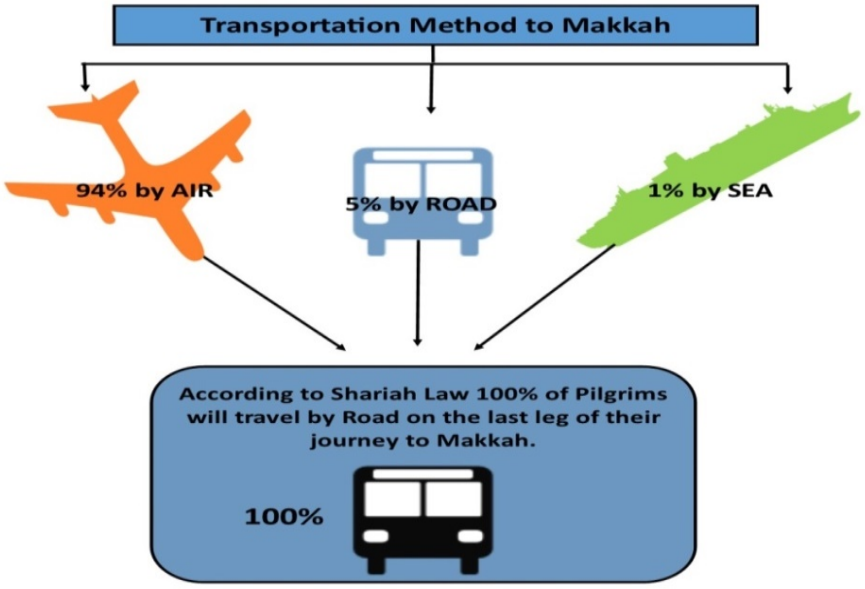



Figure 1: Transportation Methods to

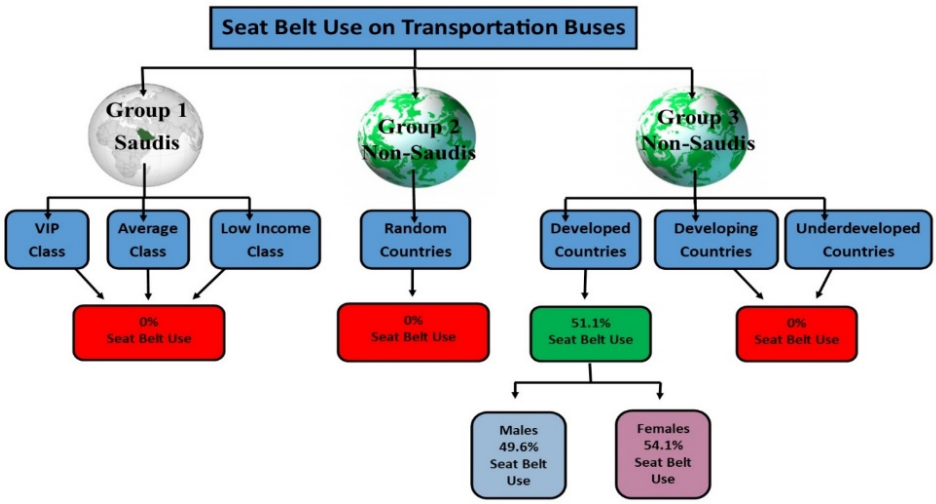



Figure 2: Seat Belt Use on Transportation Buses

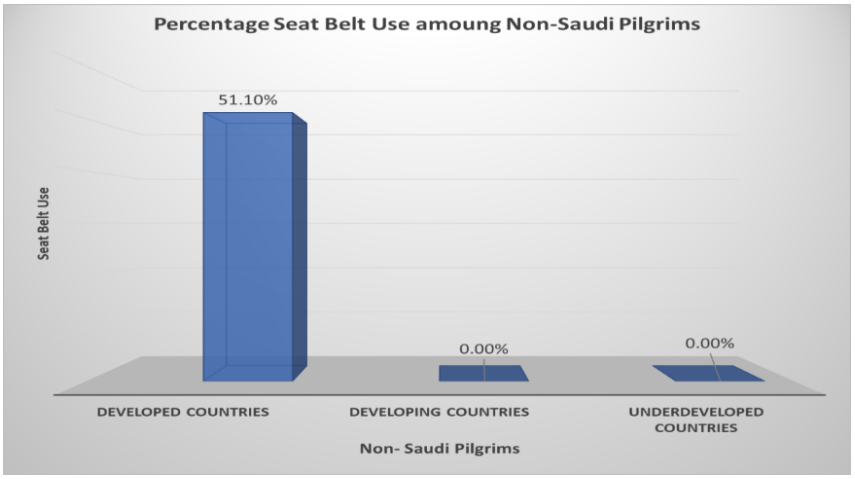



Figure 3: Percentage Seat Belt Use among Non-Saudi Pilgrims

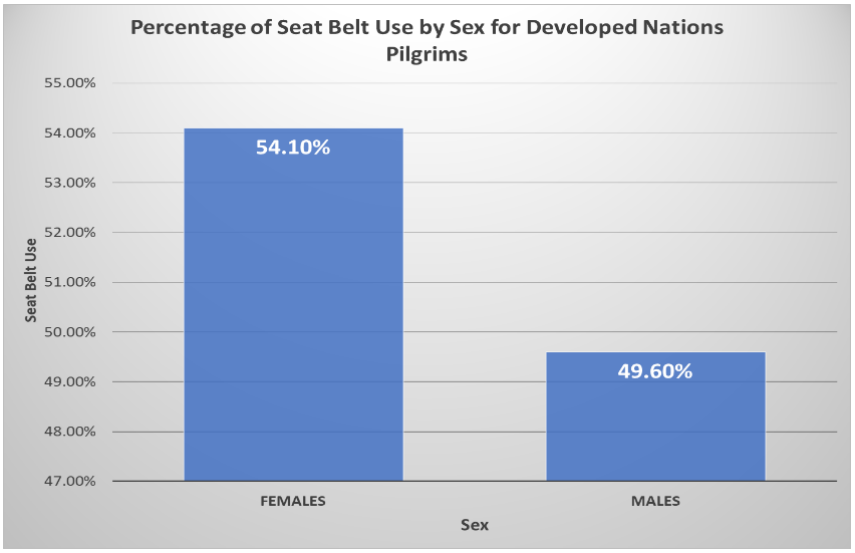



Figure 4: Percentage of Seat Belts Use by Sex for Developed Nations Pilgrims

Table 1: Saudi national pilgrims by socioeconomic status

| Type of Agency | Total Passengers | Total Male | Total Female | Male Wearing Seat Belt | Female Wearing Seat Belt |
|---|---|---|---|---|---|
| Average Class | 192 | 147 | 45 | 1 | 0 |
| Low Income Class | 180 | 90 | 90 | 0 | 0 |
| VIP Class | 97 | 56 | 41 | 0 | 0 |
| Total | 469 | 293 | 176 | 1 | 0 |

Table 2: Chi Square test in relation between social level and sex in using seat belt

| | Chi Square | Difference | Probability |
|---|---|---|---|
| Female | 40 | 12 | 0.0001 |
| Male | 40.5714 | 12 | 0.0001 |

Table 3: Results for Non-Saudi nationals by country development

| Passenger Grouping | Female Passengers | | | Male Passengers | | | Total Passengers | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Passengers | With Seat Belts | % Using Seat Belts | Total Passengers | With Seat Belts | % Using Seat Belts | Total Passengers | With Seat Belts | % Using Seat Belts |
| Developed | 61 | 33 | 54.1% | 115 | 57 | 49.6% | 176 | 90 | 51.1% |
| Developing | 136 | 0 | 0% | 248 | 0 | 0% | 384 | 0 | 0% |
| Under-developed | 76 | 0 | 0% | 375 | 0 | 0% | 675 | 0 | 0% |
| Total | 273 | 33 | 12.1% | 479 | 57 | 11.9% | 752 | 90 | 12.0% |

Table 4: Results by group

| Passenger Grouping | Female Passengers | | | Male Passengers | | | Total Passengers | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Passengers | With Seat Belts | % Using Seat Belts | Total Passengers | With Seat Belts | % Using Seat Belts | Total Passengers | With Seat Belts | % Using Seat Belts |
| Group 1: Saudi socioeconomic | 176 | 0 | 0% | 293 | 1 | 0.3% | 469 | 1 | 0.2% |
| Group 2: Non-Saudi Randomized | 300 | 0 | 0% | 375 | 0 | 0% | 675 | 0 | 0% |
| Group 3: Non-Saudi by country development | 273 | 33 | 12.1 % | 479 | 57 | 11.9 % | 752 | 90 | 12% |
| Total | 749 | 33 | 4.4% | 1147 | 58 | 5.1% | 1896 | 91 | 4.8% |