

## FACTORS INFLUENCING FACE MASK SELECTION AND DESIGN SPECIFICATIONS: RESULTS FROM PILOT STUDY AMONGST MALAYSIAN UMRAH PILGRIMS

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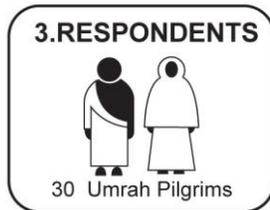
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### Graphical abstract



### Abstract

Hajj is the largest annual gathering of Muslims during which time over two million people from different parts of the world are gathered within a small area, leading to very high risks of acute respiratory infections (ARI) for the pilgrims. Therefore, preventive measures and controls should be implemented, including the implementation of non-pharmaceutical prevention methods such as the use of appropriate face masks, hand hygiene, respiratory etiquette, social distancing, and quarantine. A pilot study was conducted in 2013 to identify the types of face masks used by Malaysian Umrah pilgrims as well as to identify the problems pertaining to the face masks being used and to understand the factors influencing the selection of face masks by Malaysian pilgrims. Observations and survey methods were used in the pilot study. Data was collected from thirty respondents through a survey. This paper presents the results of the pilot study. Based on the knowledge of factors influencing face mask usage and selection from the pilot study, new face mask design(s) will be proposed for the Malaysian pilgrims. It is anticipated that the use of new face mask design(s) can reduce the risk of acute respiratory infections in Hajj and Umrah pilgrims.

Keywords: Hajj, acute respiratory infections, face mask selection factors, design, face mask

### Abstrak

Haji adalah perhimpunan terbesar umat Islam yang menghimpunkan lebih dua juta manusia daripada serata dunia di dalam kawasan yang kecil dan menyebabkan risiko untuk mendapat jangkitan pernafasan adalah tinggi di kalangan jemaah. Oleh itu, langkah-langkah pencegahan dan kawalan perlu dilaksanakan termasuklah kaedah pelaksanaan bukan farmaseutikal seperti penggunaan topeng muka yang betul, kebersihan tangan, etika pernafasan, jarak dan kuarantin. Satu kajian lapangan telah dijalankan pada tahun 2013 bagi mengenalpasti jenis-jenis topeng muka yang digunakan oleh jemaah Malaysia, mengenalpasti permasalahan pada topeng muka yang digunakan sekarang dan memahami faktor yang mempengaruhi pemilihan topeng muka oleh jemaah Malaysia. Kajian lapangan ini menggunakan kaedah melalui pemerhatian dan kaji selidik. Data dikumpulkan daripada tiga puluh responden melalui kaji selidik. Kertas kerja ini membentangkan hasil daripada kajian lapangan. Satu reka bentuk topeng muka yang baharu akan dicadangkan untuk jemaah Malaysia berdasarkan kepada faktor yang mempengaruhi penggunaan topeng muka. Dijangkakan bahawa penggunaan reka bentuk topeng muka baru boleh mengurangkan risiko jangkitan pernafasan akut pada jemaah Haji dan Umrah.

Kata kunci: Haji, jangkitan pernafasan akut, faktor pemilihan topeng muka, reka bentuk, topeng muka

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## 1.0 INTRODUCTION

Muslims perform the annual pilgrimage Hajj in Mecca (Saudi Arabia) and its surrounding areas on every twelfth month of the Islamic lunar calendar. Umrah, on the other hand, is performed by Muslims during any time of the year. Hajj is the fifth pillar of Islam, which is obligatory upon all Muslims who can afford it physically and financially. Both pilgrimages, especially the Hajj, involve many Muslims from countries all around the world. More than two million Muslims converge annually during the Hajj pilgrimage, including around twenty-two thousand pilgrims from Malaysia, who are exposed to high risk of airborne infectious diseases caused due to acute respiratory tract infections (ARIs) [1]. Overcrowded environment and limited ventilation in some locations during Hajj contributes about 80% to the risk of respiratory tract infections [2]. Influenza virus, respiratory syncytial viruses, adenoviruses, and rhinoviruses are the most commonly found respiratory viruses during the Hajj [3]. In 2012, a new respiratory illness known as the Middle East Respiratory Syndrome (MERS) was reported in Saudi Arabia. MERS is caused by a virus referred to as the MERS-Coronavirus [4]. Based on a study conducted amongst 387 Malaysian Hajj pilgrims in 2010, it was reported that the typical respiratory symptoms among the pilgrims were cough (91.5%), runny nose (79.3%), fever (59.2%), and sore throat (57.1%) [5]. In a study conducted amongst 468 Malaysian pilgrims from the 2013 Hajj season, it was found that the prevalence of the respiratory illness was 93.4% with 78.2% fulfilling the criteria for influenza-like illness [6].

There are two preventive measures for combatting respiratory tract infections, namely, pharmaceutical and non-pharmaceutical measures. Vaccinations are one of the pharmaceutical means and are supported by the non-pharmaceutical measures. Non-pharmaceutical measures are highly encouraged and supported by several countries and agencies such as the Ministry of Health (Saudi Arabia), World Health Organization (WHO), and Centers for Disease Control and Prevention (CDC). Nanofiber materials have the ability to filter out small particles while providing excellent air permeability; such materials for face masks are typically melt blown or spun bonded [7]. The proper use of face masks (such as the N95 particulate respirator) is one of the non-pharmaceutical preventive measures to prevent ARIs [8]. Other preventive non-pharmaceutical measures include hand hygiene, respiratory etiquette, travel restrictions, social distancing, and quarantine [9]. Proper implementation of preventive non-pharmaceutical measures can potentially prevent the spread of respiratory diseases among the Hajj pilgrims [10–12].

In situations where a disease has become an epidemic, Islam has made exceptions and flexibilities to cover part of the face while performing Umrah or Hajj pilgrimage [13]. Therefore, it has been suggested that pilgrims should wear face masks to reduce the spread of microorganisms and thereby mitigate the risk

of disease-causing infections [6]. Although many types of face masks are used while performing Hajj, protecting the pilgrims against airborne infectious diseases is still a major problem that needs to be solved. The two most common types of face masks used by pilgrims are the surgical masks and the N95 particulate respirators. In a study conducted amongst 468 Malaysian pilgrims from the 2013 Hajj season, it was found that 68.8% of Malaysian pilgrims used surgical masks while only 3.2% used N95 particulate respirators [6]. Surgical masks are not effective in filtering out small particles. Also, there is leakage when the user breathes [14]. Furthermore, the surgical mask is not purposely designed to fit the user's face. Even though it can only prevent splashes and droplets, aerosols can still pass through the space between the face and the mask [15]. The N95 particulate respirators were more effective than the surgical masks during the SARS outbreak in 2003 [8]. Furthermore, in a recent study, the efficiency of three types of cloth masks and one type of surgical mask were examined and compared with standard N95 particulate respirator performance [16]. It was found that the N95 particulate respirators were effective in removing most of the tested particles. It was also found that compared with cloth masks, the disposable surgical mask was more efficient in reducing particulate exposure.

Although the therapeutic effectiveness of the face masks against airborne infectious diseases is highly critical, there are other factors that affect the usage of the face masks. An important aspect that should be considered when designing face masks is the comfortability factor. One of the main reasons that the Hajj or Umrah congregation is reluctant to use face masks is because the use of face masks causes heating in the facial region and it gives the user a stuffy and discomforting feeling [17, 18]. The heating of the facial region occurs as the congregation needs to perform several physical activities as part of the pilgrimage, especially for the Hajj. The human head is a critical part of the human cooling system. If parts of the head are covered, the body temperature under the covered regions will rise above the normal body temperature [19]. Hence, new face mask designs for pilgrims should be focused on comfort, reducing the resistance during breathing and reducing heat buildup [8]. Another aspect to be considered while creating face masks for use during Hajj and Umrah is pilgrims with beards and other facial hair. Users with beard or other facial hair are prone to face mask leaks [20]. Furthermore, a 2009 study showed that the pilgrims do not use face masks properly, for example, they put the top of the facemask at the bottom of the nose upper their lips [21]. Therefore, apart from the therapeutic effectiveness of face masks, there are pilgrims' persisting issues with the usage of face masks including cost, comfortability, facial hair, improper wearing, extended usage, portability, and understanding of Islamic legality with the use of face masks during a pilgrimage.

Given the persisting issues with the usage of facial masks during Hajj and Umrah, the current pilot study was conducted. The objectives of the pilot study were to identify the preference of the face mask types by Malaysian Umrah pilgrims; to identify the problems with the face masks currently being used; and to understand the factors influencing the selection of face masks by Malaysian pilgrims. The results from the pilot study are anticipated to be used as a guide for designing new face masks which are suitable for pilgrims across gender, age, and facial profiles.

## 2.0 METHODOLOGY

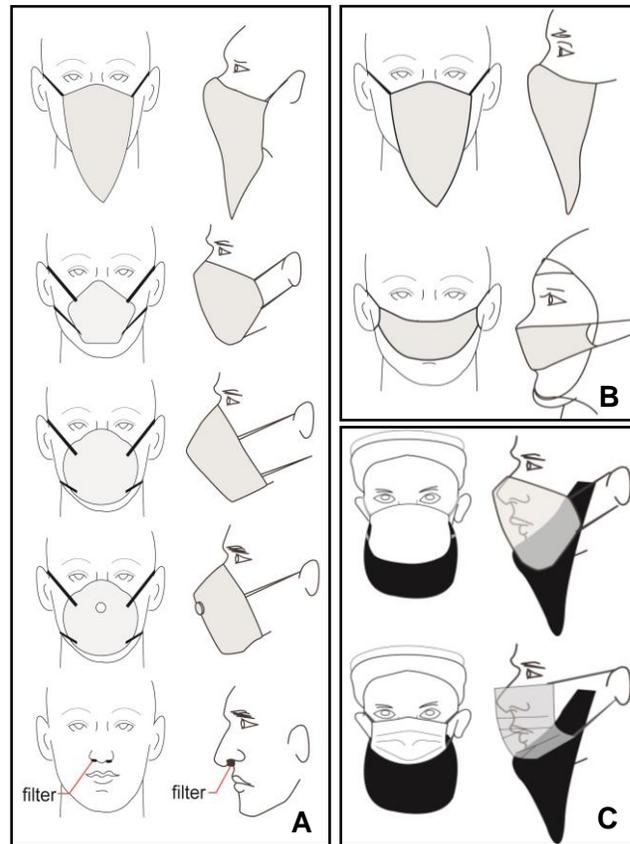
The pilot study was conducted in Mecca and Medina during the 2013 Umrah pilgrimage season. The small study [also known as a pilot study] was undertaken to facilitate the design of actual research [22]. The pilot study was conducted through two approaches, namely, qualitative and quantitative. Under the qualitative approach, researchers made observations of face masks being used by pilgrims in the two locations of study. Under the quantitative approach, the researchers used non-randomized purposive sampling to conduct a survey [23].

The study was conducted with thirty (30) Malaysian Umrah pilgrims. A set of the questionnaire in the form of a 5-point Likert scale was used. The questionnaire included questions related to the factors influencing the selection of face masks, factors influencing the use of face masks, and problems with existing face masks. The survey data was analyzed using SPSS Statistics software, hierarchical clustering analysis and factor analysis (principal component analysis extraction method).

## 3.0 RESULTS AND DISCUSSION

### 3.1 Observational Studies

Observations were conducted at two different locations, Mecca and Medina. There are several types of face mask designs used by pilgrims from various countries as shown in Figure 1. Figure 1A shows the front and side views of five different mask designs used by pilgrims during the Umrah in Mecca. Figure 1B shows the front and side views of two different mask designs used by pilgrims in Medina. It can be seen that more varieties of mask designs were used by pilgrims in Mecca compared to the pilgrims in Medina. Figure 1C shows the front and side views of bearded users wearing two commonly used face masks, N95 particulate respirator (top) and surgical face mask (bottom).



**Figure 1** The face mask designs used by pilgrims in (A) Mecca and (B) Medina. (C) Bearded users wear two commonly used face masks, N95 particulate respirator (top) and surgical face mask (bottom). In all images: front views (left) and side views (right)

### 3.2 Demographics

Table 1 summarizes the demographics of the Malaysian Umrah pilgrims that participated in the pilot study. The table includes information on the number of pilgrimages performed, the frequency of wearing face masks, and the types of face masks being used by the respondents of the pilot study. A majority of the interviewees (80%) of the pilot study were male. About 50% of the respondents were performing their first pilgrimage. Also, more than 50% of the interviewees used the face masks when it was necessary. Furthermore, about 87% of the respondents used surgical masks, and only 7% of the interviewees used N95 particulate respirators. Figure 2 shows photographs of the two commonly used face masks, surgical face mask (left) and N95 particulate respirator (right).

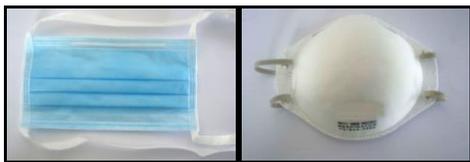
### 3.3 Factors Influencing the Use of Face Masks

Table 2 summarizes the mean responses to the questions in the survey about the factors influencing the use of face masks. Table 1 shows the three most important factors that affect the use of face masks: 'Explanation of Islamic law,' 'Motivation by health,'

and 'Universal design.' The factors that influenced the use of face masks with moderate mean values were 'Mandatory by Tabung Haji (TH),' 'Easy to Wear,' and 'Additional Functionality.' Factors that influenced the use of face masks with the lowest means were 'Used at Risky Places,' 'Durability,' and 'Difficulty for Women.'

**Table 1** Demographics of Malaysian Umrah pilgrims (N = 30)

Variable	N (%)
Sex	
Male	24 (80)
Female	6 (20)
Academic qualification	
Ph.D./Degree	4 (13.33)
Bachelor's Degree	9 (30)
Diploma	4 (13.33)
Malaysian Certificate of Education	12 (40)
Primary School	1 (3.33)
Occupations	
Government	7 (23.33)
Private	8 (26.67)
Pensions	5 (16.67)
Self-employed	7 (23.33)
Others	3 (10)
Number of pilgrimages (Haji or Umrah)	
First time	14 (46.67)
2 – 4 times	11 (36.67)
5 – 8 times	5 (16.67)
9 – 12 times	0 (0)
13 times and above	0 (0)
Frequency of wearing a face mask	
Always	0 (0)
Outside accommodation	3 (10)
During worship	0 (0)
Crowded places	7 (23.33)
When necessary	16 (53.33)
Infrequently	4 (13.33)
Types of face masks used	
Surgical mask	26 (86.67)
N95 particulate respirator	2 (6.67)
EN 149 cone mask	0 (0)
Safety mask	1 (3.33)
Cotton mask	1 (3.33)



**Figure 2** Photographs of two commonly used face masks: surgical face mask (left) and N95 particulate respirator (right)

As indicated by the respondents, explanation of Islamic law ruling over the use of face masks during pilgrimage is a major factor that influences the use of face mask. Therefore, the responsible agencies should ensure that pilgrims are aware of the importance of using face masks and explain to them the exceptions

and flexibilities allowed by Islam to cover part of the face while performing Umrah or Hajj pilgrimage [13]. Although 'Difficulty for Women' has been indicated to be the lowest factor of influence, it should be noted that only 20% of the respondents of the current study were female. It is known that female pilgrims who use veils will encounter problems with using face masks, and the mask designer should take this factor into consideration.

**Table 2** Mean responses for the questions about the factors influencing the use of face (N = 30)

Factors influencing the use of face masks	Mean score
Explanation of Islamic law	4.70
Motivation by health	4.63
Universal design	4.50
Indicator of bacterial and air pollution	4.43
Age factor	4.40
Extra function to improve quality of health	4.40
Easy to Use and Remove	4.33
Mandatory by TH	4.33
Easy to Wear	4.27
Additional Functionality	4.23
Easy Storage	4.23
Medicated Material	4.23
Frequency of Changing	4.13
Appropriate for Worship	4.03
Cost	4.00
Used at risky places	3.97
Durability	3.83
Difficulty for Women	3.73

### 3.4 Problems with the Existing Face Masks

Table 3 summarizes the mean responses for the questions in the survey about the problems with the current face masks. As evident from the table, the respondents felt that face masks being 'Uncomfortable' is a major issue. It is interesting to know that most of the interviewees did not feel that using of face masks was 'Against Sharia.' However, the mean score for this factor indicates that some of the respondents were either not exposed properly or did not understand the Islamic law ruling over the usage of face masks during a pilgrimage. To overcome the problems with the current face masks, the mask designer should optimize the comfortability and effectiveness of the face masks.

### 3.5 Factors Influencing Selection of Face Masks

Table 4 summarizes the mean responses for the questions in the survey about the factors influencing the selection of face masks. It can be seen from the table that the most important factor influencing the selection of face masks was 'Free by TH.' This result means that the pilgrims were willing to use any facemask designs as long as the masks were provided

at no cost by Tabung Haji. Also, as seen in Table 2, the majority of the respondents believed that Tabung Haji should make the use of face masks mandatory for all pilgrims. As shown in Table 4, the factors with the lowest mean responses were 'Knowledgeable of Airborne Illnesses' and 'size availability.' Nevertheless, the average scores of these factors are not too low to be ignored.

**Table 3** Mean responses for the questions about the problems with the existing face masks (N = 30)

Problem with existing face masks	Mean score
Uncomfortable	3.20
Health problems	2.93
Effectiveness	2.80
Long-term usage	2.70
Against Sharia	2.03

**Table 4** Mean responses for the questions about the factors influencing selection of face masks (N = 30)

Factor influencing the selection of face masks	Mean score
Free by TH	4.50
Disease	3.93
Period to change	3.90
Specific for Pilgrims	3.70
Knowledgeable of Airborne Illnesses	3.57
Size availability	3.57

In summary, the important factors that need to be considered while designing new face masks include the explanation of Islamic law about the use of face masks during pilgrimages; universal design for all ages, gender, and facial features; comfortability; and free distribution by Tabung Haji. Also, other factors with high mean responses need to be taken into consideration. Although the respondents do not feel some of the factors as important (e.g., size availability and difficulty for women), the designers still need to take such factors into account while designing new face masks.

### 3.6 Hierarchical Clustering and Factor Analysis

Using hierarchical clustering analysis of the survey data, we obtained a tree diagram, commonly known as a dendrogram which is shown in Figure 3. Based on the arrangement of the clusters, three principal components were identified and labeled on the dendrogram as 'Factors influencing the use of face masks,' 'Factors influencing the selection of face masks,' and 'Problems with the existing face masks.' Figure 4 shows the component plot obtained through factor analysis using principal component analysis extraction method. The top three components

identified from Figure 3 were used to encircle the related factors on the component plot (Figure 4). The encircling was made using ellipses and labeled with black circles (Factors influencing the use of face masks), empty circles (Factors influencing the selection of face masks), and gray circles (Problems with the existing face masks). It can be seen that the components 'Factors influencing the selection of face masks' and 'Factors influencing the use of face masks' are overlapping with some of the factors lying within this overlapping region.

In Figure 4, although some of the factors are present in the negative level, these factors are necessary to produce comfortable and efficient face mask designs. For example, even though the factor 'Against Sharia' has negative levels, the pilgrims should be aware that wearing face masks while performing pilgrimage is not prohibited in Islam. The Department of Islamic Development Malaysia (also known as JAKIM in Malaysia) highly recommends the use of face masks to prevent outbreaks that could endanger the health and lives of pilgrims during the Hajj or Umrah. Saudi Arabia's Ministry of Health also highly recommends and encourages the use of face mask during Hajj to reduce the transmission of airborne diseases. In a study conducted amongst 468 Malaysian pilgrims from the 2013 Hajj season, it was found that about 82.9% Malaysian pilgrims used face masks during Hajj [6]. Although face masks may not provide complete protection from infections, they reduce the incidence of infections by preventing droplet inhalation, which is considered one of the main modes of transmission of most upper respiratory tract infections.

In Figure 4, it can be seen that another factor 'Uncomfortable' presents in negative levels, is indeed one of the most important aspects of designing new face masks. Hajj is a worship that requires all pilgrims to perform physical movements in crowded and confined areas that can raise body temperature. Therefore, new face mask designs must be such that they do not induce heating of the face, can provide air permeability for easy breathing, and provide respiratory dead space [24]. Dead space is a breathing space inside the face mask and is one of the critical factors that affect the comfortability of face masks; with large dead space allowing more relaxed breathing. There are several types of face masks with dead spaces, for example, the cup-shaped and Duckbill masks that have a large breathing space area compared to other face masks such as the flat fold and pleated masks [24]. One of the approaches to reduce facial heating while wearing face masks could be through designing new face masks with reduced facial covering but without compromising the face mask efficiency. Also, new face mask designs must be suitable for men with facial hair to prevent leaks that minimize the effectiveness of the masks.

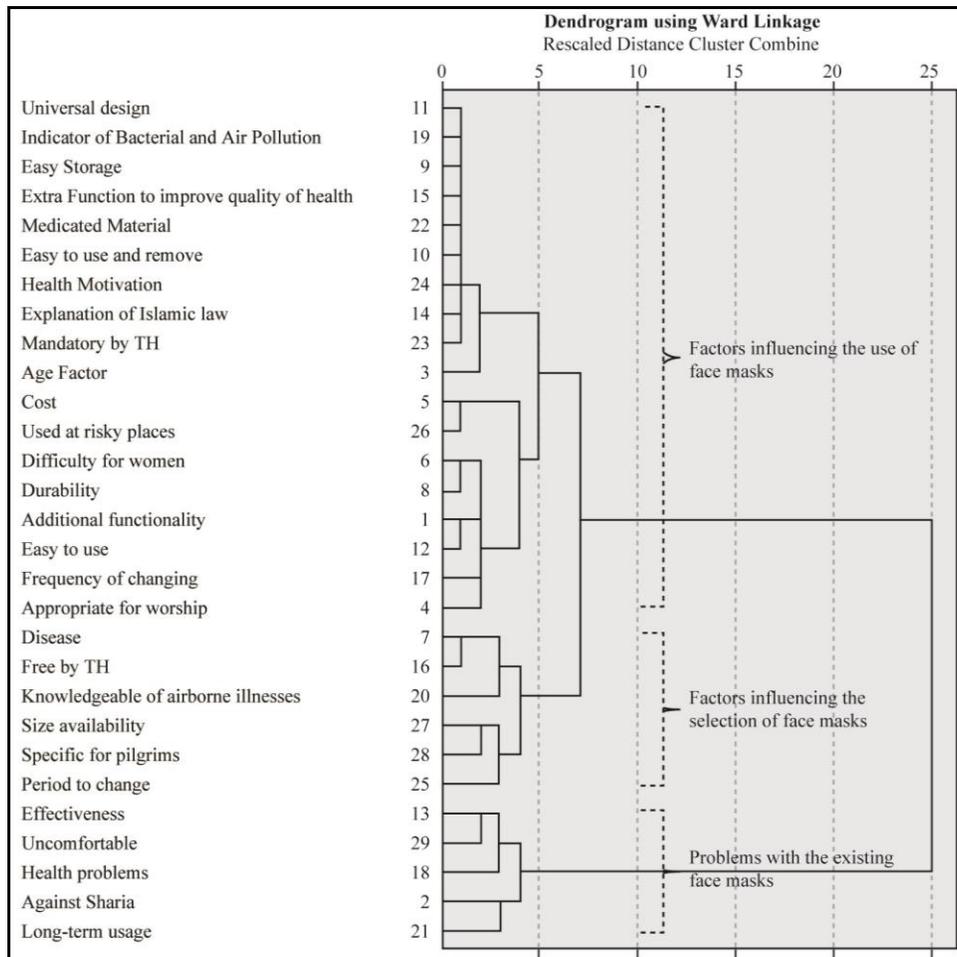


Figure 3 Dendrogram output from hierarchical cluster analysis

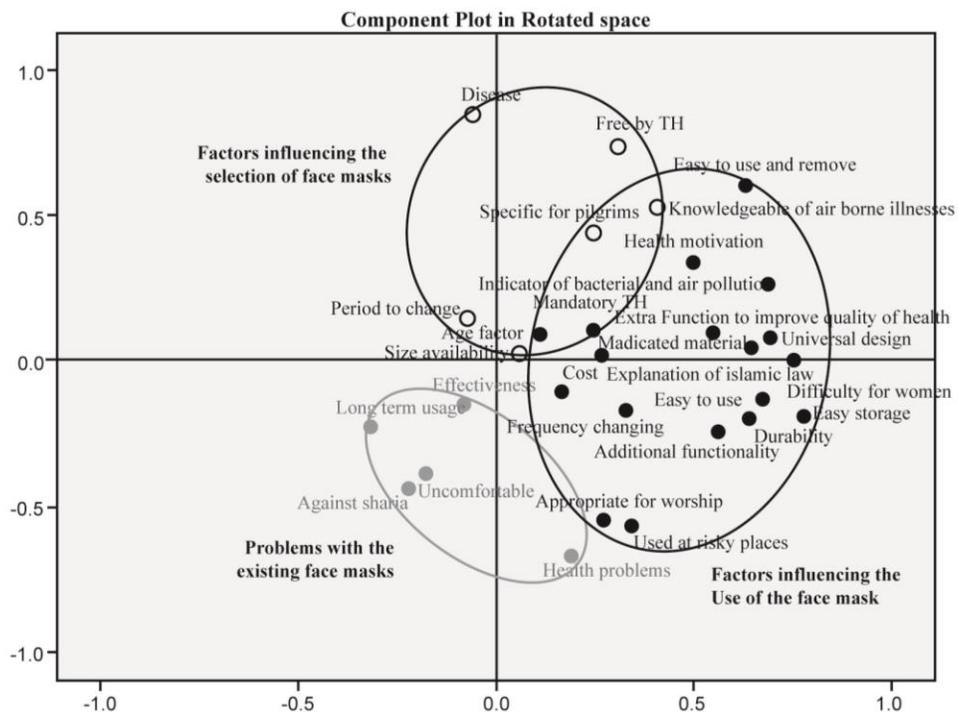


Figure 4 Component plot from factor analysis using principal component analysis extraction method

Furthermore, face masks should be user-friendly and easily disposable. While performing the Hajj, pilgrims need to bring along their personal items. Therefore, new face mask designs should be space saving, so that they are easy to be carried along. It was found that 60% pilgrims preferred to use disposable face masks [8]. However, disposable face masks should be disposed of properly [6], else the microorganisms that were attached to the face masks will become a new source of disease spread. Face masks with excellent design and added value such as medicated materials and indicators of bacterial and air pollution will provide optimum protection and comfort.

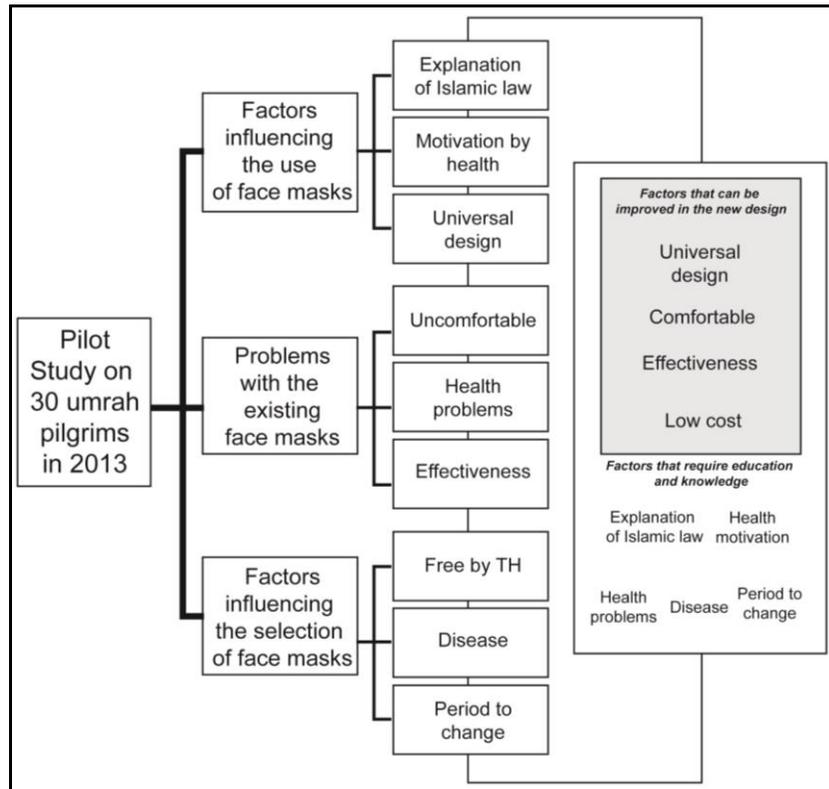
### 3.7 Design Specifications of Face Masks for Pilgrims

In the process of designing face masks, some important aspects need considerable attention such as quality, aesthetics, colors, ergonomics, safety, technology, standards and laws [25]. The results of the current pilot study are anticipated to be used in designing new face masks that would be more comfortable; does not interfere with breathing; wearable by users who have facial hair; and able to reduce heat build-up in the facial region. Figure 5 shows a preliminary model diagram based on the findings of the current study. Table 5 provides the

design specifications, along with a brief explanation of face masks for pilgrims based on previous studies and the results of the current pilot study.

**Table 5** Design specifications of face masks for pilgrims based on previous studies and the results of the current pilot study

Design specification	Explanation
Universal design— Target user	Usable by both genders; availability of different sizes; usable by pilgrims with beard, other facial hair, or other conditions that prevent a good seal between the face and the sealing surface of the face mask
Comfortable	Ergonomic; large breathing space (or dead space) for relaxed breathing; reduced facial covering without compromising the face mask efficiency
Effectiveness	Therapeutic effectiveness of the face masks against airborne infectious diseases is highly critical
Low-cost	Low-cost can allow face masks to be given free of cost by Tabung Haji, as preferred by the pilgrims



**Figure 5** Preliminary model diagram based on the findings of the current study

## 4.0 CONCLUSIONS

In conclusion, results from a pilot study conducted on Malaysian Umrah pilgrims in the 2013 Umrah season have been presented. The survey data analysis concluded that the important factors that need to be considered while designing new face masks include the explanation of Islamic law about the use of face masks during pilgrimage; universal design for all ages, gender, and facial features; comfortability; and free distribution by Tabung Haji. Also, other factors with high mean responses to the survey questions need to be taken into account. Although the respondents do not feel some of the factors as important (e.g., size availability and difficulty for women), the designers still need to take such factors into account while designing new face masks. Furthermore, face mask designers would find the preliminary model diagram and the design specifications of face masks for pilgrims based on previous studies and the results of the current pilot study to be highly beneficial. Based on the knowledge of factors influencing the use of face masks and selection of face masks, new face mask design(s) will be proposed for Malaysian pilgrims. We firmly believe that the use of new face mask design(s) can reduce the risk of acute respiratory infections in Hajj and Umrah pilgrims.

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