

# Personal Privacy Evaluation of Smart Devices Applications Serving Hajj and Umrah Rituals

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## ABSTRACT

Mobile Applications (apps) are one of the most important tools that provide many services in different and varied fields of human life such as social, health, commercial, political, and other services. These apps make information easily available to everyone, fast to get, and cheaper than traditional methods. The Hajj pilgrims and Umrah performances (Al-Rahman Holy guests) have a share of the electronic services provided by many governmental and private sectors inside the Kingdom of Saudi Arabia. The offered services ensure that these religious guests have the ability to gain useful knowledge before and during the period they are stayed in the land of the Two Holy Mosques. In this paper, we collected all possible apps related to Hajj and Umrah, from the Google Store, during the season of Hajj 1440 AH (2019 AD), which amounted to 471 apps through searching on relevant applications to Hajj and Umrah services. We studied the applications public info trying to gain personal privacy characteristics from user rating, number of evaluators, recent updates, volume of applications, languages, number of downloads, and specific services provided. The results showed that the largest percentage of the studied apps are the facilitations of the Hajj ritual with 18%, followed by 15.1% for Umrah ritual and 10.2% for prayer supplications. The results also indicated attractive 33 common languages used, showing English with most popularity of 27.4%, followed by Arabic and Urdu of 24.3% and 14.3%. In addition, the study specified the most desirable services favored by the religious guests expressing interesting valuable remarks.

**Keywords:** Hajj Services; Islamic Pilgrimage; Services; Mobile Applications; Google Play; Analytical Study.

## INTRODUCTION

Every year Millions of Muslims come to Saudi Arabia to perform Hajj and Umrah rituals (Shambour & Khan, 2019). These religious visitors are known as Al-Rahman guests pretending their main purpose of visiting is the holy lands and holy house of Allah. Many government and private sectors provide various services to Al-Rahman guests to facilitate their worships performance (Kaysi et al., 2013). Among the most prominent services provided to the guests of the Two Holy Mosques are electronic services (e-services), which facilitate the flow of various procedures and requests and save a lot of time and effort for its users who go to the Two Holy Mosques (Khan & Shambour, 2018, Aly & Gutub, 2018). The mobile apps for Hajj pilgrims and Umrah performers are considered one of the important e-services as they provide information and guidance in various fields that the guests need before they arrive and during their visit until they return back to their countries. In fact, mobile apps can be essentially used for emergencies situations, such as medical health requirements (Samkari, & Gutub, 2019) and identifying lost and found people (Gutub & Aly, 2018), as well as guiding the elderly and needy persons to their proper paths' directions (Kim et al., 2015) and giving urgent priority guidelines within the crowds (Curtis et al., 2013). The mobile apps are to be used for convenient scheduling of transportations plans (Kaysi et al., 2012) and providing full assistance against possible security and cyber threats attacks (Alsaïdi et al., 2019). This current technology adoption is part of the national strategy stressed by Saudi Arabia Kingdom vision 2030 to involve smart systems, artificial intelligence, and internet of things, as main contributor serving all important Hajj and Umrah sectors (Farooqi et al., 2019). Therefore, the

Saudi government is working to involve information and communication technology (ICT) in all its facilities for information gathering (Aly et al., 2014), data dissemination (Aly et al., 2013), and deeply use it for smart decision-making within Hajj and Umrah services (Alharthi & Gutub, 2017). The government also pushed preparing the next generation (local students) to be geared fully via information technology (Almutairi et al., 2020). It further involved specific security stego-facilities to make ease of ICT accommodating all different backgrounds and educational levels (Almutairi et al., 2019).

In this research, the key criteria were defined to measure and evaluate the apps of Hajj and Umrah pilgrims (Al-Rahman's guests) with the aim of gaining personal privacy characteristics as well as future proper development as IoT progress within Hajj and Umrah recently evaluated by Shambour & Gutub (2021). The work is to ensure the achievement of the apps desired results and goals, i.e. in providing the best trusted services for the guests of Al-Rahman. This apps study in relation to Hajj & Umrah activities can be explored differently than normal real-life mobile apps detecting four special limitation aspects, namely variation of mega crowded users, stressed service providers, restricted physical geographic locations, technical mobile computation irregularity. The users people visiting the holy cities of Makkah and Madinah increases dramatically during the Hajj and Umrah seasons (planned reaching 30 million, following vision 2030 of Saudi Arabia), as does their use of information technology and communication networks beside all IoT current applications. Hence, the quality of services provided over various e-networks is adversely not readily affected. Also, note that Hajj and Umrah apps development are still in their beginning stage of very imperfect implementations, not based on research, that needs uncommon measurement and evaluation of the computing mobile apps technicality and practicality. This study specialty is ringing the bell for considering the Hajj and Umrah privacy concerns found exceptional serving guests whom are coming to the holy sites once in life, after long waiting years, visiting on one occasion and mostly not going to come again. Therefore, their acceptable experience is very vital and important demanding to be focused on, with unique dedication of apps platforms, built to be applied and tremendously tested within Makkah ritual land that is not very smooth respecting all aspects. For example, the visiting geographically holy sites is full of high mountains, connected all around via long tunnels, making the common communication technology and mobile platforms in real challenging situation needing urgent dedicated research. Furthermore, the specialization of this exploration is considering the variations of multi-cultural and multi-education poor variation of users whom suffer restricted resources on mega densely populated physical situations. The work found that these Hajj and Umrah apps need to run very special consideration of the Islamic rituals time limits suffering mega crowded surprises within very low (to sometimes lost) network connections, i.e. to be used by pilgrims whom mostly found different in their life-styles of rare unusual Islamic practices, may be coming as unorganized users. Normally, users are running the apps aiming to be served the best and not losing their personal desires and privacy characteristics as well as helping future apps developments to progress correctly and trustfully. The main objective of this work can be expressed as to ensure the achievement of the apps desired results and goals in providing the best trusted services for the guests of Al-Rahman. The research contribution scope is focused to highlight the personal information and services of mobile apps dedicated to the religious visitors, reveal of the most private characteristics of the common electronic services, and define applicable key criteria used to evaluate mobile applications. This study involved most needed Hajj and Umrah common features focusing on confidentiality and covering apps different languages, number of users, and user rating affected the social intellectual understanding as well as the groups personality and their collective influences. Therefore, for the open source convenience, the paper is currently directed to evaluate all possibly available apps published in "Google play" store at the time of research, which can be further used as privacy practical guide for any interested apps development (serving Hajj and Umrah) facilitations differently than general security technologies dedications platforms such as counting-based secret sharing (Gutub et al., 2019), or medical crypto security (Bin-Hureib, & Gutub, 2020) as well as image privacy (Hassan & Gutub, 2021), and language dedication confidentiality (Gutub & Fattani, 2007).

This paper is organized as follows. Section two briefly reviews the previous studies. Section three provides the research methodology adopted in this work. The results and discussion were presented in the fourth section. Lastly, the paper is remarked with the conclusion and recommendations, as the fifth and final section.

## LITERATURE REVIEW

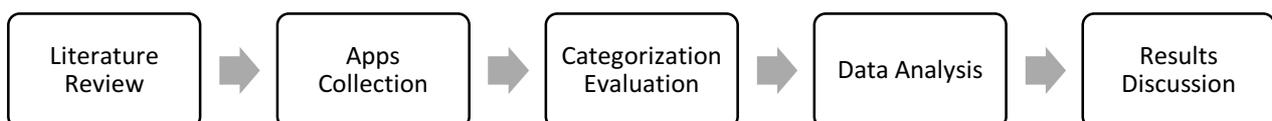
Stoyanov et al. (2015) developed a measurement tool called mobile app rating scale (MARS) to evaluate the quality of applications as well as privacy of persons using them. The MARS score is based on a five-point Likert scale consisting of 23 criteria covers four major personal rating categories: engagement, functionality, aesthetics, and information. Fraynt et al. (2018) also evaluated a set of apps designed to help retired people from military service to transition to civilian life, such as helping to find suitable jobs. The researchers used a group of six experts to evaluate 16 apps using the MARS evaluation tool. It was found that only two apps were downloaded more than 10,000 times from Google Play, and the majority were downloaded between 100 and 1000 times. The results also showed that only one application was rated above average, while half was rated below average. The researchers recommend making more high-quality apps and focusing on aspects of education and healthcare. Baskoro & Widyanti (2018) conducted a study to evaluate the usability of Indonesian application for lending small companies in terms of effectiveness, efficiency and satisfaction. Data were obtained from a total of 60 participants who were asked to perform a series of tasks on the app. Chavez et al. (2017) assessed the quality of diabetes management apps for complement clinical care. The researchers used the MARS scale to assess the quality of 89 free and most popular apps for managing type 2 diabetes. In another study, Serra et al. (2015) evaluated four e-government apps in Brazil using the Web Content Accessibility Guidelines (WCAG) 2.0. Researchers inspected 61 criteria in WCAG 2.0. The results of the evaluations showed that many of the primary access problems, widely known by researchers in the field of human-computer interaction (HCI), were found largely in the evaluated applications. This highlights the importance of further research in evaluating smart device apps in order to provide more comprehensive access to basic apps that all citizens use, such as e-government services. Khan and Shambour (2018) also conducted an analytical study of apps that provide variety of services for pilgrims and Umrah performers, in which 246 apps were studied from the Google Store and analyzed according to four main criteria: services provided, supported languages, installation rates, frequency of services and application names.

Gafni (2009) defined a set of usability measurement for mobile devices including display load, clarity of operation capabilities, playlist completeness of operation menu, easy use of input and output, and self-adaptability of display. The author also linked the defined measures to three types of problems related to mobile wireless including network, device, and mobility. Finally, Nouri et al. (2018) conducted a survey for researches published between 2008-2016 related to health apps on mobile devices. The authors classified seven main criteria including design, information/content, usability, functionality, ethical issues, security and privacy, and the perceived value of the user.

It is evident from previous studies the importance of evaluating mobile applications, which aims mainly to improve and develop the services provided. As evidenced by the review of previous studies, the lack of specialized studies in evaluating apps concerned with serving privacy information of pilgrims and Umrah performers, which requires us to work and exert effort in introducing the multiple services provided by these apps and highlighting the most important personal characteristics associated with them.

## RESEARCH METHODOLOGY

The methodology in this research is summarized in Figure (1), where the first stage begins with reviewing the literature searching for the appropriate keywords; In the second stage, an extensive analysis for Hajj and Umrah apps in the Google Store were conducted, which include the appropriate keywords, i.e. in the name or description of the application; In the third stage, ten apps related to government agencies in Kingdom of Saudi Arabia were privacy evaluated. After that, results and discussion were presented in the fourth stage, and the final stage offered the user personality remarks and future works.



**Figure 1** Research Methodology

## RELATED HAJJ AND UMRAH MOBILE APPLICATIONS

This study includes 471 mobile apps collected from Google Play during Hajj season (Aug-2019) by searching of four common keywords, two Arabic and two English, namely (عمرة), (حج), and (Hajj), (Umrah), respectively. Our study based its research on the personal user privacy properties collected from each application commonly found consisting of nine elements, as shown in Table 1.

**Table1** Features of Hajj and Umrah applications

Attribute1	Attribute2	Attribute3	Attribute4	Attribute5	Attribute6	Attribute7	Attribute8	Attribute9
Name	Publisher	Services	Download Times	Language	Number of users	User Rating	Latest update	Size (MB)

Consider Table 1 indications, the apps containing names possibly revealed is the most common privacy info unfavored to be known. The publisher, services, download times, latest update, and size indications give ideas of the user influenced business model used as well as how trustful is the app from users' point of view adoption. In fact, some apps have been found from fake producers asking for charges without giving much of service. Others gave imprecise information making main causing of action by users affecting the crowd movements and activities, i.e. apps causing personal user clear confusions. The language, number of users, and user rating affected the private social intellectual understanding as well as the groups personality and their collective influences.

A total of 61 different services were observed from the collected apps including "Hajj Rituals", "Umrah Rituals", "Supplication", "Maps", "Images", "Videos", "Places of Visit", "Hajj News", and others. After that, statistical analyses were performed using basic statistical tools on the observed features of mobile apps as described in the following subsections.

### Accessible Apps Services

Table 2 shows all the services that were observed from all apps, arranged in descending order from the most frequent service in the apps to the least frequent. The aim is to study the personal privacy information revealed from analysis of apps public data.

**Table 2** Mobile application services

Abbr.	Service Name	Apps (%)	Abbr.	Service Name	Apps (%)	Abbr.	Service Name	Apps (%)
S1	Hajj Ritual	18.0%	S22	Hajj in Quran	1.1%	S43	Hajj or Islamic History	0.30%
S2	Umrah Ritual	15.1%	S23	Hajj in Hadith	1.1%	S44	Kids learning	0.30%
S3	Supplications	10.2%	S24	Audio supplications	1.1%	S45	Virtual and augmented reality	0.30%
S4	Photos/diagrams/wallpapers	6.0%	S25	Hajj/Umrah handbook	1.1%	S46	purposes and provisions of Hajj	0.30%
S5	Video tutorial/ TV episode	3.7%	S26	Tawaf counter	1.0%	S47	Translation and text to speech	0.24%
S6	Maps	3.6%	S27	Talbia & Tkberat	0.97%	S48	Islamic chants	0.24%
S7	Prayer schedule & timing	3.2%	S28	Hajj tweets, social media	0.79%	S49	light schedule	0.24%
S8	Hajj and Umrah agency services	2.7%	S29	Hajj/Umrah program and scheduling	0.79%	S50	Advices from Umrah performance	0.18%
S9	Visit Al-Madina	2.1%	S30	Audio tutorial	0.73%	S51	Crowd status	0.12%
S10	Q&A/ fatwa	1.9%	S31	Regulatory services	0.73%	S52	Messenger & SMS	0.12%
S11	Religious or regular tips	1.8%	S32	Emergency services	0.66%	S53	Photo editor/ frames	0.12%
S12	Do and do not	1.5%	S33	Hajj news	0.54%	S54	Booking a taxi	0.12%
S13	Travel tips and checklist	1.5%	S34	Tasbeeh counter	0.54%	S55	Traffic conditions	0.12%
S14	GIS/Bluetooth -based guidance	1.5%	S35	Greeting cards	0.54%	S56	Badal Hajj and Umrah	0.12%
S15	Places to visit/ services	1.5%	S36	Communicate with the campaign	0.48%	S57	Lost & found services	0.12%

S16	Information on Hajj (phone numbers)	1.4%	S37	Complaint services	0.42%	S58	Hajj volunteers	0.06%
S17	Compass	1.3%	S38	Currency conversion	0.42%	S59	Funeral Provisions	0.06%
S18	Temperature and weather	1.3%	S39	Accommodation locator	0.42%	S60	Statistics	0.06%
S19	Health services & information	1.3%	S40	Track hajj progress	0.42%	S61	Dictionary	0.06%
S20	Live video	1.3%	S41	3D	0.30%			
S21	Complete Quran	1.2%	S42	Hajj tour	0.30%			

Interestingly, it was found that the Hajj rituals service was presented in 18% of the total collected applications, followed by the Umrah rituals and supplications services by 15.1% and 10.2% respectively. The results also showed that the private services that are less available in apps are the services related to volunteering in Hajj, funeral provisions, statistics, and a linguistic dictionary which have a percentage of 0.06%.

### Apps Download Times

The personal downloaded times of apps on smart devices is one of the main private indicators of the users' desire to use the apps. Figure 2 displays the number of apps categorized by the specific number of download times. The results show that the individual highest rate of downloading apps was between 1,000 and 5,000 times, with a rate of 25.7%. The trusted public results also indicated that the only application with the most downloaded belongs to the "Watch Live Makkah & Madinah 24 Hours HD Quality" application, which is an application that supports live video services for the Two Holy Mosques in Makkah and Madinah, as it has been downloaded more than a million times. On the other hand, the "Watch Makkah & Madinah Live 24/7 - Kaaba TV PRO" application, which supports the same direct transmission service for the Two Holy Mosques, had the lowest particular download rate, reaching 0.2%, due to the fact that the specific application is not available for free use.

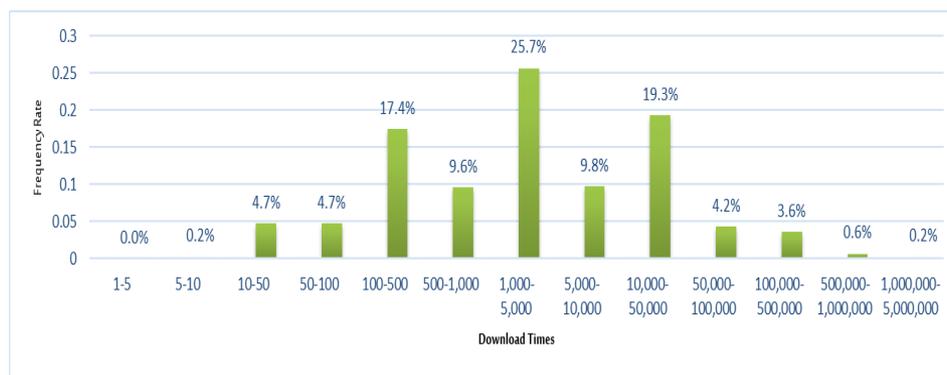


Figure 2 Download times of Apps

### Offered Apps Languages

The study revealed personal privacy number of languages commonly used in the within the Holy sites, which reached 33 languages covering most of the languages during that period. Figure 3 shows the percentage of personal languages used in applications. It turns out unexpectedly that English language is considered still the most used language in apps with a percentage of 27.4%, followed by Arabic and Urdu, at 24.3% and 14.3%, i.e. as languages not common in the area.

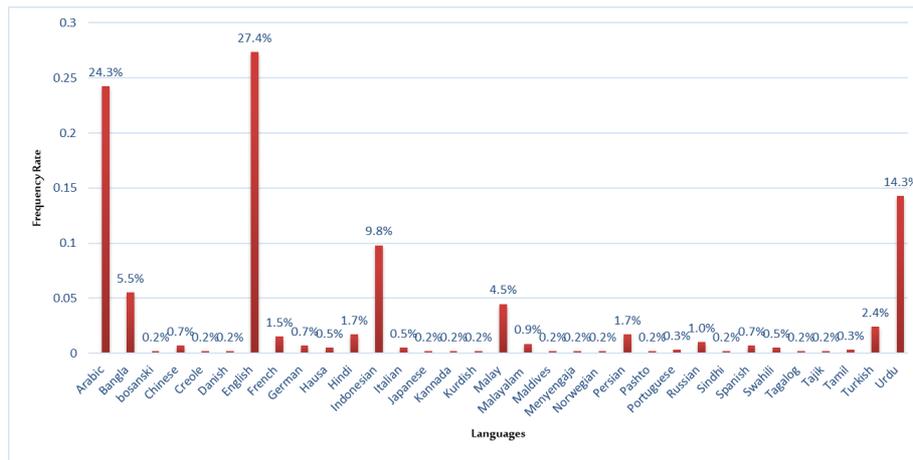


Figure 3 Private languages used in applications

The results of the analysis also showed that people suffered or complained that most apps support only one language, at a rate of 89.8%, where personal apps preferred as supporting more than three language was 1.7% as shown in Figure 4.

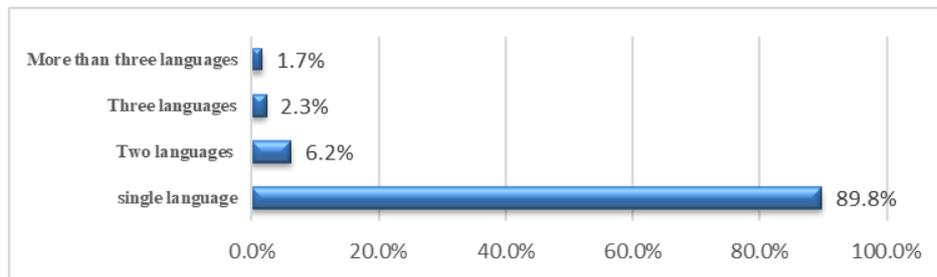


Figure 4 Categories for the personal number of languages supported by applications

### Recurring names and services of Apps

The study and investigations showed that there is duplication in the names and services of the intended apps causing user clear confusions affecting his privacy. Figure 5 shows the names of duplicated apps that belong to more than one publisher making the personal info distributed undetectably. On the other hand, the results revealed presence of some apps claiming to provide similar personal services that are repeated and more ambiguously belonging to the same publisher. For example, Figure 6 briefs the percentage of apps with languages sharing similar services. The research show that Arabic and English languages are the most frequent used in the repeated apps. However, these types of similar apps need to reconsider privacy information that could be combined with each other to be presented as a single multilingual version.

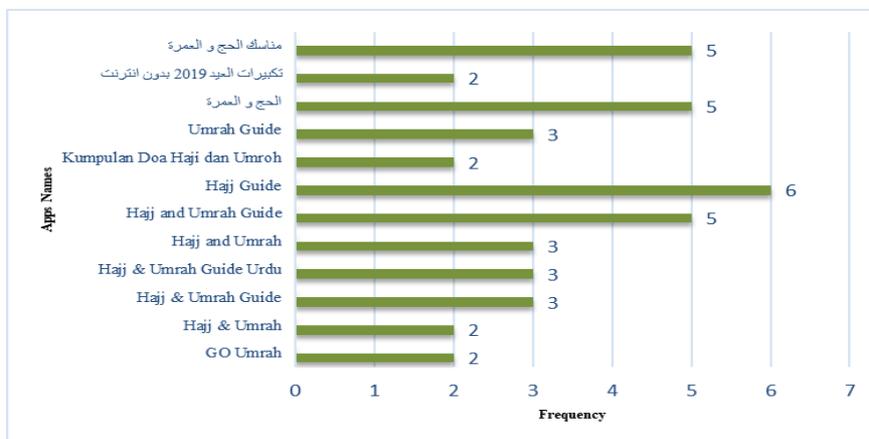


Figure 5 Duplication of App's Names and services

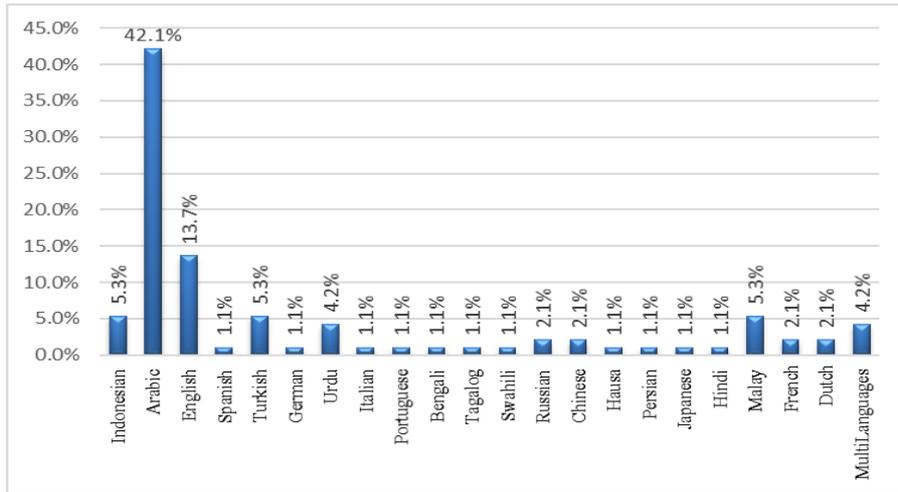


Figure 6 Apps languages that share similar services

### Rating of App Users on Google Play

Figure 7 shows the results of studied apps combined with privacy evaluation scores divided into ten categories. It is noticed from the privacy figure that the apps that have not been evaluated are equivalent to nearly a third of the total number, with a rate of 32.7%. The percentage of apps that were evaluated between [once - 100 times] amounted to 47% of the total number of evaluated applications, and this personally indicates the lack of users' desire to evaluate the apps they used, as they commonly perform the service once in life. On the other hand, the apps that were evaluated had excellent ratings, with ratings ranging from 4.5 to 4.7 out of 5. It is worth noting that the application "Watch Live Makkah & Madinah 24 Hours HD Quality" is the most highly rated program among personal usages, rated by 44,132 users. This high private evaluation rate is of more than 35% of the total number of times the assessment of all apps with attractive evaluation rate of 4.8 out of 5.

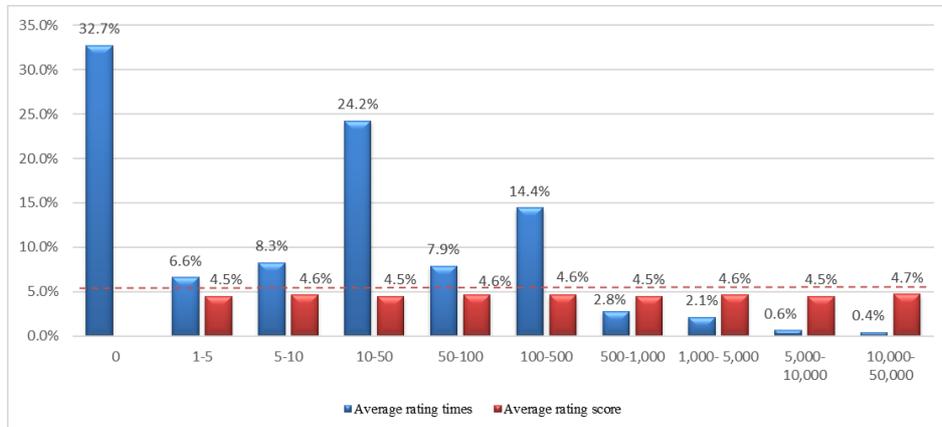


Figure 7 Evaluated apps and their privacy evaluation scores

### Update apps on Google Store

The process of updating apps is an important process especially in keeping personal information private or possibly retrieving them, which claimed essential aiming to be improving the quality of applications. It was found that the updates are strange, normally adding new services, addressing previous problems and errors, improving the general appearance of the application, updating privacy information and its presentation, and others. Figure 8 shows the general rate of the latest updates on the collected application systems, it was found that 51.6% of the total apps had updated operations during the year 1440 AH, while 19.8% were updated during the last three months (Shawwal, Dhu al-Qi'dah, Dhu al-Hijjah for the year 1440 AH). The results also showed the existence of a group of apps that did not undergo any update during the years 1431 AH - 1435 AH, which constituted 6.4% of the total number of apps, assumed to be higher in preserving privacy consideration.

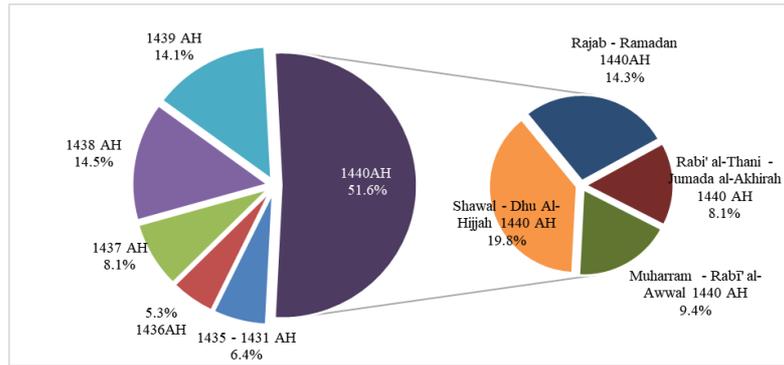


Figure 8 Updating Apps on Google Play during (1431 AH- 1440AH)

### Classification of Apps by size

The best privacy considered app in its utilization is the app that balances between the efficiency of the functions contained in the app and the efficiency of mobile devices in terms of memory, processor, screen size, etc, without degrading security level. Figure 9 clearly shows that the largest size of apps increases steadily with time. This is considered functionally reasonable due to the continuous development in smart device technologies, but revealed the private information of the user’s devices capability especially if not able handle larger sizes forcing them to change apps. This indication gave idea of the luxury level of the guests, where the largest application size reached 100 MB in the year 1440 AH, followed by 94 MB in the year 1439 AH compared to reaching 34 MB sized apps for years between 1431 AH - 1435 AH.

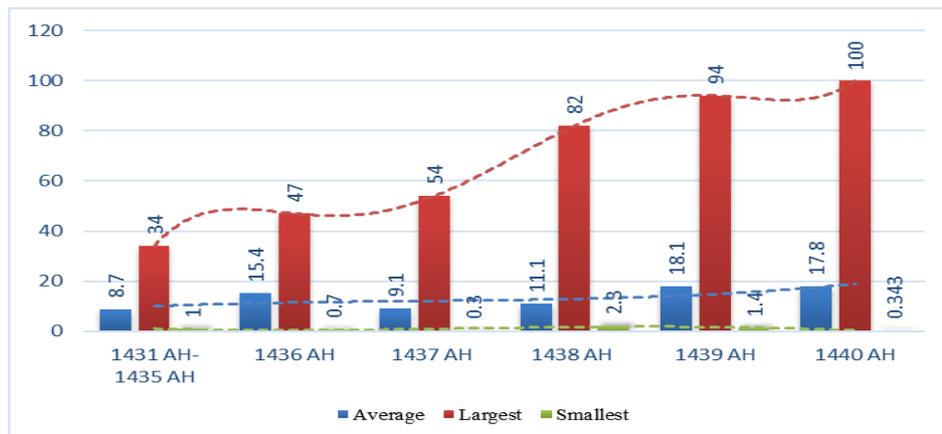


Figure 9 Classification of Apps by size

## EVALUATION OF GOVERNMENTAL APPS

The research further investigated the apps that have been developed and fully controlled by the government of Saudi Arabia. These apps have been exposed to private information much more than others. Their functionality run interestingly well and applied highest level of security measures. The research highlighted each apps pros and cons aiming to provide useful evaluation metric for solving more personal challenges to come.

### Apps Selection and Evaluation Tool

Nine apps are found officially linked to government sectors of Kingdom of Saudi Arabia. They have been built professionally to provide different services to Hajj and Umrah rituals, which are elected for in-depth personal evaluating using a popular mobile app rating scale called MARS method. It is to be mentioned that this MARS evaluation is intended for user dominant development and improvement and not specified for

security investigation. Therefore, in this research we utilized this MARS tool for raising the personal challenges hoping to provide constructive regulations. The elected governmental apps considered in this research accompanied with their specifications are given in Table 3.

**Table 3** Elected governmental apps and their personal specifications

	Application Name	Publisher	Provider	Reviews rate/# of Reviewers	Last Update	Download times	Size (MB)	Languages	Number of Services
1	Manasikana	Ministry Of Haj & Umrah	Ministry of Haj & Umrah	4.6/457	10-Sep-18	10,000 - 50,000	94	9 languages	17
2	Alharamain	General Presidency of Haramain	General Presidency of Haramain	4/585	24-Sep-19	50,000 - 100,000	38	3 languages	14
3	Hajj and Umrah Navigator	Saudi Post	Saudi Post	4.1/152	30-Jul-19	10,000 - 50,000	16	17 languages	4
4	AlMaqsad	General Presidency of Haramain	General Presidency of Haramain	4.8/387	31-Jan-19	50,000 - 100,000	34	2 languages	2
5	Umra e-services	Ministry Of Haj & Umrah	Ministry of Haj & Umrah	4.4/476	4-Jul-19	50,000 - 100,000	22	6 languages	2
6	Ershad	Ministry Of Haj & Umrah	Ministry of Haj & Umrah	4/101	1-Aug-19	10,000 - 50,000	15	2 languages	2
7	Internal Umrah	Ministry Of Haj & Umrah	Ministry of Haj & Umrah	-	19-Mar-19	1,000 - 5,000	36	2 languages	1
8	Tarwiah	National Water Company	National Water Company	4.7/167	25-Jul-19	10,000 - 50,000	8.3	7 languages	3
9	Saudia Umrah	Saudi Arabian Airlines	Saudi Arabian Airlines	2.5/10	27-Dec-18	1,000 - 5,000	5.5	2 languages	4

The category of MARS personal evaluation tool is given in Table 4 which contains five classifications for evaluating the quality of apps: engagement, functionality, aesthetics, information, and subjective quality. A total of 99 different personal evaluation results was obtained for the selected governmental apps, where eleven specialists in information technology participated in the evaluation private process. The participants have been chosen randomly holding different academic degrees and practical experiences, from the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research.

**Table 4** Category of MARS personal evaluation tool

Category	Items			
Engagement	Entertainment	Interest	Customization	Interactivity
	Target group			
Functionality	Performance	Ease of use	Navigation	Gestural design
Aesthetics	Layout	Graphics	Visual appeal	
Information	Accuracy of app description	Goals	Quality of information	Quantity of information
	Visual information	Credibility	Evidence base	
Subjective quality	Would you recommend this app?			
	Amount of time that you spend on an app?			
	Would you pay for this app?			
	What is your overall star rating of the app?			

The investigation asked each person to privately review the nine selected governmental apps before starting the real evaluation process. Then the work has been commenced in interesting manner revealing attractive personal privacy remarks as elaborated next.

## Analysis and Discussion

MARS tool was used to personally evaluate the Saudi government developed apps for Hajj and Umrah. The privacy evaluation studied every app proper confidentiality and disclosure measures. The measure figure-of-merit is graded from 1 to 5, where "1" indicates a very poor evaluation score and "5" indicates a very good evaluation. This evaluation measure considered the app's privacy practices before and after the app is downloaded revealing the correct remarks to be trusted. For example, the measure examined each Hajj and Umrah app's published info looking into how users can learn about some of the data types the app may collect, and whether that data is linked to them or used to track them. The privacy evaluation provided estimation about most commonly used app's privacy observations, counting the possible auto-recording of data personal practices as well as the third-party associates whose codes are found integrated running within the apps. The results of this apps evaluation are given in Figure 10, whereas Table 5 provides the detailed results of evaluated apps.

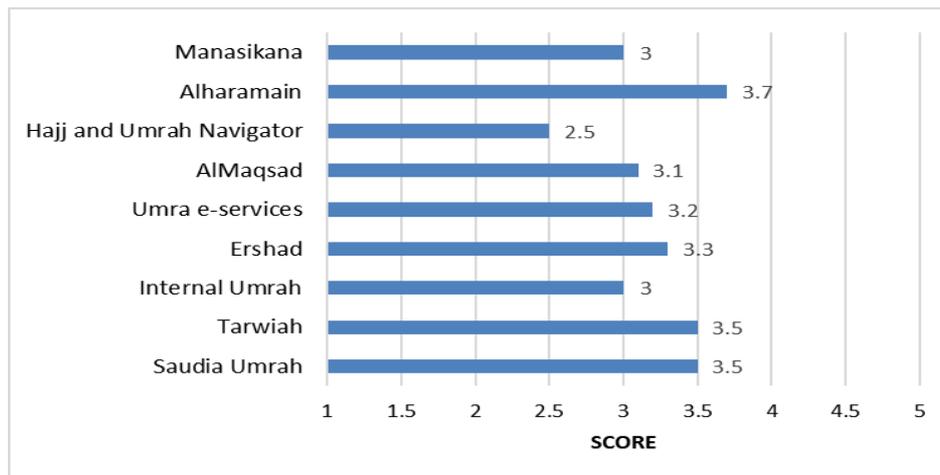


Figure 10 Results of apps privacy evaluation

Table 5 Detailed results of evaluated apps

Apps	Engagement	Functionality	Aesthetics	Information	Subjective quality	Total
Manasikana	2.8	3.4	3.2	3.4	2.4	3
Alharamain	3.9	3.7	3.9	3.8	3.2	3.7
Hajj and Umrah Nav.	2.4	2.5	2.6	3.2	1.9	2.5
AlMaqsad	3.2	3.5	3.2	3.4	2.4	3.1
Umra e-services	2.7	3.9	3.3	3.6	2.7	3.2
Ershad	3	4	3.4	3.4	2.7	3.3
Internal Umrah	2.7	3.7	3.4	3.3	2	3
Tarwiah	3.5	4.3	3.6	3.5	2.5	3.5
Saudia Umrah	3.3	3.6	4	3.5	2.9	3.5

The results show that the highest MARS rating was found in Alharamain app, which received a score of "below good" with a score of 3.7 out of 5, followed by Tarwiah and Saudi Umrah apps with a rating of "above acceptable" of 3.5 for both. The results also indicated that the "functionality" criterion was the best criterion for all apps, with a rate of 3.6, which relates to the performance of the application, its private ease of use, and the movement between app interfaces. On the other hand, results showed that the lowest rating score, at a rate of 2.5, was obtained in "Subjective quality" criterion, which is related to the users' opinion on recommending others to use. Privacy features of time spent, payment for use, and overall app star rating reflected the weak acceptance of users in their adoption of the app in general.

The statistical private results also revealed that the two apps, Manasikana and Alharamain, were the most inclusive of services with 17 and 14 personal services, respectively, as shown in Table 5. On the other hand, the Hajj and Umrah Navigator app was unique in providing 17 languages, followed by the application of

Manasikana in 9 languages. The research also noted that Manasikana app was the oldest in terms of updating apps on the Google Store, as the last update time was in more than 12 months, i.e. 12/29/1439 AH, respectively.

Generally, it was evident from the evaluation results that the Hajj and Umrah apps need more privacy accommodating attention by officials, specifically in their developing and updating software departments. The research suggests allocating a professional specific work security team that conducts the evaluation privacy process and provides appropriate suggestions to improve the security performance and efficiency of the apps.

## CONCLUSION

In this paper, the available Hajj and Umrah apps on the Google Store were observed during the Hajj season 1440 AH (2019) focusing on personal privacy features. The research studied 471 different apps including special governmental owned and controlled professional apps. The technical exploration for targeted apps started by searching four keywords in the name or description of the apps including: "عمرة", "حج", "Hajj", and "Umrah", revealing interesting focused remarks. All available personal features were studied for general development as well as privacy consideration. The work well-thought-out personal users rating, number of users downloading and who have rated, the latest updates, the size of the apps, app languages, times of downloads, and services provided. The research personal feedback showed that the largest percentage of the studied apps mainly hint to Hajj and Umrah rituals services without checking privacy authenticity indicating possible untrusted actions. The results general overview showed that the most desired services among users was to watch live channels of the Two Holy Mosques which is not mostly intended service within the apps.

The paper also evaluated personal privacy via professional group study of Hajj and Umrah apps by participating of specialists in the field of information technology from the Custodian of the Two Holy Mosques Institute for Hajj and Umrah Research. Personal privacy remarks showed that the app serving watching the Two Holy Mosques had the best average MARS score compared to other applications with a score of 3.7 out of 5, followed by Tarawiyah and Saudi Umrah apps, with a score of "above acceptable" of 3.5 for both. In addition, it was noticed that there were sub-acceptable evaluation scores related to the general satisfaction of users in their use of the studied applications, as the average score for Subjective Quality of the applications studied was 2.5 out of 5, which reflects the need for more development work and effort to improve the services provided as well as personal security measures involvement as essential research prospective.

The research progress remarked many general explorations that have dealt with similar mobile apps issues in general, but cannot be used practically and efficiently for Hajj and Umrah services considering IoT and smart crowd management needs via available wireless and mobile technologies as well as the framework remarks of secure app computing (Kheshaifaty & Gutub, 2020) and current arithmetic communication hardware and effective speeds analysis (Gutub, 2007). In other words, this research highlighted clearly that Hajj and Umrah apps studies is needed to be further considered for upcoming research, i.e. explored from current integrated IoT apps privacy smartness (Alasaf & Gutub, 2019) in terms of transmission and architecture complexity (Gutub et al., 2011), sensing e-banking and cost (Al-Shaarani et al., 2020), as well as energy consumption (Gutub et al., 2010), data classification (Savas et al., 2005), security (Gutub & Al-Qurashi, 2020), reliability (Parvez & Gutub, 2011), scalability (Abdelgawad et al., 2014), and computing efficiency (Gutub, 2007a). The apps improvement work and its current focus is still in its early stage for experience convenience, but can be used as background building foundation for future related Hajj and Umrah research to come.

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