



## Research article

# Towards associating negative experiences and recommendations reported by Hajj pilgrims in a mass-scale survey

Adnan Quaium<sup>a,d,1</sup>, Najla Abdulrahman Al-Nabhan<sup>c,1</sup>, Masfiqur Rahaman<sup>a,\*,1</sup>, Saiful Islam Salim<sup>a,1</sup>, Tarik Reza Toha<sup>a</sup>, Jannatun Noor<sup>a</sup>, Mainul Hossain<sup>a,c</sup>, Nafisa Islam<sup>b</sup>, Aaiyeesha Mostak<sup>a</sup>, Md Shihabul Islam<sup>a</sup>, Md. Masum Mushfiq<sup>a</sup>, Ishrat Jahan<sup>a</sup>, A.B.M. Alim Al Islam<sup>a</sup>

<sup>a</sup> Next-generation Computing (NeC) Research Group, Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, Dhaka, 1000, Bangladesh

<sup>b</sup> Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, 1000, Bangladesh

<sup>c</sup> Department of Computer Science, King Saud University, Riyadh, 11362, Saudi Arabia

<sup>d</sup> Department of Electrical and Electronic Engineering, Ahsanullah University of Science and Technology, Dhaka, 1208, Bangladesh

<sup>e</sup> Computing for Sustainability and Social Good (C2SG) Group, Department of Electrical and Electronic Engineering, School of Data and Sciences, BRAC University, Dhaka, 22222, Bangladesh

## ARTICLE INFO

### Keywords:

Religious tourism  
Pilgrimage  
Islamic pilgrimage  
Satisfaction  
Negative experiences  
Suggestions for management

## ABSTRACT

The annual Hajj presents diversified negative experiences to millions of pilgrims worldwide. The negative experiences and recommendations to overcome them as per pilgrims' feedback are yet to be analyzed from an aggregated perspective in the literature, which we do in this paper. To do so, first, we perform a large-scale survey (n = 988) using our comprehensive questionnaire. Then, we perform both quantitative (e.g., clustering) and qualitative (e.g., thematic) analyses on the survey data. Our quantitative analysis reveals up to seven clusters of negative experiences. Further, going beyond the quantitative analysis, our qualitative analysis reveals 21 types of negative experiences, 20 types of recommendations, and nine themes connecting the negative experiences and recommendations. Accordingly, we reveal associations among the negative experiences and recommendations based on the themes in thematic analysis and present the associations through a tripartite graph. However, we have some limitations in this study, such as fewer female and young participants. In future, we plan to collect more responses from female and young participants and extend our work by analyzing linkages in the tripartite graph by augmenting the edges within the graph with appropriate weights. Overall, the findings of this study are expected to facilitate the prioritization of tasks for the management personnel in charge of the Hajj pilgrimage.

## 1. Introduction

Tourism for religious purposes gains significant attraction to researchers in the field of travel and tourism in recent years [1,2]. In general, religious tourism includes pilgrimage, religious festivals, religious conferences, and so on. Among different religious tourism

\* Corresponding author.

E-mail address: [0421052008@grad.cse.buet.ac.bd](mailto:0421052008@grad.cse.buet.ac.bd) (M. Rahaman).

<sup>1</sup> Authors contributed equally to this research.

<https://doi.org/10.1016/j.heliyon.2023.e15486>

Received 25 November 2022; Received in revised form 9 April 2023; Accepted 11 April 2023

Available online 14 April 2023

2405-8440/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

events, the Hajj pilgrimage is an important field of research due to its immensity and diversity [3,4]. Researchers are studying different aspects of the Hajj pilgrimage including spirituality, stakeholder relations, expectations, and disappointments among others [2,5,6]. Among those aspects, understanding pilgrims' disappointment and experience of different negative experiences is very important for administrations and management because they can take measures to eradicate such experiences. In this study, we explore different negative experiences, understand recommendations to resolve those experiences and associate negative experiences with recommendations from the pilgrims' perspectives. Here, we define negative experiences as different problems, hurdles, and unexpected events that make the pilgrimage problematic. On the other hand, recommendations are advice and solutions from pilgrims to resolve the negative experiences.

Hajj is a pilgrimage to Mecca in Saudi Arabia during the Islamic calendar's final month (Dhul-Hijjah). It is obligatory for a Muslim, who has the financial capacity and other required capabilities to make it at least once in his/her lifetime [7]. Each year, 2-3 million people of different ethnicities and nationalities from all around the globe perform Hajj [8]. Though during the COVID-19 pandemic, in the years 2020 and 2021, this number falls to a very small value of 1000 and 60,000 respectively, as an exception, in 2019, around 2.5 million people took part in Hajj [9-11]. In 2022, the number of Hajj pilgrims has increased to one million compared to the years 2020 and 2021 [12]. It is expected to get the event back to its real crowds or even much larger, once the extent of the ongoing pandemic gets pacified. Hajj is a demonstration of Muslim's submission to the Almighty (Allah). Therefore, its fulfillment has religious and social significance for Muslims. Because of the expenses associated with Hajj, performing it is also a financial obligation for them. The financial expenses include plane tickets, housing, transportation, and food among others. Pilgrims have to spend a considerable amount of money to perform all the rituals during the Hajj season which varies by country. However, sometimes, pilgrims face unexpected experiences that lead to dissatisfaction and discomfort for them.

Some of the negative experiences (e.g., health, heavy crowds, way-finding, and accommodation problems) are already investigated in the existing literature [13-17]. However, such existing studies have some limitations. First, they analyzed a specific negative experience, rather than all negative experiences in aggregation. Therefore, the existing studies fail to reveal any association between all the negative experiences and recommendations. Understanding such associations is important, as this can facilitate the management personnel for planning better services during Hajj. Second, for such studies, which method of analysis (e.g., quantitative or qualitative) is more appropriate is yet to be studied in the literature. Finally, though they performed quantitative analysis on the pilgrimage experience, we did not find any study where thematic analysis was performed to comprehensively analyze the negative experiences of Hajj pilgrims. However, thematic analysis is a widely used method to analyze qualitative responses.

To address these gaps in the literature, we perform a mass-scale<sup>2</sup> survey covering a total of 988 pilgrims who have performed Hajj, Umrah, or both at least once in their lifetime. After collecting the survey responses, we select participants who performed the Hajj pilgrimage at least once and this constitutes 694 participants. Then, we perform a quantitative analysis followed by a thematic analysis of the responses from 694 Hajj pilgrims. Based on the findings of both types of analyses, we investigate which method of analysis gives more comprehensive outcomes in analyzing negative experiences during the Hajj pilgrimage. We consider this study more comprehensive due to the large sample size (n=988) as well as the consideration of almost all types of negative experiences and possible recommendations in aggregation. Moreover, both the negative experiences and recommendations were revealed by the participants which provide more comprehensive findings.

Our findings from the analyses reveal nine themes, 21 negative experiences, and 20 recommendations. Then, we prepare a tripartite graph consisting of negative experiences, themes, and recommendations. The themes are listed as - 1) negative impacts of overcrowding and their mitigation, 2) accommodation issues due to agencies' mismanagement, 3) difficulties and special needs of female, aged, and disabled pilgrims, 4) pilgrims getting lost and difficulty in getting them back, 5) pilgrims' experiences of violations of laws and norms, 6) sickness of and treatment for pilgrims, 7) support from law enforcing agencies and volunteers, 8) technological limitations and expectation to technologies, and 9) feeling of pilgrims after Hajj. Based on our work in this paper, we answer the following research questions in this study.

- **RQ1:** How far can we compare quantitative and qualitative approaches in analyzing negative experiences in a comprehensive manner?
- **RQ2:** What are the negative experiences and possible recommendations from the pilgrims' viewpoint during the Hajj pilgrimage?
- **RQ3:** From an aggregated perspective, how can the different types of negative experiences be categorized into themes? Based on the themes, how can the negative experiences and recommendations be associated with each other?

## 2. Related work

Religious tourism (e.g., The Hajj in Mecca), driven by spiritual beliefs, is a global occurrence that dates back to the origin of religion and encompasses all types of religious affiliations [19,20]. A few of them explore the territory of the religious tourism experiences [21-23]. Compared to other religious tourism, the Hajj pilgrimage to Mecca is distinct due to the gathering of a large number of pilgrims over a period of several days. Due to having a massive crowd in a short period at Mecca, pilgrims face different kinds of negative experiences while performing Hajj [24-26]. It can be ameliorated by exploring the real-life experiences and recommendations of Hajj pilgrims.

<sup>2</sup> In the earlier literature, we find an average sample size of 371 with a standard deviation of 368 for survey-based studies [18]. In comparison to their range of sample size, we consider our study mass scale, as we have collected more responses (n=988).

Several research studies report diversified real-life negative experiences faced by the Hajj pilgrims [25,17,27,28]. Ali et al., 2020 [25] discussed different issues and challenges in Hajj management from Bangladesh's perspective. These include illegal human trafficking, government monopoly of pilgrimage airfare, excessive pilgrimage fees, insufficient accommodation, scarcity of transport, and so on. Apart from Bangladeshi pilgrims, Rahman et al., 2017 [26] revealed the experiences of pilgrims from Pakistan, Myanmar, and New Zealand. Pilgrims from Myanmar and Pakistan expressed their dissatisfaction regarding accommodation and camp quality, whereas pilgrims from Australia and New Zealand were content with the overall quality. Besides, pilgrims from both countries observed better conditions in Medina than in Mecca. The distinction of experience between developing countries and developed countries is prominent in this study. In studying accessibility to technology, Alayed and Asma 2022 [29] studied Arab old people using a pandemic-driven mobile app named Eatmarna during the COVID-19 period. Their study provided insight into the challenges that were faced by elderly people when using pandemic-driven apps.

Considering health issues, many studies investigated pilgrims' health condition during the Hajj pilgrimage and different factors associated with it [17,30–32]. Taibah et al., 2020 [17] inquired about which health-related threats concern foreign Hajj pilgrims visiting Saudi Arabia, how they typically seek information to be better prepared against these threats, and what economic, social, language, and cultural barriers they face. Noweir et al., 2008 [30] describe the relation between heat casualties and climate heat load during Hajj seasons. Besides, Parker et al., 2022 [31] studied the effect of supervised exercise programs on the physical and mental health of Hajj pilgrims. This study found the supervised exercise programs for Hajj pilgrims having a positive effect on their physical and mental conditioning, which may reduce morbidity. Moreover, Ridda et al., 2021 [33] investigated the key aspects of public health concerns during the Hajj pilgrimage. They proposed a framework to ensure safe and healthy mass gatherings during Hajj/Umrah.

Apart from Hajj, Jyotsna and Sai 2022 [34] investigated the key influencing factors and expected outcomes of the Hindu pilgrimage experience in India. They performed an Interactive Qualitative Analysis to understand different drivers and factors influencing the pilgrimage experiences. Their study finds destination popularity, safety, local culture, accessibility, hygiene, the timing of the visit, pilgrim turnout, and temple service pricing as significant drivers for better pilgrimage management.

Besides, some studies investigated necessary measures to be taken to ease pilgrimage experiences [35–38]. To ease navigation in Hajj, Alkharoubi 2020 [35] conducted a study to improve pilgrims' way-finding experiences during the period of Hajj. Their study reveals recommendations including educational and training programs on way-finding systems for pilgrims, introducing more pedestrian walkways and services, integrating navigation apps like Google Maps, and using tracking chips that link between pilgrims' bracelets and way-finding elements. In some studies, pilgrims suggested that they must be guided by a volunteer who belongs to the same nationality as that group [36,37]. In the context of mobile applications, Majrashi et al., 2018 [38] conducted a study to investigate the experiences of Hajj mobile service users during Hajj 2017. They performed thematic analysis and associated the emerged themes with specific implications for designing a better user experience of mobile applications for Hajj. However, they did not show any graphical association between negative user experiences and recommendations to resolve those experiences.

In the existing literature, most of the studies investigate negative pilgrimage experiences in different contexts. Besides, a few studies report recommendations from pilgrims to improve the experience for some specific contexts. However, these studies have yet to present a comprehensive analysis of the negative experiences faced by pilgrims and recommendations to resolve those by the same group of pilgrims in an aggregated perspective e.g., showing the association between negative experiences and recommendations. In addition, these studies fail to reveal most of the negative experiences and recommendations during Hajj. Moreover, these studies do not perform any aggregated thematic analysis of the negative experiences and recommendations. Whereas, Thematic Analysis is a commonly used form of qualitative research analysis that focuses on identifying, analyzing, and interpreting patterns of meaning within qualitative data [39–41]. Therefore, considering the gaps in existing literature, we have conducted a survey followed by necessary analyses including Thematic Analysis to investigate pilgrimage experiences.

### 3. Methodology

In our study, first, we conduct the data collection and preprocessing of the data. Then, we adopt a mixed design analysis where first, we perform qualitative analysis, such as the Thematic Analysis of the responses followed by generating a tripartite graph. In parallel, we perform clustering to find similarities in the responses which is a quantitative method. We present the methodology of our study as a flowchart in Fig. 1.

#### 3.1. Data collection

In this section, we demonstrate the different steps we follow during the collection of responses from pilgrims.

##### 3.1.1. Questionnaire preparation

In our study, to understand pilgrim's experience during the Hajj pilgrimage, we prepare a questionnaire. We choose English as the language for the remote questionnaire. Besides, we choose both English and Bengali for the in-person questionnaire as most of the participants in the local community understand Bengali well. The questionnaire consists of 49 questions. We design the questionnaire in a self-completed written form and storytelling manner such that pilgrims can remember their experience easily and answer the

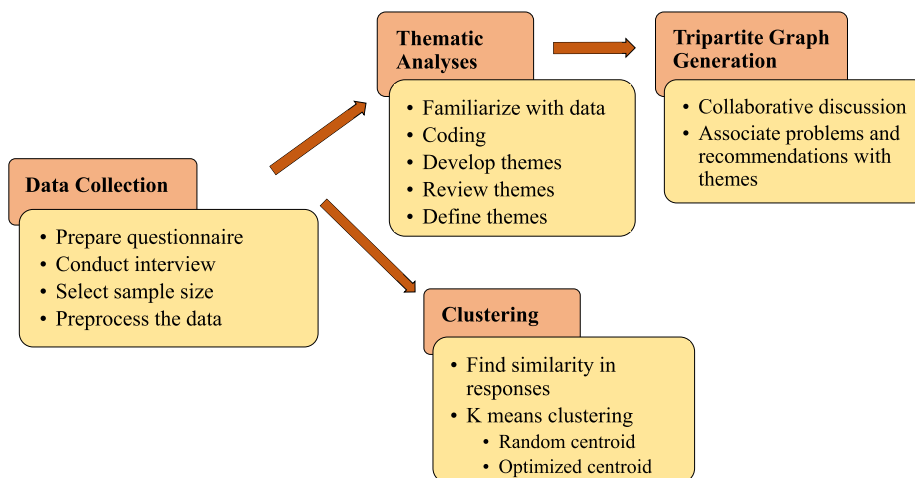


Fig. 1. Our proposed methodology in this study.

questions without any interviewer or help from other persons. The questionnaire consists of binary choice, multiple choice, and open-ended<sup>3</sup> questions. For a detailed overview, we include our questionnaire as a supplementary file.

As the questionnaire used in this study is researcher-made (i.e., authors prepared this questionnaire through open discussions among themselves), we validate the questionnaire with the help of experienced ones and through statistical methods. First, one of the authors who is a citizen of Saudi Arabia and currently residing there helped us to validate the questionnaire. As she has experience with the Hajj pilgrimage multiple times, she helped a lot in suggesting her opinion regarding different problems during the pilgrimage. Second, to better understand the situation there, a group of authors has gone to Saudi Arabia and performed the Umrah pilgrimage. This also helped to validate our questionnaire in light of their experience. Finally, we measure the internal consistency reliability of our questionnaire using the Kuder-Richardson Formula 20 or KR-20 test which gives a value ranging from 0 to 1, with a higher value indicating higher reliability [44,45]. The KR-20 score of our questionnaire is 0.62 which is above 0.5 and thus, we can say that our questionnaire is reliable for conducting the survey.

### 3.1.2. Survey conduction

We have taken approval from the ethics committee of the authors' institution regarding the survey conduction. We have asked for consent from participant pilgrims at the beginning of the survey. During the in-person survey, we inform pilgrims that they will be asked about their negative experiences and difficulties during the pilgrimage. First, we collect demographic information (gender, age, education, language, and experience with using smart devices). Then, we ask if the pilgrim gets lost anytime during Hajj. If the pilgrim answers yes, we proceed to some relevant questions related to getting lost and ask about his/her recommendation to resolve this problem. If s/he answers no, we ask the next question on negative experiences. In the same manner, we ask other questions about negative experiences, such as getting sick, getting drinking water, scarcity of washrooms, and finding transport among others.

During the remote survey, the authors disseminate the remote questionnaire through emails and social media, such as Facebook. Following both surveys, we collect responses from 988 pilgrims (in-person: 752 and remote: 236) who performed either Hajj, Umrah, or both at least once.

### 3.1.3. Selection of sample size

To collect responses from the participant pilgrims, we have used a random sampling technique so that the collected responses be unbiased and can be representative of the entire population. To determine the sample size, we follow the Data Saturation method which is a well-established method for qualitative data collection. The rationale towards following Data Saturation method is that we have received sufficient free-form responses (i.e., responses accumulated through 'Others' field in the questionnaire) from the participants and the Thematic Analysis which we adopt in this study is based on those responses. Following this method, we continue collecting responses until no new relevant information emerges. Besides, the sample size (n=988) we accumulate is justifiable according to a recent study on papers published in CHI '14 where the sample size for remote surveys has an average figure of 371 [18].

<sup>3</sup> We have provided 'Others' option in 21 questions among a total of 49 questions in our questionnaire allowing respondents to give free-form answers. Here, it is worth mentioning that the alternatives provided along with the 'Others' option are presented simply to facilitate providing answers by the respondents, rather than limiting their answers to those alternatives [42,43]. The simple facilitating part becomes evident from our collected responses, as we received many free opinions from the respondents (presented in Appendix A.2). The whole Thematic Analysis in our paper is based on those free opinions. Therefore, we consider the questions having 'Others' options as open-ended ones.

**Table 1**  
Demography of the 694 participants pilgrims.

Distribution	Number of participants	Percentage (%)
<i>Gender</i>		
Male	483	70
Female	211	30
<i>Age groups</i>		
Youth (1-14)	5	1
Young adulthood (15-24)	36	5
Middle adulthood (25-44)	225	32
Older adulthood (45-64)	383	55
Retirement (65+)	45	6
<i>Education level</i>		
Below primary school	161	23
Primary school	78	11
High school	160	23
Bachelor degree	295	43
<i>Country of living</i>		
Bangladesh	616	89
Saudi Arabia	19	3
Malaysia	11	2
India	9	1
United States	5	1
Others	36	6
<i>Language</i>		
Bengali	638	92
English	332	48
Hindi	72	10
Arabic	94	14
Urdu	84	12
Bahasa Malay	12	2
Others	36	5

### 3.1.4. Data preprocessing

Among the survey responses ( $n=988$ ) in our study, we identify some responses which were not collected as per the regulations of the survey (e.g., should be first-hand data, should explain each question comprehensively, etc.). We consider such responses to be untrustworthy. Following the removal of such responses, we get 900 credible responses.

Then, among the participants of our survey, some performed only Hajj, some performed Umrah, and some performed both. As there exist significant differences in the times and activities performed during Hajj and Umrah, there remain substantial differences in the experiences of the pilgrims who performed Hajj and who performed Umrah. Therefore, in this study, we consider responses from only those participants who performed Hajj at least once ( $n=694$ ) in their lifetime.

### 3.2. Participants' demography

We provide a highlight of the demographic characteristics of the selected 694 participants in Table 1. Here, participants are mostly from Bangladesh, 89% ( $n=616$ ), and others are from 21 different countries such as Saudi Arabia, Kuwait, Qatar, Malaysia, India, Pakistan, Algeria, United States, Australia, Nigeria, Egypt, Germany, Indonesia, Ireland, etc. Though a vast majority of participants ( $n=616$ ) in our study are from locals in Bangladesh, the number of international participants ( $n=78$ ) is also substantial. Therefore, to get a wider picture of the Hajj pilgrimage, we consider it justifiable to analyze responses from all local and international pilgrims. Apart from nationality, the ages of the pilgrims (during the survey period) ranged from 13 years to 88 years (average of 49 years), and the age while performing Hajj ranged from 6 years to 82 years (average of 47 years). 70% of the pilgrims self-report as male, whereas the rest are female. 23% of the participants' literacy level is below fifth grade and 43% are in the undergraduate stage or above.

### 3.3. Quality of survey responses

We compute pair-wise hamming distances between survey responses to understand the diversity in our responses or to know how similar the responses are, i.e., two responses having lesser hamming distance values are more similar [46]. Fig. 2 shows the density values (or probability density function) of the calculated hamming distances. The figure exhibits a Gaussian or Normal distribution shape. We fit the probability density function to a Gaussian distribution using R and get the parameter values as: mean = 0.43 and standard deviation = 0.14. This finding, i.e., fitting the probability distribution function to a Gaussian distribution, implies that the received responses are not very similar and they exhibit substantial differences from each other in general. This finding confirms that our collected dataset possesses diversified information within it, as it is mostly free from having a repetitive nature.

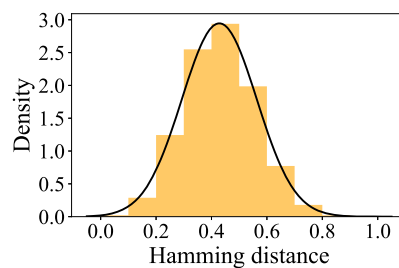


Fig. 2. Distribution of hamming distances between survey responses with normal distribution fit.

Besides, it is worth mentioning that the quantitative part of the dataset (which is completely disjoint from the qualitative part of the survey responses within the same dataset) was explored in a prior study conducted by Salim et al., 2021 [47] to check for the credibility of the data collectors. However, in that prior study, we did not use any qualitative data of this dataset. Thus, even though the quantitative part of the dataset was explored before, the qualitative part of the dataset is explored for the first time in this paper.

### 3.4. Clustering on survey responses

We have collected survey responses from 694 pilgrims who have performed Hajj at least once in their lifetime. From our analysis of the quality of survey responses, this is clear that our collective responses are much more diverse. Now, to better understand the responses and their similarity, we perform clustering on the responses. Specifically, the purpose of clustering is to know how many similar types of responses prevail in the data. From the similar types of responses, we hope to identify similar problems or similar recommendations which may allow us to compare those experiences and recommendations with themes that answer our RQ3.

In our questionnaire, there are two types of questions i.e., demography and negative experiences. Besides, most of the questions have categorical options. Therefore, we perform k-modes clustering on the responses to find possible clusters [48]. In clustering, we do not consider the open-ended questions that pilgrims can answer with open-ended responses. The open-ended responses are considered when we perform thematic analysis which we discuss in a later subsection. Rather, we perform clustering only on the closed-ended responses. We use the kmodes library available in python for clustering [49].

k-Modes algorithm uses dissimilarities (total mismatches) to measure the distance between two data points. This implies that the lesser the dissimilarities the more similar the responses are. Besides, in this method of clustering, centroids are updated by Modes. To choose the initial centroid for k-modes clustering, we adopt two approaches i.e., random centroid and optimized centroid. In the random centroid approach, we choose the initial centroid of the cluster randomly. In the optimized centroid approach, we use a genetic algorithm to optimize the centroid and use the optimized centroid as the initial one.

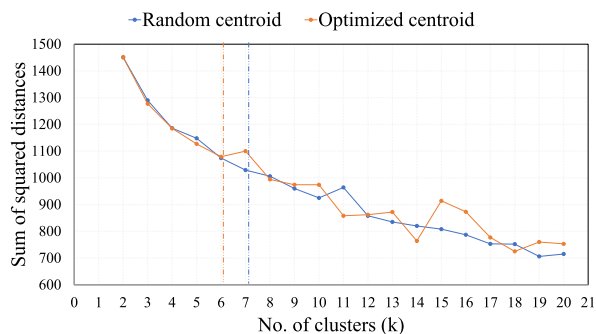
### 3.5. Thematic analysis

In our survey questionnaire, we have provided some open-ended questions so that participants can answer those questions in an open-ended manner. At the end of the survey, we received a handsome amount of open-ended responses from the participants in text format. Though we get enough amount of data for quantitative analysis, such analysis is not appropriate for open-ended responses. Whereas, qualitative analysis is better to analyze open-ended responses. Moreover, in a recent study on appropriate sample size for research, it is found that in some 41 qualitative studies before 2016, the sample size has a mean and standard deviation of 155 and 257 respectively [18]. Hence, we have enough responses according to this study, and the necessity of analyzing open-ended responses, we find it justifiable to analyze our data qualitatively. Thus, we use thematic analysis to understand negative experiences and inherent themes in responses [50,51]. To accomplish the task of thematic analysis, we went through the data several times, and systematically identify along with cluster the themes or codes that were present. Two researchers independently generate the codes, compare them, and reiterate the responses until we have a consistent code book. Then, in a discussion, they merge their codes and generate a final codebook. They further organize and taxonomize our codes into higher-level categories. Finally, the researchers give each of these high-level categories appropriate names which eventually conclude the themes.

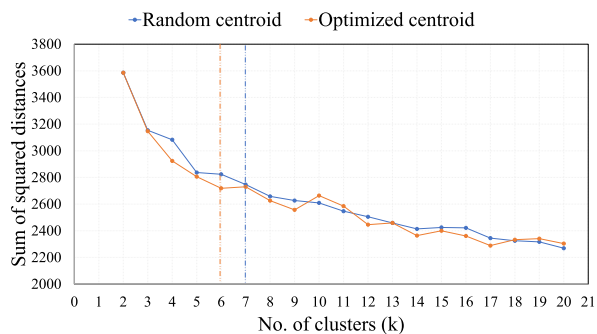
Based on the themes, we build a graph network associating themes with negative experiences and recommendations. The motivation behind building such a graph network is to know which negative experiences are similar as well as which recommendations are similar. After finalizing the themes, we go through several collaborative discussions to associate each theme with relevant negative experiences and recommendations. We also take help from the codebook for finding the associations. Since our research is partitioned into three disjoint sets (i.e., negative experiences, themes, recommendations), we try to build a tripartite graph network to relate those three sets.

## 4. Results

We describe the results of our above-mentioned analyses in this section. This section constitutes the results of clustering-based analysis, thematic analysis, and generation of graphs. Then, in Section 5 (Discussion), we answer in detail how these results answer our research questions.



(a) Number of clusters considering only the negative experiences reported by the pilgrims



(b) Number of clusters considering both the negative experiences reported by the pilgrims and the demography of the pilgrims

Fig. 3. Number of clusters considering only the negative experiences reported by the pilgrims as well as both the negative experiences and demography of the participants. The optimal number of clusters using the elbow method is shown by vertical dotted lines.

Table 2

Description of response count and information content in each cluster (considering only negative experiences).

Random centroid			Optimized centroid		
Cluster id	#Responses	Information	Cluster id	#Responses	Information
C1	173	Negative experiences in - Entering into Masjid Al haram	C1	226	Negative experiences in - Entering into Masjid Al haram - Arafah
C2	99	Negative experiences in - Finding hygienic washroom - Entering into Masjid Al haram	C2	240	Very few report of negative experiences
C3	70	Negative experiences in - Finding camp at Mina	C3	53	- Getting lost - Finding camp at Mina
C4	54	- Getting lost during pilgrimage	C4	93	Faced almost all negative experiences
C5	52	Many negative experiences	C5	24	Negative experiences in - Getting food - Finding camp at Mina - Finding washroom
C6	216	Very few report of negative experiences	C6	58	Negative experiences - Getting food - Finding washroom
C7	30	Negative experiences in - Finding camp at Mina - Getting food - Finding transportation - Communication			

4.1. Results on cluster analysis

Our clustering-based approach results in some insightful findings along with some challenges. The key challenge is to identify the optimal number of clusters. We apply Elbow method for different number of clusters (k) to find an optimal k value. However, as shown in Fig. 3a and 3b, the knee point is not clearly visible. Thus, we use the kneed library available in python to locate the knee point precisely which is also being used by some recent studies [52–54].

In Fig. 3a, according to the Elbow method and knee locator function, the optimal number of clusters for random centroid and optimal centroid are seven and six respectively (marked by blue and orange vertical lines). This implies that we have seven and six types of responses for random and optimal centroid respectively considering only the negative experience-related responses. Moreover, in Fig. 3b considering both problem and demography the number of clusters does not change. This signifies that the demography of pilgrims does not have any significant impact on the types of responses.

**Table 3**

Description of response count and information content in each cluster (considering both negative experiences and demographics of pilgrims).

Random centroid			Optimized centroid		
Cluster id	#Responses	Information	Cluster id	#Responses	Information
C1	195	- Aged pilgrims - Fluent in speaking English - Mixed opinion towards negative experiences	C1	121	- Female pilgrims - Fluent in speaking English - Transportation
C2	68	- Graduate or have higher degree - Little negative experiences	C2	165	- Aged pilgrims - Few can speak in English
C3	97	- Aged pilgrims - Mixed opinion towards negative experiences	C3	131	- Aged pilgrims - Fluent in speaking English - Few faced negative experiences
C4	76	- Graduate or have higher degree - Fluent in speaking English - Negative experience inside Masjid Al Haram	C4	121	- Fluent in speaking English - Some pilgrims faced negative experiences
C5	58	- Aged pilgrims - Many negative experiences	C5	42	- Some pilgrims can speak in English - Many negative experiences
C6	122	- Aged pilgrims - No smart device - Little negative experiences	C6	114	- Aged pilgrims - Not fluent in speaking English - Faced very few problems
C7	78	- Graduate or have higher degree - Fluent in speaking English - Many negative experiences			

Then, we dig deeper into each cluster (e.g., number of responses and information in a cluster) to better understand what those clusters constitute of. In doing so, we read through the responses for each cluster and identify the negative experiences and demographics for that cluster. The result is shown in Table 2 and 3 for only negative experiences and both negative experiences and demographics respectively. In each table, we show three attributes (e.g., Cluster id, number of responses, and information in corresponding Cluster id).

#### 4.2. Results on thematic analysis and graph

Our thematic analysis reveals nine themes that cover 21 problem events and 20 recommendations. Problems and recommendations from participants are listed in Table 4. Our revealed themes and short description for each theme are provided in Table 5. Alongside themes, our analysis reveals a tripartite graph that connects negative experiences and recommendations to themes. The tripartite graph is illustrated in Fig. A.4 of Appendix A.1. This graph represents a visual gist of the whole thematic analysis as it presents all nine themes with negative experiences and recommendations in a single picture. In the remainder of this section, we describe each theme in detail and present the tripartite graph for each theme.

##### 4.2.1. Negative impacts of overcrowding and their mitigation

Overcrowding is one of the leading reasons for many problems in the event of Hajj including difficulties in Masjid al-Haram, lack of transportation, lack of sanitation, getting lost, etc. If such a heavy crowd can be managed efficiently, many of those problems are expected to be resolved, or at least their extent should be reduced.

One of the crowded locations in Hajj is Masjid al-Haram. Masjid al-Haram has a total of 210 gates [55]. Among those, some remain closed due to heavy crowds inside the mosque. There is a specific time duration of opening and closing gates as stated by one participant, "A person was not allowed to enter if s/he went outside the time set there." P575 mentioned, "A serious problem is when crowd increases in Masjid al-Haram, volunteers keep closing the gates one after another. Then a pilgrim has to run from one gate to another to enter the mosque and often can not enter." For the same reason, P650 missed her prayer as stated, "They asked to enter through another gate and because of that my prayer was missed." P585 regrets by saying, "I can't even touch the Hajar al-Aswad (The Black Stone). This is the biggest regret in my life." To reduce the extent of such experiences P492 suggests making a corridor leading to Hajar al-Aswad as stated, "Authority should make a corridor by setting fence beside Rokne Yamani to Hajar al-Aswad. It will help to provide access for limited people to touch the black stone."



**Table 4**  
Negative experiences and recommendations from participant pilgrims.

Negative experience		Recommendation	
1.	Difficulties related to Masjid al-Haram	1.	Remembering a particular spot to meet
2.	Lack of privacy for female pilgrims	2.	Improving the food and shelter facilities
3.	Failed to touch the Hajar al-Aswad	3.	Easing the access to Mataf
4.	Lack of transportation facilities	4.	Taking extra care for disabled and aged pilgrims
5.	Getting lost	5.	Employing technology in the crowd guidance system
6.	Difficulty in navigation	6.	Monitoring of the Hajj agencies
7.	Lack of sound facilities	7.	Improving the management of Hajj authorities
8.	Lack of sanitation facilities	8.	Extending the present infrastructures
9.	Harsh environment	9.	Providing extra facilities for female pilgrims
10.	Mismanagements of Hajj authorities	10.	Improving the telecommunication facilities
11.	Language barrier	11.	Increasing the number of well-trained volunteers
12.	Lack of food and shelter facilities	12.	Easing the navigation
13.	Losing belongings	13.	Improving the security
14.	Lack of cooperation	14.	Improving the sound system
15.	Lack of telecommunication facilities	15.	Improving the sanitation facilities
16.	Accident	16.	Monitoring the price of necessary services and products
17.	Difficulties faced by pilgrims with special needs	17.	Increase the awareness of pilgrims
18.	Carelessness of Hajj agencies	18.	Improving the transportation facilities
19.	Lack of medical facilities	19.	Improving the medical facilities
20.	Unexpected behavior towards pilgrims	20.	Improving the multilingual services
21.	Lack of basic knowledge and etiquette		

**Table 5**  
Description of themes.

Theme	Description
Negative impacts of overcrowding and their mitigations	How overcrowding situations exhibit different negative impacts (congestion in Mataf, transportation, sanitation, etc.) during Hajj and what might the solutions for those impacts
Accommodation issues due to agencies' mismanagement	How mismanagement of Hajj agencies cause accommodation problems to pilgrims and how to resolve those problems
Difficulties and special needs of female, aged, and disabled pilgrims	What are the difficulties faced by and special needs of female, aged, and disabled pilgrims, and ways to fulfill the needs
Lost pilgrims and getting them back	What are the reasons behind getting pilgrims lost and how to resolve this problem
Pilgrims' experiences of violations of laws and norms	What are the violations of laws and norms (having theft, losing belongings, etc.) faced by the pilgrims, and how to resolve them
Sickness of and treatment for pilgrims	How often pilgrims get sick and how far they get proper treatment
Support from law enforcing agencies and volunteers	How far the pilgrims get support from law enforcing agencies and volunteers, and how language barriers exhibit an impact here
Technological limitations and expectation to technologies	What technological limitations (limited navigation, no support while getting lost, poor sound facility, etc.) are faced by the pilgrims and what technological expectations pilgrims have
The feeling of pilgrims after Hajj	How the pilgrims feel, sense, and retrospect after the completion of Hajj

#### 4.2.2. Accommodation issues due to agencies' mismanagement

The accommodation problem is one of the most severe problems during the Hajj season. As millions of people from all over the world come to a specific location for their pilgrimage, the shortage of hotels and sometimes quality and service become very worse, especially in Mina where pilgrims reside in tents. Besides, the carelessness of Hajj agencies makes the situation more unpredictable.

Hajj agencies are responsible for managing the food and shelter facilities for the pilgrims. They often provide low-quality food and shelter to the pilgrims. Hence, discord among Hajj agencies and pilgrims occurs frequently. For instance, P586 shares his and his wife's Hajj experience, "Camp was much overloaded and cheap-rated. As the Muallem (the agency's representatives) and Hajj agencies were dishonest, they rented low-rated and long-distance tents. Therefore, pilgrims quarreled with the Muallems almost every time. As we faced this type of problem, we didn't stay in the tent. We stayed those time under a tree with my wife". Besides, the number of beds at each tent is not enough for the allocated pilgrims, and in some cases, pilgrims had to reside in walkways as mentioned by P495, "Every year we see that the Muassasah (responsible authority) give fewer beds than the number of pilgrims. Each pilgrim must have beds in a proper place, not in walkways"

The participant also mentioned his recommendation regarding this harassment as stated, *“Please, this is my heartiest request to you, please, please, please, the Hajj agencies and the Mualllems should be monitored very tightly as they can’t do those types of crimes. I cried there thinking this, our brothers go to perform Hajj but they can’t perform it according to sunnah. If we break sunnah, I doubt, whether Allah will accept our Hajj. Pilgrims should go to Hajj after studying a lot about Hajj and the sunnah. Awareness should be raised there.”*

#### 4.2.3. Difficulties and special needs of female, aged, and disabled pilgrims

During the events of Hajj, female, aged, and disabled pilgrims face many problems which need special care, such as ensuring privacy for female pilgrims, ensuring wheelchair facilities for old and disabled pilgrims, etc. Privacy of female pilgrims is a prime concern, especially in the tents of Mina where millions of people reside in a very congested situation. Often, the allocated pilgrims in a tent are far more than the capacity. In this situation, sometimes, it is difficult to maintain the privacy of pilgrims, especially for female pilgrims as reported by P498, *“There should be a sufficient arrangement in the tents to separate females’ area so that females in the same group can stay comfortably with their veil.”* Besides, the prayer place allocated for female pilgrims is not enough in the Masjid an-Nabawi as stated by P203, *“It would be better if there were more space for females to pray inside the Masjid an-Nabawi and importantly, time for females to visit Riadh ul Jannah should be fixed and declared.”*

Pilgrims suggest making room for people with special needs. For example, the management of wheelchairs for persons with disabilities should be maintained in a better way. Some pilgrims reported about the pathways which are not suitable for a wheelchair on some roads as P54 suggested, *“Make sure that one on a wheelchair can reach all rituals on a wheelchair, does not have to navigate between cars, does not have to be carried through sandy roads, does not face inaccessible curbs that are not maneuverable using a wheelchair.”*

#### 4.2.4. Losing pilgrims and getting them back

Getting lost during Hajj is a very common difficulty faced by pilgrims. In our survey, we found that more than 25% of the pilgrims get lost at least once during Hajj. The reasons behind getting lost are much more diverse. Around 18% and 38% of the lost pilgrims mentioned that they get lost due to the lack of knowledge of necessary names and directions respectively. Additionally, there are about 18% of the lost pilgrims pointed language barrier as a problem for their getting lost. Even the local volunteers are not familiar with the directions of Hajj places which is mentioned by P510, *“Local Hajj guides, e.g., police were not familiar with directions in Mina”*. P431 states, *“I was standing right there where I got lost so that when someone comes back looking for me, he or she can find me easily. I had no device or wristband or id card with me then and was unable to speak to the volunteers because of the language barrier.”*

To address the getting lost problem, pilgrims propose several recommendations. P382 suggests, *“Direction symbols should be large and tents should have the country flag”*. P103 suggests, *“Tents of different countries should have different colors to identify easily.”*

#### 4.2.5. Pilgrims’ experiences of violations of laws and norms

During Hajj, pilgrims often face several unexpected experiences, such as losing belongings, carelessness of Hajj agencies, etc. Pilgrims often lost their belongings during Hajj. This occurs not only in the Hajj places but also in the Airport. P11 states, *“I lost my luggage at the airport medical facility”*. Moreover, a pilgrim faced robbery during Hajj. However, they get a little help from the security personnel. For instance, P515 explains, *“In 2009, I was looted for all my money and cards in the wudu (ceremonial washing before prayer) place of the mosque. The police could not understand my problem. The Hajj office did not endorse my complaint. I and my wife were without help. Police did not stop to help us”*.

The response to the theft was overwhelming. There were some incidents at the King Abdulaziz International Airport at Jeddah as well. When asked about lost and found incidents, several participants indicated that they lost money and belongings (i.e., necessary documents, umbrellas, shoes, bags, etc.). The majority of them lost their necessary documents (i.e., passports, national identification cards, etc.). This happened in different places, i.e., airports, Mecca, Medina, Mina, etc. Moreover, P255 complains that he had to pay an amount of money to get back his bag - *“I lost my bag on the bus for which I had to spend 100 riyals to get back.”*

#### 4.2.6. Sickness of and treatment for pilgrims

As Hajj involves a high level of physical activities, along with the scorching heat of Saudi Arabia, pilgrims often feel sick. The temperature imbalance between the inside and outside of the tent often causes severe illness to some pilgrims. P75 states, *“Because of the air conditioner, I became severely ill. The temperature difference between inside and outside affected me during sleep”*. The extremely hot and uncomfortable weather makes the pilgrims more vulnerable to getting sick. Some pilgrims feel sick due to taking shower in hot water. For instance, P166 recalls this issue stating, *“I felt sick after having a bath in Arafat’s hot water”*. Around 6% of the participants in our survey became partially or severely sick when they got lost during Hajj.

The difficulties due to sickness became very severe when the sick pilgrims can not get the proper treatment due to miscommunication with the medical staff. Sometimes, such miscommunication leads to an incorrect diagnosis. P99 mentions his experience of misdiagnosis in the medical camp, *“I feel so much pain in my leg due to dehydration during traveling from Mecca to Medina. However, the doctors failed to diagnose my illness. Later, having saline mitigates my illness”*. The medical staff often are not so cooperative with the sick pilgrims. P225 adds, *“When I was sick, doctors of Medina were not so helpful”*.

#### 4.2.7. Support from law enforcing agencies and volunteers

Despite the sacredness in its very nature, some unlawful incidents occur during the Hajj pilgrimage, such as theft, pickpocketing, bribery, robbery, etc. Pilgrims can complain to law enforcement agencies i.e., police, or seek help from volunteers in such events. However, some survey participants point out that police and security forces tend to ignore these complaints. The same types of complaints are reported upon the volunteers also. Volunteers are the people who participate in different kinds of activities to ensure

pilgrims' comfort and receive them with hospitality and generosity with the support and supervision of the Ministry of Hajj and Umrah. Many pilgrims mentioned that due to the language barrier, they were unsuccessful in communicating with them. P431 describes the experience of getting lost during Hajj. *"I was unable to speak to the volunteers because of the language barrier"*. P659 states, *"As most of the volunteers did not understand English, they could not help us."*

In parallel with stating negative experiences, pilgrims provide necessary recommendations for the betterment of the services from the law enforcement agencies and the volunteers. P259 states, *"The number of volunteers needs to be increased."* Whereas P627 states, *"More female volunteers should be appointed"*. Some pilgrims suggest improving the activities of law enforcement agencies and volunteers. P678 states, *"Police should be more active to maintain crowd at Mataf, especially at Multazam and Hajar al-Aswad"*.

#### 4.2.8. Technological limitations and expectations to technologies

Pilgrims frequently face a lack of technological support during Hajj. Several pilgrims report not having internet service in several places, e.g., hotels, open places, etc. Both P218 and P223 report, *"I could not avail WiFi connection in the hotel"*. In addition, P533 mentions, *"Mobile internet was insanely expensive"*. P40 indicates the prolonged activation period for mobile internet, *"I got lost because my mobile internet was not yet activated at that time. If the internet was activated at that time, it was highly unlikely to get lost. Google maps help a lot."*

Several pilgrims suggest incorporating technology to reduce the number of lost pilgrims as P538 states, *"Like Google Maps, there should be an app for locating the tents of Mina"*. In addition, P680 states, *"Big screen display should be introduced for the ease of navigation"*. P625 proposes a similar idea, *"Map should be displayed on the big screen in the road of Mina"*. Apart from that, some other technical proposals were there for the improvement of the Hajj experience. As P528 states, *"Audio system in Arafat should be extended so that everybody can hear and attend the prayers at the Nimra Mosque"*.

#### 4.2.9. Feelings of pilgrims after Hajj

Pilgrims around the world save their earnings for years to perform the Hajj pilgrimage. During Hajj, these pilgrims spend the days in prayer and supplication. Though most pilgrims overlook the negative experiences they faced during the pilgrimage, some disappointment prevails. One of these is being not able to kiss the black stone, named Hajar al-Aswad. According to the tradition of the Hajj, pilgrims are supposed to kiss, touch, or gesture toward the stone as they pass it. As P585 states, *"I could not even touch the Hajar al-Aswad. This was the biggest regret in my life."*

Besides, several pilgrims accuse the agencies of violating the rituals of the Hajj. P267, P275, P589, and P590 report, *"The agent lied about the sacrifice."* Moreover, P585 states, *"To save money, hajj agencies violated sahih sunnah (correct rituals) of hajj. For saving money, agencies took pilgrims to Arafat at 7 Dhu'l Hajj after the Maghrib prayer (after sunset). However, our prophet told us to go to Arafat at 8 Dhu'l hajj after the Fajar prayer (after the dawn). That was totally against our prophet's sunnah. That is why my wife and I did not follow the agencies. Rather we followed our prophet's rituals."*

In Appendix A.2, we prepare a list of comments from pilgrims. We enlist only those comments that we do not include in the above-mentioned writings to shape the paper within a reasonable size.

## 5. Discussion

We attain a rich understanding of the negative experiences faced by the pilgrims, the quality of services provided by different agencies as well as usage of technology to mitigate the negative experiences by exploring perceptions related to the disappointments of the pilgrims. This reinforces the issues faced by pilgrims from all over the world. Identifying these factors can mold the pilgrimage more pleasant. We organize this section to answer the research questions in this study. Later, we discuss our contribution compared to the other studies in the same research domain.

### 5.1. RQ1: suitable method for analyzing the negative experiences

Since we adopt a mixed-method approach, a discussion on the test and validation of each approach is necessary. In this section, we address this by comparing the outcome of qualitative and quantitative approaches. Our survey questionnaire consists of both open-ended and closed-ended questions. Closed-ended questions have a limited set of possible answers. Whereas open-ended questions allow the participants to give a free-form answer to elaborate on their points. These answers can vary from one participant to another to a large extent. Since closed-ended questions can be answered from a limited set of possible answers, quantitative analysis can give meaningful insights in this case. Therefore, quantitative analysis can be performed on closed-ended questions only. To perform quantitative analysis, we employ k-modes clustering on the closed-ended questions. In Fig. 3a, we get seven and six clusters for random and optimal centroid respectively considering negative experiences as well as demographics-related questions. We also present the number of responses and information content in each cluster in earlier section depicting the outcome in Table 2 and 3. From these tables, we get an idea of demographics and experience of different negative experiences for the pilgrims. In Thematic Analysis, considering both open-ended questions and closed-ended questions, we achieve nine themes along with 21 negative experiences and 20 recommendations. Since we consider the open-ended responses in Thematic Analysis, the themes show more comprehensive results than quantitative analysis.

The rationale for tending towards qualitative approach comes from some limitations of quantitative approach. In the quantitative approach (e.g., clustering), each cluster consists of a set of demographics and negative experiences. However, this approach can not tell us why these demographics are at risk. Besides, why, when, and how the pilgrims faced those negative experiences are also

not answered in quantitative analysis. To answer these questions, we use the open-ended responses and through qualitative analysis (e.g., Thematic Analysis), we identify the reason, location, and timing of a specific negative experience.

### 5.2. RQ2: negative experiences and recommendations from an aggregated perspective

Exploratory studies like ours are a good source of findings on the negative experiences faced by the pilgrims in Hajj as well as the recommendations suggested by the pilgrims. In Table 4, we enlisted 21 negative experiences faced by pilgrims and 20 recommendations to address such experiences. Our findings can help management personnel in identifying potential negative experiences and take necessary steps to resolve such experiences. In the following paragraphs, we discuss the application of our study i.e., how our findings can help management personnel to organize a better Hajj pilgrimage.

As a consequence of overcrowding and mismanagement, pilgrims faced problems during taking part in various Hajj rituals, especially while entering and moving around the Masjid al-Haram. According to pilgrims' recommendation, if management-level authorities ease the access to Mataf in the Masjid al-Haram by employing technology, such as the crowd guidance system, such hassle to enter Masjid al-Haram will mitigate. Besides extending the present infrastructure to make room for more people, increasing the number of well-trained volunteers can help in this regard.

During pilgrimage season, in some cases, the female pilgrims do not get separate accommodations and required privacy. There are also reports of poor food, lack of transportation, and lack of sanitation facilities. To improve accommodation, food, transportation, and sanitation, pilgrims recommend strict monitoring of Hajj agencies, as agencies are responsible to manage such services. If Hajj authorities (e.g., government-run organizations) in every country take steps to monitor Hajj agencies (e.g., different private entities who manage pilgrims from their own countries), cases of such negative experiences can be reduced.

Getting lost during Hajj is one of the severe negative experiences found in our study. In most cases, women and aged individuals get lost. In reducing the cases of getting lost, pilgrims recommend increasing the well-trained volunteers and self-awareness (e.g., remembering a particular spot to meet) of individuals. Besides, if authorities can ensure better telecommunication, multilingual services, navigation system, etc., such experience of getting lost can be reduced.

During the Hajj pilgrimage, pilgrims often face unexpected experiences, such as losing belongings, uncooperative behavior from police and volunteers, etc. In this regard, pilgrims recommend improving the activities of the law enforcement agencies and the volunteers in some important spots, such as Mataf and Hajar al-Aswad, as these two spots remain highly crowded most of the time. Besides, if Hajj management authorities employ only the best-trained police and volunteers during the Hajj season, such situations can be avoided.

Sickness during performing rituals is a common phenomenon in the Hajj pilgrimage. Pilgrims report scorching heat in Saudi Arabia, lack of medical services, and language barrier as the main reason for the severity of sickness. Therefore, if Hajj management authorities can ensure air-conditioned accommodations, proper medical services, and multilingual services, the extent of sickness can be diminished.

Pilgrims report a lack of telecommunication, navigation, and sound facility during the pilgrimage. Therefore, Hajj authorities should improve electricity, and audio facilities in appropriate places, such as Arafat. Besides, pilgrims recommend that authorities should employ easily available as well as low-cost telecommunication services.

### 5.3. RQ3: identifying themes and based on themes, analyze the association between negative experiences and recommendations

In this part, we discuss the categorization of different types of negative experiences faced by pilgrims into different themes from an aggregated perspective. In addition, based on the themes, we explore the association of the negative experiences and recommendations with each other from the aggregated perspective. In Table 5, we provide a short description of each theme, and in Fig. A.4 of Appendix A.1, we illustrate the association of negative experiences and recommendations based on themes.

Our thematic analysis reveals nine themes. Each theme represents a specific type of experience. Then, we associate pilgrims' negative experiences and recommendations based on themes which form a tripartite graph in Fig. A.4 of Appendix A.1. In Section 4.2, we provide a detailed description of each theme and corresponding tripartite graph-based association. Using our developed tripartite graph, Hajj authorities can identify similar types of negative experiences and recommendations. Then, the Hajj authorities can implement those recommendations to resolve the negative experiences. The tripartite relation we revealed, can facilitate new research scope for other types of pilgrimages and mass gatherings.

### 5.4. Our research contributions

In our study, we develop a comprehensive questionnaire and perform a mass-scale survey of 988 pilgrims. Prior work performed surveys on pilgrims on a small-scale [31,13,56]. Moreover, those surveys focused on specific negative experiences, such as health issues, navigation, transport, etc., [57,29,58]. In this study, we dig deeper into the possible negative experiences during the pilgrimage. Then, we try to find a cluster of experiences through a quantitative clustering approach and qualitative thematic analysis. We are the first to perform such a mixed-method analysis of the pilgrimage experience.

Through quantitative analysis, we get seven clusters in the survey responses. Then, we perform rigorous aggregated thematic analysis to synthesize the negative experiences faced by the pilgrims. Our analysis points out nine themes which are pretty close to the number of clusters (seven clusters) from the previous quantitative analysis. Besides, in the process of thematic analysis, we find 21 negative experiences and 20 recommendations from the pilgrims. Several studies performed the thematic analysis in different

fields of study [59–65]. However, performing thematic analysis to analyze qualitative responses in the context of Hajj is yet to be explored in the literature. Our study fills the gap by introducing thematic analysis for understanding pilgrims' experience in the mass-scale Hajj pilgrimage.

Moreover, several studies focus on pilgrims' recommendations to alleviate the negative pilgrimage experiences at Hajj [35–38]. However, these studies did not develop any association or linkage between the negative experiences and recommendations proposed by the pilgrims. In this context, our research analyzes the associations between negative experiences and recommendations based on our thematic analysis. Our analysis unveils a tripartite association network that associates negative experiences, themes, and recommendations.

## 6. Limitations

The participant pilgrims in our study have diverse demographics covering different ages, gender, professions, languages, etc. However, considering the nationality, 89% of the pilgrims ( $n = 616$ ) among the 694 are from Bangladesh. Therefore, our study may not reflect the global perspective of Hajj and the negative experience-theme-recommendation graph may form a different shape from a global perspective. Besides, fewer female pilgrims ( $n = 297$ ) participate in this study, as we have conducted the survey in many rural places in Bangladesh where female members of the families reside in a very conservative environment, and in many cases they show unwillingness to participate. Finally, the average age of the participant pilgrims in our remote survey is 49 years with a standard deviation of 15 years. The reason is that most of the social media users are young in Bangladesh and most of them are yet to perform the Hajj pilgrimage [66]. As a consequence, we get remote responses mostly from aged people.

## 7. Conclusion and future work

In this study, we perform a rigorous study to better understand the diversified negative experiences faced by the Hajj pilgrims and their recommendations to overcome the negative experiences. We conduct the study from an aggregated perspective, unlike the existing research studies that mostly explore a specific problem in isolation and mostly ignore associations over negative experiences. Thus, our study presents a novel aspect of unveiling associations between negative experiences and recommendations. To the best of our knowledge, such an aggregated analysis reveals the associations in the context of the Hajj pilgrimage is the first of its kind in the literature.

In our study, we survey Hajj pilgrims covering both local and international pilgrims. Next, we perform quantitative analyses where we employ k-modes clustering to extract similar responses. Our clustering reveals up to seven clusters. Then, we employ a qualitative approach and perform a thematic analysis of the open-ended responses collected by the survey. In our thematic analysis, we extract and understand the themes inherent within the responses that comprise negative experiences experienced by the pilgrims and their recommendations as well. Our analysis reveals nine important themes pertinent to the negative experiences and recommendations. Our revealed themes cover highly congested crowds, accommodation problems, special needs for female, aged, and disabled pilgrims, technological limitations, getting lost during the pilgrimage, irresponsible behavior of volunteers and police, etc. We associate the themes with both negative experiences and recommendations. Accordingly, we reveal a tripartite graph network subsuming the negative experiences, themes, and recommendations. The tripartite graph reveals associations among the nine themes, 21 problem events, and 20 recommendations. In summary, our key contributions in this study include a) extracting themes from the negative experiences of the Hajj pilgrims, b) finding several associations among themes, negative experiences, and recommendations, and c) unveiling that qualitative analysis of the survey responses can reveal the most comprehensive results for religious pilgrimages like Hajj.

In the future, we plan to collect more responses from female and young participants. We also plan to analyze the demographics of participants in each cluster from our cluster analysis. Then, we will extend our work by analyzing the linkage between different entities (e.g., negative experiences, themes, and recommendations) with the help of an appropriate theoretical framework. Besides, we will analyze our proposed graph by augmenting it with quantitative weight for each edge. Here, our goal will be to apply different bi-ranking and tri-ranking-based algorithms over the augmented graph for revealing other insights from the negative experiences and recommendations to eventually facilitate overcoming the negative experiences.

## CRediT authorship contribution statement

Adnan Quaium: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Najla Abdulrahman Al-Nabhan: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Masfiqur Rahaman: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Saiful Islam Salim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Tarik Reza Toha: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Jannatun Noor: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Mainul Hossain: Conceived and designed the experiments; Wrote the paper.

Nafisa Islam: Conceived and designed the experiments; Wrote the paper.

Aaiyeesha Mostak: Conceived and designed the experiments; Wrote the paper.  
 Md Shihabul Islam: Conceived and designed the experiments; Wrote the paper.  
 Md. Masum Mushfiq: Conceived and designed the experiments; Wrote the paper.  
 Ishrat Jahan: Analyzed and interpreted the data; Wrote the paper.  
 A. B. M. Alim Al Islam: Conceived and designed the experiments; Wrote the paper.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Najla Abdulrahman Al-Nabhan reports financial support was provided by Ministry of Education in Saudi Arabia (project number DRI-KSU-762).

## Data availability

Data will be made available on request.

## Acknowledgement

The authors extend their appreciation to the Deputy-ship for Research & Innovation, Ministry of Education in Saudi Arabia for funding this research work through the project number (DRI-KSU-762).

## Appendix A

### A.1. Tripartite graph representation

Our revealed negative experience-theme-recommendation graph is illustrated in Fig. A.4.

### A.2. Themes and corresponding responses

Here, we enlist the themes and corresponding free-text responses from Hajj pilgrims.

#### 1. Negative impacts of overcrowding and their mitigation:

*"While traveling from Mecca to Medina there were very few toilets and those had very little water supply."* - P572

*"Intermittent water supply in Mecca Medina, unavailability of height toilet, fewer toilets in Arafat, less water supply, lesser protection safety in women washrooms in Arafat."* - P528

#### 2. Accommodation issues due to agencies' mismanagement:

*"Because of air conditioner I became severely ill. The temperature difference outside and inside affected me during sleep."* - P75

*"As the temptation of money, Hajj agencies and Muallems goes beyond sahih sunnah (complete rules and regulations) of hajj. For money-saving, Muallems took pilgrims to Arafat at 7 Dhul Hijjah after Magrib. However, our prophet said to go to Arafat at 8 Dhul Hijjah after Fajr. This is totally against our prophet's sunnah. However, I and my wife were against Moallem and we do all thing as our prophet said to us."* - P585

#### 3. Difficulties and special needs of female, aged, and disabled pilgrims:

*"In Mecca, female should be allocated a separate place for prayer and Tawaf."* - P333

*"Wheelchairs should be labeled and maintained strictly"* - P433

*"There should be a certain age limit for performing Hajj."* - P361

*"Hajj should be performed at an early age, as soon as it gets Fardh (obligatory) for one."* - P637

*"Free wheelchair for elderly persons should be increased."* - P438

#### 4. Lost pilgrims and getting them back:

*"Road and tent number should be more clear."* - P594

*"There should be road maps at each cross-section (in Mina)."* - P573

*"I went to the green light as our team preplanned it."* - P258

#### 5. Pilgrims' experiences of violations of laws and norms:

*"To save the money, hajj agencies violated sahih sunnah (authentic rituals) of hajj. For saving money, agencies took pilgrims to Arafat at 7 Dhu'l Hajj after the maghrib prayer (after the sunset). But our prophet told us to go to Arafat at 8 Dhu'l hajj after the Fajar prayer (after the dawn). That was totally against our prophets' sunnah. But my wife and I did not follow the agencies. Rather we followed our prophets' rituals."* - P585

#### 6. Sickness of and treatment for pilgrims:

*"Sufficient saline water should be arranged (for the pilgrims)"* - P99

*"The healthcare system can be free or cheaper for the pilgrims. The doctors' expenses and prices of medicine can be reduced at least"* - P575

*"Services should be better in the medical camps"* - P231

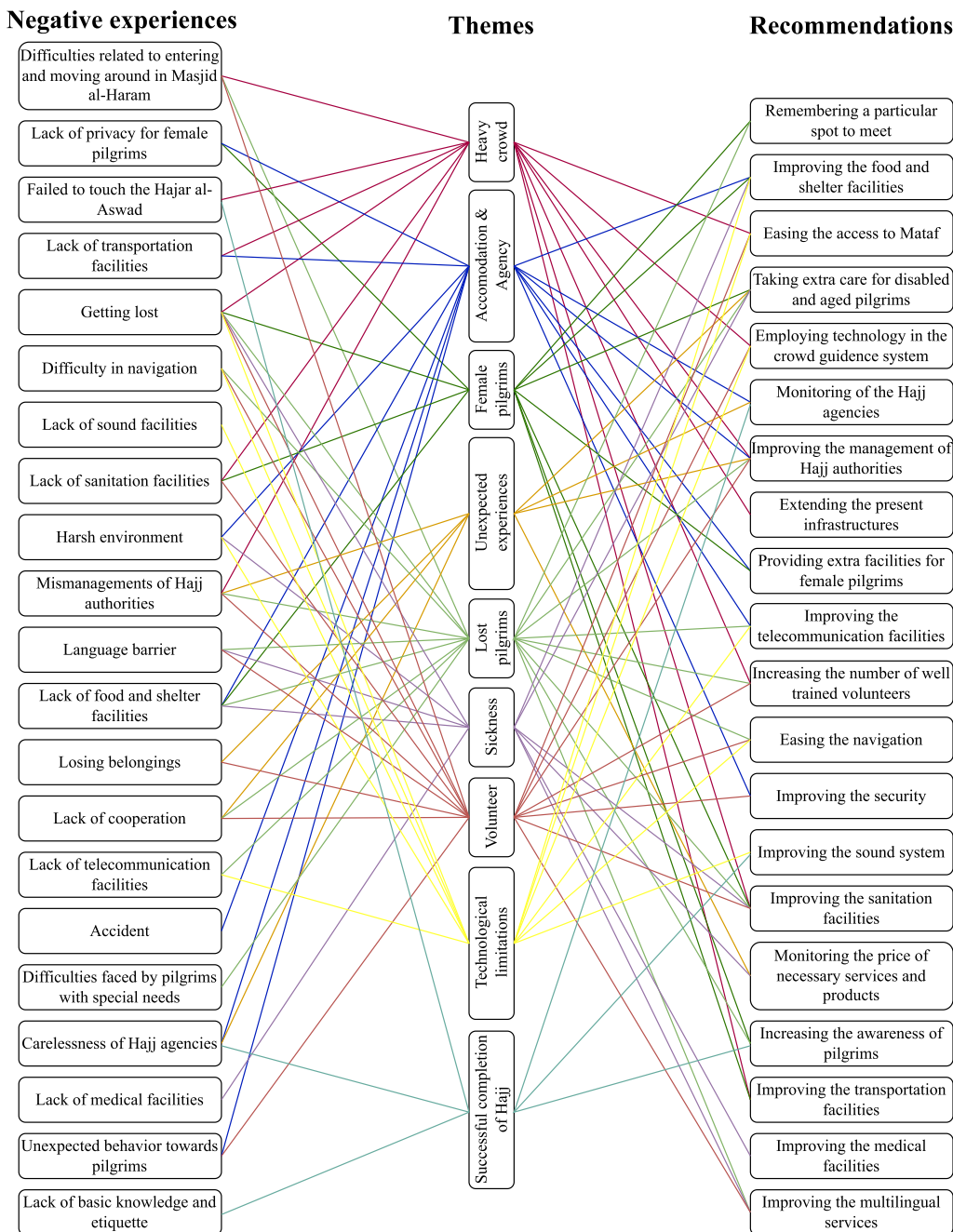


Fig. A.4. Tripartite graph of the themes along with negative experiences and recommendations.

**7. Support from law enforcing agencies and volunteers:**

“The local guards who speak Arabic are not always helpful and sometimes even act somewhat rude.” - P430  
 “Security police were very rude sometimes (at Masjid al-Haram).” - P207  
 “Pilgrims from other groups take over other peoples’ tents by force.” - P495

**8. Technological limitations and expectation to technologies:**

“It was too hot inside the tents (because of the inadequate air conditioning system)”. - P656  
 “We could not hear khutba (of the imam) for a sound system problem.” - P492  
 “Electricity facilities (in Arafat) need to be further improved.” - P611

**9. Feeling of pilgrims after Hajj:**

“Many pilgrims do not know the rules and regulations of Hajj properly, which create problems for others.” - P544  
 “Majority of the pilgrims are ignorant of basic disciplines, rules, and etiquette, which cause extreme chaos and dirtiness.” - P208

## Appendix B. Supplementary material

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e15486>.

## References

- [1] F. Nisha, C. Cheung, Locating Muslimah in the travel and tourism research, *Tour. Manag. Perspectives* 41 (2022) 100940, <https://doi.org/10.1016/j.tmp.2022.100940>.
- [2] C.P. Lin, The salience of stakeholders in religious tourism: a case study of the Dajia Mazu pilgrimage, *Ann. Tour. Res.* 86 (2021) 103091, <https://doi.org/10.1016/j.annals.2020.103091>.
- [3] H.M. Almuhrzi, A.M. Alsawafi, Muslim perspectives on spiritual and religious travel beyond Hajj: Toward understanding motivations for Umrah travel in Oman, *Tour. Manag. Perspectives* 24 (2017) 235–242, <https://doi.org/10.1016/j.tmp.2017.07.016>.
- [4] H. Zamani-Farahani, R. Eid, Muslim world: a study of tourism & pilgrimage among OIC Member States, *Tour. Manag. Perspectives* 19 (2016) 144–149, <https://doi.org/10.1016/j.tmp.2015.12.009>.
- [5] G. Michalkó, A. Irimiás, D.J. Timothy, Disappointment in tourism: perspectives on tourism destination management, *Tour. Manag. Perspectives* 16 (2015) 85–91, <https://doi.org/10.1016/j.tmp.2015.07.007>.
- [6] H. Oktadiana, P.L. Pearce, K. Chon, Muslim travellers' needs: what don't we know?, *Tour. Manag. Perspectives* 20 (2016) 124–130, <https://doi.org/10.1016/j.tmp.2016.08.004>.
- [7] T.E. of Encyclopaedia Britannica, hajj, <https://www.britannica.com/topic/hajj>, 2023. (Accessed 17 March 2023).
- [8] Statista, Annual number of Hajj pilgrims to Saudi Arabia from 1999 to 2021, <https://www.statista.com/statistics/617696/saudi-arabia-total-hajj-pilgrims/>, 2022. (Accessed 17 March 2023).
- [9] A. News, Around 2.5 million pilgrims take part in hajj this year, <https://www.arabnews.com/node/1538466/saudi-arabia>, 2019. (Accessed 3 February 2023).
- [10] C. Travel, 'Unprecedented' Hajj begins – with 1,000 pilgrims, rather than the usual 2 million, <https://edition.cnn.com/travel/article/hajj-2020-coronavirus-intl/index.html>, 2020. (Accessed 3 February 2023).
- [11] A. Jazeera, Pilgrims head to Mina as Hajj 2021 officially begins, <https://www.aljazeera.com/news/2021/7/18/saudi-arabia-stages-second-scaled-down-hajj-of-coronavirus-era>, 2021. (Accessed 3 February 2023).
- [12] Reuters, Muslim pilgrims flock to Mecca for first post-pandemic Hajj, <https://www.reuters.com/world/middle-east/muslim-pilgrims-flock-mecca-first-post-pandemic-haj-2022-07-01/>, 2022. (Accessed 3 February 2023).
- [13] M.M. Islam, The satisfaction of Bangladeshi pilgrims: service gaps in spiritual tourism based on gender and expenditure, *Int. J. Religious Tour. Pilgr.* 9 (2021) 10.
- [14] A.A. Khan, E.K. Noji, Hajj Stampede disaster, 2015: reflections from the frontlines, *Am. J. Disaster Medicine* 11 (2016) 59–68, <https://doi.org/10.5055/ajdm.2016.0225>.
- [15] S. Maneval, Mass accommodation for the “guests of god”: changing experiences of Hajj-pilgrims in Jeddah, <https://doi.org/10.25673/33837>, 2020.
- [16] F. Sharaf, M. El-Samony, N. Bouqellah, A. Al-Madani, M. Abu-Alruhaylah, Y. Ashour, N. Dar-Odeh, O.A. Hammad, Ethnicity is a major determinant of the pattern of dermatological diseases among pilgrims during the Hajj in 2019, *Dermatol. Rep.* 13 (2021), <https://doi.org/10.4081/dr.2021.8934>.
- [17] H. Taibah, S. Arlikatti, S.A. Andrew, P. Maghelal, B. DelGrosso, Health information, attitudes and actions at religious venues: evidence from Hajj pilgrims, *Int. J. Disaster Risk Reduct.* 51 (2020), <https://doi.org/10.1016/j.ijdrr.2020.101886>.
- [18] K. Caine, Local standards for sample size at CHI, in: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, CHI '16*, Association for Computing Machinery, New York, NY, USA, 2016, pp. 981–992.
- [19] N. Luz, Pilgrimage and religious tourism in Islam, *Ann. Tour. Res.* 82 (2020) 102915, <https://doi.org/10.1016/j.annals.2020.102915>.
- [20] A. Durán-Sánchez, J. Álvarez-García, M.d.l.C. del Río-Rama, C. Oliveira, Religious tourism and pilgrimage: bibliometric overview, *Religions* 9 (2018) 249, <https://doi.org/10.3390/rel9090249>.
- [21] M. Terzidou, Re-materialising the religious tourism experience: a post-human perspective, *Ann. Tour. Res.* 83 (2020) 102924, <https://doi.org/10.1016/j.annals.2020.102924>.
- [22] R. Raj, K.A. Griffin, *Religious Tourism and Pilgrimage Management: An International Perspective*, CABI, 2015.
- [23] B. Kim, S. Kim, B. King, Religious tourism studies: evolution, progress, and future prospects, *Tour. Recreat. Res.* 45 (2020) 185–203, <https://doi.org/10.1080/02508281.2019.1664084>.
- [24] J. Qurashi, The Hajj: crowding and congestion problems for pilgrims and hosts, in: *Overtourism*, De Gruyter Oldenbourg, 2019, pp. 185–198.
- [25] I. Ali, A. Azman, P.S.J. Singh, M. Yahaya, Z.A. Hatta, M.S. Islam, Hajj and Umrah management in Bangladesh: issues, challenges and human rights perspective, in: *Building Sustainable Communities*, Springer, 2020, pp. 781–801.
- [26] J. Rahman, M. Thu, N. Arshad, M. Van der Putten, Mass gatherings and public health: case studies from the Hajj to Mecca, *Annu. Glob. Health* 83 (2017) 386–393, <https://doi.org/10.1016/j.aogh.2016.12.001>.
- [27] H. Taibah, S. Arlikatti, S. Andrew, Risk communication for religious crowds: preferences of Hajj pilgrims, *Disaster Prevention and Management*, <https://doi.org/10.1108/DPM-09-2017-0215>, 2018.
- [28] A. Preko, A. Allaberganov, I. Mohammed, A. Martins, R. Amponsah, Understanding spiritual journey to Hajj: Ghana and Uzbekistan perspectives, *J. Islam. Mark.* 13 (2) (2022) 446–465, <https://doi.org/10.1108/JIMA-06-2020-0176>.
- [29] A.S. Alayed, Pandemic-driven mobile technology in Saudi Arabia: experience of the elderly pilgrims and visitors during covid-19, in: Q. Gao, J. Zhou (Eds.), *Human Aspects of IT for the Aged Population. Design, Interaction and Technology Acceptance*, Springer International Publishing, Cham, 2022, pp. 139–150.
- [30] M.H. Noweir, A.O. Bafail, I.M. Jomoah, Study of heat exposure during Hajj (pilgrimage), *Environ. Monit. Assess.* 147 (2008) 279–295, <https://doi.org/10.1007/s10661-007-0120-6>.
- [31] S. Parker, M.N. Jaffer, O. Mahomed, Effect of a supervised exercise-training programme on morbidity and wellness of South African hajj pilgrims in 2018: a pilot study, *Int. J. Travel. Medicine Glob. Health* 10 (2022), <https://doi.org/10.34172/IJTMGH.2022.12>.
- [32] S. Yezli, A. Mushi, Y. Almuzaini, B. Balkhi, Y. Yassin, A. Khan, Prevalence of diabetes and hypertension among Hajj pilgrims: a systematic review, *Int. J. Environ. Res. Public Health* 18 (2021), <https://doi.org/10.3390/ijerph18031155>.
- [33] I. Ridda, S. Mansoor, R. Briggs, J. Gishe, D. Aatmn, Preparedness for Mass Gathering During Hajj and Umrah, Springer International Publishing, Cham, 2021, pp. 1215–1235.
- [34] J.H. Jyotsna, L.P. Sai, Modelling pilgrim-tourist experience in Hindu religious destinations: an interactive qualitative analysis, *J. Tour. Cult. Change* (0 2022) 1–19, <https://doi.org/10.1080/14766825.2022.2095914>.
- [35] A. Alkharoubi, Wyfinding for Pedestrians in the Crowded Areas of Al-Hajj: How Can Wayfinding System Designs Increase the Efficiency of Wayfinding and Navigation Performances for Pedestrian Pilgrims During the Islamic Pilgrimage (Al-Hajj), Ph.D. thesis, 2020, <https://hdl.handle.net/11299/215160>.
- [36] E.A. Khan, An RFID-based system for pilgrim management in King Abdul Aziz international airport, in: *2011 International Conference on Information Management, Innovation Management and Industrial Engineering*, vol. 1, IEEE, 2011, pp. 124–129.
- [37] M. Mohandes, An RFID-based pilgrim identification system (a pilot study), in: *2008 11th International Conference on Optimization of Electrical and Electronic Equipment, IEEE*, 2008, pp. 107–112.



- [38] K. Majrashi, User need and experience of Hajj mobile and ubiquitous systems: designing for the largest religious annual gathering, *Cogent Eng.* 5 (2018) 1480303, <https://doi.org/10.1080/23311916.2018.1480303>.
- [39] G. Terry, N. Hayfield, V. Clarke, V. Braun, Thematic analysis, in: *The SAGE Handbook of Qualitative Research in Psychology*, vol. 2, 2017, pp. 17–37.
- [40] V. Clarke, V. Braun, N. Hayfield, Thematic analysis, in: *Qualitative Psychology: A Practical Guide to Research Methods*, vol. 3, 2015, pp. 222–248.
- [41] K.A. Neuendorf, Content analysis and thematic analysis, in: *Advanced Research Methods for Applied Psychology*, Routledge, 2018, pp. 211–223.
- [42] B.L. Weathington, C.J. Cunningham, D.J. Pittenger, Research methods for the behavioral and social sciences, <https://www.wiley.com/en-us/Research+Methods+for+the+Behavioral+and+Social+Sciences-p-9780470458037>, 2010.
- [43] N.W. Lawrence, Basics of social research: qualitative and quantitative approaches, <https://www.pearson.com/en-gb/subject-catalog/p/basics-of-social-research-pearson-new-international-edition/P200000005112/9781292020341>, 2007.
- [44] G.F. Kuder, M.W. Richardson, The theory of the estimation of test reliability, *Psychometrika* 2 (1937) 151–160, <https://doi.org/10.1007/BF02288391>.
- [45] C. Damsa, M. Langford, D. Uehara, R. Scherer, Teachers' agency and online education in times of crisis, *Comput. Hum. Behav.* 121 (2021) 106793, <https://doi.org/10.1016/j.chb.2021.106793>.
- [46] B. Waggner, W.N. Waggner, W.M. Waggner, Pulse Code Modulation Techniques, Springer Science & Business Media, 1995, <https://link.springer.com/book/9780442014360#book-header>.
- [47] S.I. Salim, N.A. Al-Nabhan, M. Rahaman, N. Islam, T.R. Toha, J. Noor, A. Quaium, A. Mostak, M. Hossain, M.M. Mushfiq, A.B.M.A.A. Islam, Human-survey interaction (HSD): a study on integrity of human data collectors in a mass-scale Hajj pilgrimage survey, *IEEE Access* 9 (2021) 112528–112551, <https://doi.org/10.1109/ACCESS.2021.3103046>.
- [48] Z. Huang, Clustering large data sets with mixed numeric and categorical values, in: *Proceedings of the 1st Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD)*, Citeseer, 1997, pp. 21–34, <https://api.semanticscholar.org/CorpusID:3007488>.
- [49] PyPi, kmodes 0.12.1, <https://pypi.org/project/kmodes/>, 2022. (Accessed 3 March 2023).
- [50] V. Braun, V. Clarke, Thematic analysis, in: *APA Handbook of Research Methods in Psychology*, vol. 2, 2012, pp. 57–71.
- [51] H. Gavin, Thematic analysis, in: *Understanding Research Methods and Statistics in Psychology*, 2008, pp. 273–282.
- [52] PyPi, kneed 0.7.0, <https://pypi.org/project/kneed/>, 2022. (Accessed 3 March 2023).
- [53] E. Cuevas, An agent-based model to evaluate the COVID-19 transmission risks in facilities, *Comput. Biol. Med.* 121 (2020) 103827, <https://doi.org/10.1016/j.combiomed.2020.103827>.
- [54] T.A. Doherty, A.J. Winchester, S. Macpherson, D.N. Johnstone, V. Pareek, E.M. Tennyson, S. Kosar, F.U. Kosasih, M. Anaya, M. Abdi-Jalebi, et al., Performance-limiting nanoscale trap clusters at grain junctions in halide perovskites, *Nature* 580 (2020) 360–366, <https://doi.org/10.1038/s41586-020-2184-1>.
- [55] M.L. Martens, The Masjid al-Haram: balancing tradition and renewal at the heart of Islam, *Int. J. Islam. Archit.* 9 (2020) 119–132, [https://doi.org/10.1386/ijia\\_00006\\_1](https://doi.org/10.1386/ijia_00006_1).
- [56] M. Almeahmadi, G. Pescaroli, J. Alqahtani, O. Tope, Investigating health risk perceptions during the Hajj: pre-travel advice and adherence to preventative health measures, *Afr. J. Respir. Med.* 16 (2021) 1–6, <https://www.africanjournalofrespiratorymedicine.com/articles/investigating-health-risk-perceptions-during-the-hajj-pretravel-advice-and-adherence-to-preventative-health-measures.pdf>.
- [57] N.M. Noor Nik Zuraina, H. Hasan, S. Mohamad, S. Suraiya, Diagnostic detection of intended bacteria associated with respiratory tract infections among kelantanese Malaysian hajj pilgrims by a ready-to-use, thermostable multiplex pcr assay, *Saudi J. Biol. Sci.* 29 (2022) 103349, <https://doi.org/10.1016/j.sjbs.2022.103349>.
- [58] I. Kaysi, M. Sayour, B. Alshalalfah, A. Gutub, Rapid Transit Service in the Unique Context of Holy Makkah: Assessing the First Year of Operation during the 2010 Pilgrimage Season, 2012, pp. 253–267, <https://doi.org/10.2495/UT120231>.
- [59] V.K. Cannanure, J.S. Niweteto, Y.T. Adji, A.Y. Hermann, K.K. Jasinska, T.X. Brown, A. Ogan, I'm fine where I am, but I want to do more: exploring teacher aspirations in rural Côte d'Ivoire, in: *Proceedings of the 3rd ACM SIGCAS Conference on Computing and Sustainable Societies, COMPASS '20*, Association for Computing Machinery, New York, NY, USA, 2020, pp. 1–12.
- [60] M.N. Al-Ameen, T. Tamanna, S. Nandy, M.A.M. Ahsan, P. Chandra, S.I. Ahmed, We don't give a second thought before providing our information: understanding users' perceptions of information collection by apps in urban Bangladesh, in: *Proceedings of the 3rd ACM SIGCAS Conference on Computing and Sustainable Societies, COMPASS '20*, Association for Computing Machinery, New York, NY, USA, 2020, pp. 32–43.
- [61] S. Chen, X. Liu, J. Yan, G. Hu, Y. Shi, Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: a thematic analysis, *Inf. Syst. E-Bus. Manag.* (2020) 1–27, <https://doi.org/10.1007/s10257-020-00467-3>.
- [62] K.L. Peel, A beginner's guide to applied educational research using thematic analysis, *Pract. Assess. Res. Eval.* 25 (2020) 2, <https://doi.org/10.7275/ryr5-k983>.
- [63] W. Xu, K. Zammit, Applying thematic analysis to education: a hybrid approach to interpreting data in practitioner research, *Int. J. Qual. Methods* 19 (2020) 1609406920918810, <https://doi.org/10.1177/1609406920918810>.
- [64] M. Thelwall, Word association thematic analysis: a social media text exploration strategy, *Synth. Lect. Inf. Concept. Retr. Services* 13 (2021) i–111, <https://doi.org/10.2200/S01071ED1V01Y202012ICR072>.
- [65] R. Abdullah, P. Guo, R. Harding, Preferences and experiences of muslim patients and their families in muslim-majority countries for end-of-life care: a systematic review and thematic analysis, *J. Pain Symptom Manag.* (2020), <https://doi.org/10.1016/j.jpainsymman.2020.06.032>.
- [66] S. Ahmed, M. Hossain, M. Haque, Usage of Facebook: Bangladesh perspective, *SSRN Electron. J.* (2012), <https://doi.org/10.2139/ssrn.2167116>.