JOURNAL OF INTERNATIONAL CRISIS AND RISK COMMUNICATION RESEARCH
ISSN: 2576-0017
2024, VOL 7, S7

# Ensuring Food and Water Safety at King Abdulaziz International Airport: Observational Study on Environmental Health Departments' Surveillance Activities.

**Ayman Anwar Samman[1], Fahd Fuad Qumri[1], Nedal Jamal Almasri[1], Mohammad Jamal Felmban[1], Ahmed Ibrahim Hassan[2], Khaled Mohammad Alzahrani[3], Hussam Abdulrahman Alhazmi[4], Hisham Abdulhakem Khalashi[5], Mohammad Abutaleb Alfalahi[5], Hussain Abdullah Alghamdi[6], Saeed Mohammad Alamri[6],**

*1MD, Health Surveillance Centers at King Abdulaziz International Airport, Jeddah, Saudi Arabia.*
*2MSc, Health Surveillance Centers at King Abdulaziz International Airport, Jeddah, Saudi Arabia.*
*3MD, Jeddah Health Affairs, Public Health Administration, Jeddah, Saudi Arabia.*
*4MD, Public Health and Preventive Medicine Administration, Makkah, Saudi Arabia.*
*5Dip, Health Surveillance Centers at King Abdulaziz International Airport, Jeddah, Saudi Arabia.*
*6BSc, Health Surveillance Centers at King Abdulaziz International Airport, Jeddah, Saudi Arabia.*

## Introduction

Airports are an important part of any society because they facilitate travel to different destinations around the world. There are many airports around the world, and they form a center for different people to meet as they board and alight flights. It is also an opportunity for people to restock their essential supplies including, specifically food and water. This means that these essentials need to meet public health standards for them to be safe for consumption. Airports are key in the discussion on the need to ensure safety of food and water because they serve millions of people each year. An example of an airport of interest is the King Abdul Aziz Jeddah Airport (KAIA). The airport forms a hub for many tourists seeking to visit the country and enjoy its unique touristic places. A study Saudi Arabia showed that the country welcomed more than 2.5 million Hajj pilgrims and an estimated 10 million Umrah visitors, with a significant proportion passing through Jeddah Airport. This is to show the importance of an airport and the number of people using it to access important services and travels. However, the airport can also be a public health risk, especially if essential supplies like food and water are unsafe for consumption. People depend on airport services to replenish these commodities and serving the people unsanitary food increases a risk of a disease outbreak. Some of the diseases that are more likely to be transmitted in this setting include typhoid and cholera. These diseases are highly contagious and often lead to adverse health outcomes, including death of individuals. It means significant effort needs to be put in place to ensure safety of the food and water given to the people using airports. It also transfers majority of the responsibility to the airport management to ensure standard practices.

One of the primary measures that has guided the regulation was implemented by the Saudi Food and Drug Authority (SFDA). The regulation focused on promoting adherence to Hazard analysis and Critical Control Points (HACCP) frameworks. In promoting the adherence, the guideline was expected to improve food and water safety. However, this was not the case because operational challenges during peak hours remained unresolved and increased the risk of non-compliance, especially peak hours. A study was done to compare effectiveness of the controls in similar global hubs like Heathrow in the UK and Changi in Singapore. The findings showed that success of the other areas was influenced by continuous monitoring, staff training and use of

advanced technologies. A significant challenge of the study was limited data on food and water safety performance in non-Western countries that cater to large numbers of people like the KAIA Airport. This study seeks to identify trends, recurring issues, and seasonal variations in compliance with the food and water safety regulations, and provide actionable insights to improve compliance at KAIA Airport. The findings can also be applied to inform strategies for managing safety risks in other high-volume transportation hubs.

## Literature Review

### Airport and Food Safety Practices

Hazard Analysis and Critical Control Points (HACCP) framework is an approach that allows airport management teams to evaluate safety procedures within the food production process (6,7). This allows for timely intervention to avoid outbreaks in the airport. The approach has been successful in most of the places where it has been implemented. An example of this is seen in the high levels of safety in major airports like Heathrow (UK) and Changi (Singapore) (11,12). The approach has been shown to reduce the rate of food and safety violations by up to 30% (13,14). However, the guideline has also been associated with challenges that affect implementation or overall efficiency of the airport. Some of the most common challenges that have been discussed in studies include high employee turnover, inconsistent training levels, and pressure to maintain rapid service (15). These challenges apply to different airports like in cases where smaller regional hubs find it difficult to adhere to the procedures because of financial constraints.

### Water Safety in Airport Setting

Water is a crucial part of the production process in an airport. Water is used in various processes within the airport including cooking, drinking and washing, which means that contamination will affect many people. The process of ensuring safety of water is more sophisticated because it passes through multiple stages including treatment, storage, and distribution before being served to an individual (16,17). This presents multiple challenges because contamination can occur on any of the stages provided. The World Health Organization (WHO) and the International Health Regulations (IHR) recommend routine water quality assessment in public facilities. The guidelines emphasize the need to ensure real-time monitoring of microbial indicators like Escherichia coli, and chemical parameters (18,19). Adhering to this recommendation has been shown to reduce the prevalence of water borne diseases by up to 40% (20). KAIA Airport has the advantage because they have religiously complied with Saudi Arabia's water safety regulations. However, there is a need to ensure continued compliance even during the peak season to avoid possible outbreaks (21).

### Challenges Unique to Religious Tourism

One of the challenges of religious tourism is the sudden surge of travelers. Religious tourism involves people traveling during a particular time of the year to a religious destination. In KAIA Airport, more of the religious tourists travel during the Hajj season (6,8). This means that the number of people using the airport during this time surges for a short period before declining when the season ends. The risk management process during this time is challenging because the tourists prefer communal meal consumption and have a different standard of water safety (10). This is a unique challenge that the airport needs to understand and implement appropriate strategies to prevent outbreaks. The issue can be managed by implementing advanced monitoring technologies and localizing treatment. The intervention helps to prepare health professional staff stationed at the airport for the Hajj season where there will be an increase in religious visitors. A practical example is the implementation of fast inspection systems and real-time data integration to improve compliance rates by up to 25% in high-demand environments (22).

**Comparative insights from International Airports**

Insights can be borrowed from approaches implemented by other airports to improve public health outcomes. Changi Airport in Singapore is known for employing a multi-layered approach to food and water safety (13,14). Some of the notable adoptions include regular inspections, advanced microbial testing, and comprehensive staff training programs. These interventions have allowed the facility to reduce the risk of an outbreak. Similarly, Heathrow Airport used regular inspections, staff training and frequent audits to promote compliance with safety standards. However, the only challenge is the fact that these airports operate within different contexts. Changi and Heathrow specifically have robust infrastructure and resources that are different in KAIA Airport. Airports like KAIA face cultural differences in food handling. These challenges require more personalized approaches to optimize effectiveness of interventions (23,24).

**Regulatory Frameworks and Global Guidelines**

WHO's International Health Regulations (2005) is a major regularize of operations in airports. The regulation stipulates guidelines for people entering a country and the process of handling those people. The objective of these regulations is to prevent occurrence of an outbreak at the point of entry (18). However, airports in Saudi Arabia are also required to adhere to Saudi Arabia's Ministry of Health standards. In which are meant to ensure safety of operations including in airports. This regulator demands regular passenger screening, food and water inspections, and vector control. Failure to adhere to the guidelines of this regulator increases the possibility of public health risks. Despite the regulations, there are challenges. The challenges can be attributed to the unique demands of travelers during Hajj and Umrah. These challenges require adoption of regular checks, data collection and analysis to achieve the necessary level of regulatory compliance (15,18).

**Gaps in Research**

A major limitation in the literature is the insufficient information on challenges faced by airports in the Middle East and other regions with high volumes of religious or cultural tourism. As KAIA is considered as the gate way of the two holy cities. Most of the available research focus on airports in the western setting which benefit from advanced infrastructure, and well-established frameworks (8,19). These factors allow the airports to enjoy better and more efficient regulations through all seasons. However, countries in non-Western settings face unique challenges like fluctuating demand, making it difficult to effectively regulate production processes. Another limitation in studies was overlooking the role of seasonal variations in shaping compliance trends. Most of the available literature have acknowledged the potential challenges faced by airports catering to the needs of pilgrims during peak seasons (6,9). However, there are few studies that have explored the implications of the variations on food and water protocols. This necessitates longitudinal research to capture the complexities between operational pressures, regulatory enforcement and public health outcomes.

In summary, the literature highlights the importance of implementing robust measures to promote food and water safety practices in high-traffic airports. High traffic airports present a unique challenge of seasonal variations of visitors, and this makes it challenging to effectively implement the robust measures. Some studies have shown the importance of implementing global frameworks like HACCP and the WHO's IHR to enhance safety of processes. However, they remain a significant challenge because these frameworks fail to consider the complexities of environments like KAIA Airport. The appropriate intervention would require evaluating the unique factors and incorporating them to the adaptation process.

## Methodology

### Study Design

The study used a retrospective observational approach to determine food and water safety compliance at King Abdul Aziz Jeddah Airport. The study took place between October 2023 to October 2024 to have adequate information on the different seasons. Retrospective observational design was the most appropriate because it allowed for the assessment of compliance trends without interfering with real-time operations (1,2). However, data from the observation was complemented with secondary data sources to evaluate operational practices, identify recurring issues, and propose evidence-based recommendations for the identified risks. Quantitative analysis was used to evaluate compliance rates, violation trends, and seasonal variations.

### Data Sources

The first data source was inspection records which contained data from monthly inspections. The inspections were conducted across 115 food facilities within the airport including restaurants, cafes, snack bars, and lounges. The records provided information on compliance outcomes that was either fully compliant, or non-compliant. The second data source was findings from food sample testing. A total of 30 food samples were tested for microbial and chemical testing during the study period. The microbial testing was meant to identify common pathogens including Salmonella spp., Escherichia coli (E. coli), and Listeria monocytogenes. Conversely, the chemical testing evaluated contaminants like pesticide residues and heavy metals to determine adherence to Saudi Food and Drug Authority (SFDA) and the World Health Organization (WHO) standards.

The third data source was water sampling testing. A total of 30 water samples were analyzed for microbial and chemical quality. The tests involved use of microbial indicators like total coliforms and E. coli, and chemical parameters like residual chlorine levels and pH to determine compliance. A variation made to improve efficiency was increasing water sample testing during high-demand periods like Hajj.

### Analytical Approach

The quantitative analysis involved descriptive statistics where monthly compliance rates were calculated and stratified according to facility type and operational period. The frequency and types of violations were also analyzed to determine recurring issues and seasonal trends. The second analysis was inferential statistics like Chi-square tests to determine relationship between compliance, and impact of seasonal variations on compliance rates. The inferential statistics also involved using a p-value threshold of $<0.05$ to determine statistical significance. The last approach was performing a time-series analysis to visualize seasonal changes in compliance and sample safety outcomes to determine deviations during peak periods.

### Ethical Considerations

Ethical considerations were made including anonymity, safty of the data, and securing ethical approval from Institutional review board in Jeddah Health affair (approval No. A02075) to adhere proper research protocols.

## Results

### Food Visits and Compliance Trends

A total of 1,609 field visits were conducted across 115 food facilities at King Abdul Aziz Jeddah Airport. The overall compliance rate was established to be 98.9%, indicating a high level of compliance to the safety protocols. There were minor seasonal variations in compliance rates where adherence decreased to 96.7% during the July 2024 peak Hajj season. However, the compliance rates were higher during off-peak months at 100% in March and April. Out of the

1,609 visits, 1,592 (98.9%) of the inspections were fully compliant. Non-compliant visits were 17 (1.1%).

The research team tried to answer the question: do compliance rate vary across months? In align with the study aims and objectives. The null hypothesis (H0H0) for this question is:

***"There is no significant association between compliance rates (compliant vs. non-compliant visits) and the months of observation."***

The researchers calculated each month's frequency to get Chi square Contribution for each month (compliant stores vs non-compliant)

Table 1: total number of visits.

| **Group (Month)** | **Category 1 (Compliant)** | **Category 2 (Non-Compliant)** | **Total** |
|---|---|---|---|
| Oct-23 | 105 | 3 | 108 |
| Nov-23 | 109 | 0 | 109 |
| Dec-23 | 112 | 0 | 112 |
| Jan-24 | 104 | 1 | 105 |
| Feb-24 | 102 | 1 | 103 |
| Mar-24 | 110 | 0 | 110 |
| Apr-24 | 106 | 0 | 106 |
| May-24 | 198 | 4 | 202 |
| Jun-24 | 185 | 3 | 188 |
| Jul-24 | 117 | 4 | 121 |
| Aug-24 | 106 | 0 | 106 |
| Sep-24 | 102 | 1 | 103 |
| Oct-24 | 136 | 0 | 136 |
| **Total** | 1592 | 17 | 1609 |

To calculate the frequencies: we used the row total * column total. Divided by grand total.

Table 2: frequencies of each month.

| **Group (Month)** | **Category 1 (Compliant)** | **Category 2 (Non-Compliant)** |
|---|---|---|
| Oct-23 | 106.859 | 1.141 |
| Nov-23 | 107.848 | 1.152 |
| Dec-23 | 110.817 | 1.183 |
| Jan-24 | 103.891 | 1.109 |
| Feb-24 | 101.912 | 1.088 |
| Mar-24 | 108.838 | 1.162 |
| Apr-24 | 104.88 | 1.12 |
| May-24 | 199.866 | 2.134 |
| Jun-24 | 186.014 | 1.986 |
| Jul-24 | 119.722 | 1.278 |
| Aug-24 | 104.88 | 1.12 |
| Sep-24 | 101.912 | 1.088 |
| Oct-24 | 134.563 | 1.437 |

Then we calculated Chi square contribution for each cell as follows:

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

For example: Oct 23 category 1

The results as follows: $\chi_{11}^2 = \frac{(105 - 106.859)^2}{106.859} = 0.032$

Table 3: contribution of each

| Group (Month) | Category 1 (Compliant) | Category 2 (Non-Compliant) |
|---|---|---|
| Oct-23 | 0.032 | 3.028 |
| Nov-23 | 0.012 | 1.152 |
| Dec-23 | 0.013 | 1.183 |
| Jan-24 | 0.000 | 0.011 |
| Feb-24 | 0.000 | 0.007 |
| Mar-24 | 0.012 | 1.162 |
| Apr-24 | 0.012 | 1.120 |
| May-24 | 0.017 | 1.631 |
| Jun-24 | 0.006 | 0.517 |
| Jul-24 | 0.062 | 5.794 |
| Aug-24 | 0.012 | 1.120 |
| Sep-24 | 0.000 | 0.007 |
| Oct-24 | 0.032 | 3.028 |

Then we added up all contributions to get the total chi square static $\chi 2=18.362$
After that degree of freedom is calculated as follows:
*df=(Number of Rows−1)×(Number of Columns−1)=(13−1)(2−1)=12*
To determine the p-value, we used the Chi-Square distribution with:

- X2=18.362
- df=12

By using a Chi-Square table:

- the p-value is approximately **0.105**. which is more than p-value 0.05.

The results indicate that the variation in compliance rates (compliant vs. non-compliant visits) across months is not statistically significant. This suggests that any observed differences in compliance rates are likely due to chance and not a meaningful pattern.
The Chi-Square test of independence was conducted to examine whether compliance rates (compliant vs. non-compliant visits) vary significantly across months. The results showed no significant association between the months and compliance rates. Thus, compliance rates do not significantly fluctuate across months.

The researchers noticed from the reports that the first corrective action that was taken to improve compliance was reporting identified issues to relevant authorities. It was followed by implementing measures like upgrading equipment, retraining staff and conducting additional follow-up inspections. In which may improved the compliance rate overall.

**Association between compliance rate and health certificates status**

The researchers aimed to investigate the non-compliance issues, which were primarily related to health certificates that were still under process. According to Saudi regulations, a valid health certificate is required for each worker involved in food handling. The researcher collected the number of valid certificates or under process certificates for each visit during the time indicated

above Oct23 to Oct24. For that we used Chi square of independence to answer the question: Are compliance levels related to health certificates?

The null hypothesis for this Chi-Square Test of Independence is:

***Compliance levels (compliant vs. non-compliant visits) are independent of health certificate status (valid vs. under process).***

In other words, the validity of health certificates does not influence whether a visit is compliant or non-compliant.

A Chi-Square Test of Independence was performed to examine the relationship between health certificate status (valid vs. under process) and compliance levels (compliant vs. non-compliant visits). The test provided the following results:

Table 4: chi square 2 by 2.

| | complied visits | non complied | Marginal Row Totals |
|---|---|---|---|
| valid health certificates | 1848 (1903.07) [1.59] | 2588 (2532.93) [1.2] | 4436 |
| under process | 273 (217.93) [13.91] | 235 (290.07) [10.45] | 508 |
| Marginal Column Totals | 2121 | 2823 | 4944 (Grand Total) |

The chi-square statistic is 27.1574. The p-value is < 0.00001. Significant at $p < .05$.

Since $p<0.05$, we reject the null hypothesis, indicating that compliance levels and health certificate status are not independent. This suggests a significant relationship between these variables. The findings demonstrate that facilities with workers holding valid health certificates are significantly more likely to have compliant visits compared to those with workers whose certificates are under process. The observed discrepancy highlights the critical role of valid health certification in ensuring compliance with safety standards.

**Water Sample Testing**

A total of 36 water samples were collected and analyzed for microbial and chemical safety. Results indicated a 91.7% compliance rate and 3 failures during the peak operational seasons.

Water testing frequency increased during the high-peak months like June, and failures were traced to infrastructure vulnerabilities.

Table 5: water sample testing results.

| Month | Water Samples Tested | Met Standards | Failed Standards | Actions Taken | Type of Action |
|---|---|---|---|---|---|
| Oct-23 | 0 | 0 | 0 | None | None |
| Nov-23 | 0 | 0 | 0 | None | None |
| Dec-23 | 5 | 5 | 0 | None | None |
| Jan-24 | 5 | 5 | 0 | None | None |
| Feb-24 | 5 | 4 | 1 | Retesting | Retesting |
| Mar-24 | 5 | 5 | 0 | None | None |

| | | | | | |
|---|---|---|---|---|---|
| Apr-24 | 5 | 5 | 0 | None | None |
| May-24 | 0 | 0 | 0 | None | None |
| Jun-24 | 10 | 8 | 2 | Water filter replacement, reporting | Equipment replacement |
| Jul-24 | 5 | 5 | 0 | None | None |
| Aug-24 | 1 | 1 | 0 | None | None |
| Sep-24 | 0 | 0 | 0 | None | None |
| Oct-24 | 0 | 0 | 0 | None | None |

However the researchers wanted to answer the question: Do water tests vary across the months? For that we used proportion Z test as the number of tests is small and only comparable between two months that has test that not met the test criteria.
The Null Hypothesis (H0H0) is:
***The proportion of samples meeting the criteria is the same for the two months (p1=p2)***
The proportion of samples meeting the criteria for each month is:

$$p_1 = \frac{x_1}{n_1}, \quad p_2 = \frac{x_2}{n_2}$$

$p_1 = \frac{4}{5} = 0.8$ for Feb-24.

$p_2 = \frac{8}{10} = 0.8$ for Jun-24.

By calculating the pooled proportion, we get: p= 0.08 and standard error SE= 0.219 and z statistics as Z=0.
Using the Z-statistic, the two-tailed p-value from a standard normal distribution table is: p=1.0
Since p>0.05, we fail to reject the null hypothesis. There is no significant difference in the proportion of samples meeting the criteria between February 2024 and June 2024.

**Food Sample Testing**
A total of 38 food samples were tested over the 12-month period, and findings showed a 100% compliance rate. All the food samples were free from microbial contamination and chemical hazards. And there are no need to perform statistical analysis.

**Discussion**

The study showed a high level of compliance rate of 98.9% in the 1,609 inspections. The rate is high indicating a high level of effectiveness in adhering to Saudi Arabia's regulatory frameworks and routine monitoring systems. It supports the findings of previous research studies that showed how other airports like Heathrow and Changi achieved high compliance rates by implementing rigorous inspections and adhering to HACCP principles (1,2).

One thing that was evident was the seasonal fluctuations, and respective decline in compliance during peak periods like Hajj. The compliance rates for July 2024 dropped to 96.7%

indicating a strain on resources and operational capacity during such periods. However, by conducting the statistical analysis, the results indicate that the variation in compliance rates (compliant vs. non-compliant visits) across months is not statistically significant. This suggests that any observed differences in compliance rates are likely due to chance and not a meaningful pattern.

Yet, the results indicates that compliance rate is associated with the validity of the health certificates of workers that are associated with food handling. The findings demonstrate that facilities with workers holding valid health certificates are significantly more likely to have compliant visits compared to those with workers whose certificates are under process. The observed discrepancy highlights the critical role of valid health certification in ensuring compliance with safety standards.

The water compliance rate was high at 91.7% for the 36 samples. Failures were observed in the months of February and June 2024 indicating underlying vulnerabilities in water management during peak seasons. The bacterial contamination and chemical contamination failures were attributed to faulty filtration systems in the shop that was randomly checked. These systems require regular infrastructure maintenance and real-time monitoring to improve compliance (7). However there was no significant result by comparing the two months that has test results that did not met the standards.

The findings of the study are consistent with the research from studies focusing on similar settings. The finding highlighted the importance of proactive water quality monitoring in reducing the prevalence of waterborne diseases (4).

There was 100% compliance to the food tests indicating adherence to safety protocols. There was an absence of microbial or chemical contamination in all the 38 food samples. Success of this adherence can be attributed to the airport's implementation of the HACCP frameworks and staff training programs (5). The findings or the study reflect information provided in outside literature where other airports like Changi Airport reported high levels of compliance that was linked to implementation of the HACCP compliance framework. It was also associated with a reduction in the rate of foodborne illness outbreaks (6).

**Strength**

The study uses descriptive and inferential statistics to provide a comprehensive understanding of compliance rates and underlying factors. It also highlights the operational challenges faced during peak periods like during the Hajj, and recommends actionable strategies to optimize resource utilization. Lastly, the study highlights on the importance of health certificates validity is it shows significant associating with the compliance rates of visits.

**Limitations**

The study used a relatively small sample size of 38 food samples and 36 water samples, affecting generalizability of findings. Second limitation was the one-year study period which fails to capture long-term trends. The study also relied on secondary data, restricting its ability to control data quality.

**Policy Implications and Recommendations**

There is a need to implement advanced monitoring systems. The recommendation is to implement AI-driven monitoring systems to the evaluation process. This technology offers continuous monitoring and real-time information sharing for timely interventions (7). The second recommendation is implementing preventive maintenance strategies. Crucial elements like the filtration systems need to be changed regularly and evaluated to prevent disruption in supply of water or contamination. The last recommendation is implementing regular staff training and

minimize the tame taken to renew the health cirtificates (as renewing the cirtificates requires training for food handling and medical check) . Staff are an integral part of the food and safety measures of the airport and regular training allows them to have the necessary information to comply with the indicated guidelines. The study aligns with Saudi Arabia's Vision 2030 goals because it provides insights of strategies to improve safety and efficiency of airport operations. Policymakers should use the findings to develop policies that could promote safety standards in the airport.

**Future Research**

Future research should focus on conducting longitudinal studies. These studies are more appropriate because of the ability to capture long-term safety trends and evaluate sustainability of compliance measures. The studies should also explore integration of advanced technologies like digital tracking systems to determine effectiveness in monitoring safety practices. Lastly, future studies should investigate the socio-cultural factors affecting food and water safety compliance. This applies to unique contexts of religious tourism where the factors affect compliance rates.

**Conclusion**

The study shows the importance of maintaining high levels of food and water safety standards at King Abdul Aziz Jeddah Airport. The findings demonstrate robust compliance, non-seasonal variations, and infrastructure. They also highlight opportunities for improvement to improve public health outcomes especially during peak seasons. However, these vulnerabilities can be addressed by implementing advanced monitoring systems, preventive maintenance strategies, and targeted staff training programs. The airport can also safeguard public health and reinforce its role as a global gateway for religious tourism. These strategies will benefit Jeddah airport and contribute to the broader goal of effectively managing food and water safety in high-traffic transport hubs worldwide.

Reference List

1. World Health Organization (WHO). (2015). Estimates of the global burden of foodborne diseases: Foodborne Disease Burden Epidemiology Reference Group 2007-2015. WHO. Retrieved from https://www.who.int
2. World Health Organization (WHO). (2020). Guidelines on drinking-water quality. 4th edition. WHO Press. Retrieved from https://www.who.int/water_sanitation_health
3. General Authority for Statistics, Saudi Arabia. (2023). Annual Hajj Statistics Report. Riyadh: GASTAT. Retrieved from https://www.stats.gov.sa
4. Saudi Food and Drug Authority (SFDA). (2020). Food Safety Requirements in Public and Transport Facilities. Riyadh: SFDA. Retrieved from https://www.sfda.gov.sa
5. Centers for Disease Control and Prevention (CDC). (2019). Preventing Foodborne Illnesses at Mass Gatherings: Case Studies. CDC. Retrieved from https://www.cdc.gov/foodsafety
6. Heathrow Airport. (2021). Annual Environmental and Operational Safety Report. London: Heathrow Airport Holdings.
7. Changi Airport Group. (2022). Safety Standards and Compliance in High-Volume Airport Operations. Singapore: CAG Press.
8. International Air Transport Association (IATA). (2018). Managing Health and Hygiene in Air Travel. Montreal: IATA Publications.
9. Centers for Disease Control and Prevention (CDC). (2017). Guidelines for Preventing Waterborne Diseases in Airports. CDC. Retrieved from https://www.cdc.gov

10. Royal Commission for Mecca City and Holy Sites. (2023). Health and Safety Standards for Pilgrims. Jeddah: RCM Press.
11. Ministry of Hajj and Umrah, Saudi Arabia. (2023). Hajj Operational Guidelines for Transport Hubs. Riyadh: Ministry of Hajj and Umrah.
12. Alsharif, A. & Alkhateeb, M. (2020). Food and Water Safety in High-Volume Religious Gatherings: A Case Study of Mecca and Medina. Saudi Medical Journal, 41(3), 245-251.
13. Kramer, A., Schwebke, I., & Kampf, G. (2006). How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infectious Diseases, 6(130). https://doi.org/10.1186/1471-2334-6-130
14. Ebrahim, S. H., & Memish, Z. A. (2020). Mass gatherings and global health security. The Lancet, 395(10230), 2073–2075. https://doi.org/10.1016/S0140-6736(20)31250-5
15. Memish, Z. A., Stephens, G. M., Steffen, R., & Ahmed, Q. A. (2012). Emergence of medicine for mass gatherings: lessons from the Hajj. The Lancet Infectious Diseases, 12(1), 56–65. https://doi.org/10.1016/S1473-3099(11)70337-1
16. Choudhary, S., Sharma, P., & Khandekar, P. (2022). Compliance with HACCP Standards in High-Density Tourist Areas. Journal of Food Safety, 42(2), e12981.
17. World Health Organization (WHO). (2008). International Health Regulations (2005): Areas of Application. Geneva: WHO Press.
18. Food and Agriculture Organization (FAO). (2021). Codex Alimentarius: General Principles of Food Hygiene. FAO and WHO.
19. Al-Qahtani, A. (2020). Infrastructure Challenges in the Kingdom's Pilgrimage Transport Network. Journal of Middle Eastern Studies, 52(4), 120-135.
20. Sampson, J. & Morgan, P. (2019). Critical Pathways for Airport Sanitation: A Review of Global Standards. Environmental Safety Journal, 62(6), 841-855.
21. Jones, T. & Franklin, M. (2017). Waterborne Diseases in Airports: A Systematic Analysis. Global Health & Hygiene Journal, 18(4), 211-219.
22. Sato, K. & Yamamoto, T. (2021). Airport Food Safety in Asia: Examining High-Traffic Hubs. Asian Journal of Public Health, 33(8), 569-582.
23. Green, D. & Black, H. (2022). Mass Gathering Health Impacts: Focus on Food and Water Safety. Global Safety Outlook, 47(3), 489-502.
24. Memish, Z. A., Al-Tawfiq, J. A., & Zumla, A. (2020). Hajj 2020 and the impact of the COVID-19 pandemic.Nature Reviews, 18(4), 240-242. https://doi.org/10.1038/s41572-020-0175-9