THE IMPACT OF SMART TECHNOLOGIES AND SAFE MEASURES OF EGYPTIAN AIRPORTS ON PASSENGER'S SATISFACTION

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ABSTRACT

This study explores the characteristics of Cairo International Airport and their impact on passenger satisfaction, focusing on two key dimensions: smart and safe features. The research aims to assess the airport's performance in these areas, identify gaps, and propose recommendations for improvement. A mixed-methods approach was employed, utilizing observation and a survey analyzed through SPSS V.22. The findings reveal varied performance across the dimensions. While safety showed strong positive impacts on passenger satisfaction, smart features demonstrated moderate effects. However, significant gaps were identified in the implementation of advanced smart technologies and enhanced passenger-centric amenities. Statistical analysis confirmed the significant relationships between these characteristics and passenger satisfaction, with safety aspects emerging as the most influential. The study underscores the need for strategic investments in smart infrastructure, alongside maintaining high standards in security measures. These improvements are critical for enhancing passenger experiences and aligning the airport with global standards. The study concludes with actionable recommendations, emphasizing a balanced integration of the four dimensions to achieve operational excellence and elevate Cairo International Airport's global competitiveness.

KEYWORDS: Smart Airport, Safe and Security,Internet of Things (IOT), Passenger's Satisfaction, Egypt.

INTRODUCTION

The integration of smart technologies provides effective solutions to manage challenges such as surges in passenger flow, particularly during peak travel times. These technologies, including the Internet of Things (IoT), big data, and artificial intelligence, offer airports the tools to streamline processes and improve service delivery (Mohamed et al., 2018).

The Smart characteristic, which involves the use of advanced technologies like IoT and data analytics to optimize operations, remains underutilized in many airports, including Cairo International. This lack of innovation impacts the airport's ability to streamline passenger flows, reduce waiting times, and enhance operational coordination (AlMashari et al., 2018). Similarly, although sustainability has become a global priority, Green initiatives at airports are often limited or poorly implemented, leading to inefficient use of resources and a larger carbon footprint (Upadhyay & Bijalwan, 2015).

Finally, Safety, as one of the most critical components of airport operations, presents a continuous challenge. The need for rigorous security measures and the implementation of safety protocols, while essential for protecting passengers, can lead to delays and longer waiting times, potentially impacting passenger satisfaction (Narongou & Sun, 2021). While these security measures are essential for ensuring a safe environment, they must be balanced with efficiency to avoid frustration and inconvenience for travelers.

Given these challenges, this study seeks to investigate how the integration of these two key characteristics—Smart and Safety—can influence passenger satisfaction at Cairo International Airport. The research aims to identify gaps in the current practices and explore how these characteristics can be better utilized to enhance the overall passenger experience, providing valuable insights for airport management and policymakers.

RESEARCH OBJECTIVES

The main objective of this study is to examine the impact of two pivotal characteristics smart and safe —on passenger satisfaction at Cairo International Airport. These characteristics are essential for enhancing the modern airport experience and aligning with global standards. From this overarching objective, the study derives a set of specific sub-objectives to provide a more detailed investigation:

- To assess the current presence of smart and safe measures at Cairo International Airport.

- To measure the impact of each of the studied characteristics (smart and safe) on passenger satisfaction at Cairo International Airport.
- To propose an executive plan to enhance the implementation of green and humanistic characteristics, improving passenger satisfaction and overall airport performance.

RESEARCH HYPOTHESES

There are hypotheses for this research as follows:
H1: There is a significant relationship between the attributes of Smart Airports and passenger satisfaction
H2: There is a significant relationship between the attributes of Safe and Security Airports and passenger satisfaction.

LITERATURE REVIEW

OVERVIEW of SMART

The term "smart" has been defined in various ways within the literature. The Oxford Dictionary describes it as "clean, clever, modern, and quick" (Oxford, 2008). In business contexts, "smart" often denotes increased productivity, creativity, and relevance (Deresiewicz, 2014). From the standpoint of business intelligence, smart systems or technologies are characterized by their ability to efficiently meet customer needs through tailored functionalities (Sun & Strang, 2018).
The concept also extends to the acquisition and application of knowledge and skills. Smart technologies are data-driven systems that utilize sensors and Artificial Intelligence (AI) to enable autonomous operations (Vermeulen, 2017). These systems incorporate technologies such as analytics, machine learning, and AI (Frogeri et al., 2019). Furthermore, smart systems rely on internet-connected devices to deliver intelligent, adaptive functionalities (Xu et al., 2020).

DEFINITIONS OF SMART AIRPORT

A smart airport is an integrated system that utilizes advanced airport processing solutions to deliver "the best possible aviation ecosystem" (Oakleaf et al., 2022). It encompasses the management, recording, and processing of all airport-related activities, including passenger experiences and operational management within the broader aviation ecosystem.
The concept of a smart airport underscores the importance of full digital connectivity through various smart systems and technologies, such as the Internet of Things (IoT) and big data analytics. These technologies enable

innovative solutions that address traditional challenges while advancing the vision of smart airports (Mariani et al., 2019).

The primary objective of a smart airport is to integrate Information and Communication Technology (ICT) systems—comprising hardware, software, cloud computing, and processes—to enhance passenger experiences, build trust among stakeholders, create competitive advantages, and reduce costs (Mariani et al., 2019; Nau & Benoit, 2017; Jašari, 2015).

SMART AIRPORT MANAGEMENT

Smart airport management refers to a comprehensive framework that integrates and shares critical ICT infrastructures and systems to optimize airport operations, enhance passenger experiences, and improve service quality across the aviation ecosystem (Nau & Benoit, 2017). It is a specialized domain within aviation management, focusing on both passenger satisfaction and operational efficiency, supported by digital technologies that enable seamless and interconnected processes (Newbold, 2020).

Effective management of smart airports requires the application of fundamental management functions, including planning, organizing, leading, and controlling. These functions guide the selection and implementation of sustainable technologies and systems to improve operational efficiency. Management, as a dynamic social process, entails the responsibility for economically and effectively planning and regulating activities to fulfill organizational objectives (Sun, 2019). Examining smart airports from a management perspective is crucial to comprehensively address their operational complexities and strategic requirements.

APPLICATION TO SMART AIRPORT OPERATION

Airport management plays a crucial role in ensuring efficient operations with limited resources. It involves coordinating with both internal and external agencies, maintaining timely service delivery, ensuring passenger security, and complying with regulations. Airport terminal operations are primarily focused on passenger services, baggage handling, and regulatory clearance. Smart technology offers innovative solutions to address the challenges posed by increasing passenger flows, especially during peak hours (Mohamed, Gomaa, & El-Sherif, 2018). The application of smart technology in airports can be categorized as follows:

- **Self-Service Check-In Kiosks**: Passengers can check in using various methods such as mobile phones, personalized services, and automated kiosks, reducing the need for ground staff and minimizing human errors (Wittmer, 2011). Unlike previous systems where airlines had exclusive kiosks, smart airports now integrate all airline

services into shared kiosks, thus optimizing terminal space and reducing operational costs (Mantouka et al., 2019).

- **Self-Boarding**: Self-boarding gates allow passengers to scan their boarding passes independently, enabling quicker processing times and reducing the need for ground staff involvement. This process not only lowers staffing costs but also enhances customer satisfaction by decreasing waiting times at the gate (Jaffer & Timbrell, 2014).
- **Indoor Navigation**: Mobile applications can provide real-time, personalized flight information and guide passengers within the terminal, improving their navigation experience. These apps integrate airport maps and alert passengers about gate changes and boarding procedures, potentially reducing the need for extensive terminal signage (Rajapaksha & Jayasuriya, 2020).
- **Smart Wheelchairs**: Autonomous, self-driving wheelchairs and golf carts could reduce the need for ground staff assistance for passengers with reduced mobility. These self-driving vehicles can be manually controlled or programmed to navigate through the terminal (Mantouka et al., 2019).
- **Smart Wearables**: Wearable devices such as smart watches, glasses, and headphones equipped with sensors can provide passengers with timely alerts about check-in procedures, gate changes, and other amenities within the airport (Kong et al., 2019). These devices enhance real-time communication and improve passenger experience during their journey (Jalali & Zeinali, 2018).
- **Biometric Services**: Biometric identification, using features like facial recognition or fingerprint scanning, is increasingly utilized for airport security, immigration, and baggage claim (Heracleous et al., 2006). This technology streamlines processes and reduces the need for manual identity checks (Scherer et al., 2000).

INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is a technological paradigm that envisions a future in which every day physical objects are interconnected through the internet, allowing them to identify and communicate with each other autonomously. This network of devices communicates using IP connectivity without the need for human intervention. The IoT ecosystem includes smart objects, intelligent devices, smartphones, and tablets, which rely on technologies such as Radio Frequency Identification (RFID), Quick Response (QR) codes, sensors, and wireless communication for device interconnectivity (Singh & Singh, 2015).

DEFINITIONS OF THE INTERNET OF THINGS (IOT)

The IoT represents an emerging technology that enables objects to connect to the internet, allowing them to recognize themselves and exhibit intelligent behaviors by making decisions based on the information they exchange. These objects can either gather information from other connected devices or integrate with various services. As the IoT enables seamless communication between devices, ensuring that any object can connect to the internet at any time, from any location, to offer a range of services such as notifications, security, energy savings, automation, communication, computing, and entertainment. This transformative concept gives rise to innovative applications like smart vehicles and smart homes (Zeinab & Elmustafa, 2017; Kaur & Singh, 2016; Saranya & Nitha, 2015).

Additionally, several critical components of the Internet of Things (IoT) include:

- **RFID (Radio-Frequency Identification):** A compact electronic device consisting of a chip and antenna, used to automatically identify and track tagged objects through radio waves (Rajaraman, 2017).
- **WSN (Wireless Sensor Network):** A network of spatially distributed sensors designed to monitor various physical conditions such as temperature, motion, or pressure, providing real-time data for IoT applications (Prabhu et al., 2017).
- **WPAN (Wireless Personal Area Network):** A short-range wireless network that facilitates the interconnection of devices within the vicinity of an individual's workspace, enhancing personal device communication (Nandyala & Kim, 2016).
- **WBAN (Wireless Body Area Network):** A network of wearable devices, such as sensors and actuators, positioned on or within the human body to monitor health metrics and enable physiological data transfer (Singh & Prasad, 2022).
- **HAN (Home Area Network):** A local network that connects digital devices within or around a home, enabling seamless communication and automation of household functions (Khan et al., 2016).
- **NAN (Neighborhood Area Network):** A network designed to provide quick, low-cost internet connectivity, often facilitated by Wi-Fi hotspots, enabling access across a localized area (Huang& Zhu, 2022).
- **M2M (Machine to Machine):** A technology that allows devices to autonomously communicate with one another, optimizing the performance of connected systems through real-time data exchanges (Chen et al., 2012).

- **CC (Cloud Computing):** A computing model that delivers on-demand network access to shared resources, such as storage and applications, enabling the shift of data processing and storage tasks to the cloud, particularly in mobile environments (Domenech et al., 2022).
- **DC (Data Center):** A centralized repository for the storage, management, and distribution of data, ensuring efficient access and dissemination across the IoT ecosystem (Hogan, 2022).

EXAMPLES OF SMART AIRPORTS IN THE WORLD

Several airports around the world have implemented smart technologies to enhance operational efficiency, improve passenger experience, and streamline security processes. These innovations highlight the growing trend toward the integration of digital and automated solutions in the aviation industry. The following are notable examples of smart airports globally:

- **London Heathrow Airport**

Heathrow, one of the world's busiest airports, is trialing autonomous robots to guide passengers through Terminal 5. Additionally, the airport has introduced self-driving luggage vehicles, automated bag drop machines, and self-boarding technology throughout the terminal. These advancements are complemented by extensive staff training programs designed to ensure airport employees are equipped with the necessary skills to use specialized apps that assist in resolving customer issues (Jayasuriya & Rajapaksha, 2020).

- **Hamad International Airport**

Hamad International Airport in Doha has integrated next-generation self-service check-in kiosks and self-service bag drops, which incorporate biometric technology. The airport has also introduced a mobile Automated Visa Document Check, which enables ground service operators to verify passenger visa documentation before boarding. This technology significantly enhances the efficiency of airport operations and reduces processing time for passengers (Reyes, 2021).

- **Singapore Changi Airport**

Changi Airport is known for its cutting-edge technological integration, which includes sensors, data analytics, and artificial intelligence to improve both the customer experience and operational productivity. A notable innovation is the development of a blockchain-based digital wallet, allowing passengers to use their frequent flyer rewards at participating airport retailers. This system enhances the overall passenger experience by providing seamless integration between travel rewards and retail services (Kováčiková et al., 2022).

SAFE AND SECURITY

Safety and security represent the cornerstone of the aviation industry, safeguarding passengers, staff, and operations alike. The perception of safety during travel, however, is a multifaceted phenomenon influenced by environmental, psychological, and societal factors. Studies have shown that perceived safety often extends beyond actual risks, shaped by emotional and cognitive responses to the travel environment (Weiss et al., 2016).

Airports, as critical nodes in the aviation network, must address a wide spectrum of safety and security considerations. These range from robust infrastructure and comprehensive personnel training to the implementation of cutting-edge technological systems. The tragic events of September 11, 2001, served as a wake-up call, highlighting vulnerabilities and prompting global initiatives led by organizations such as the International Civil Aviation Organization (ICAO) to develop standardized safety and security protocols (Piètre-Cambacédès & Bouissou, 2013).

THE IMPORTANCE OF SECURITY AND SAFETY

Security and safety are critical elements of airport operations, acting as the backbone of passenger trust and operational reliability. The significance of these components extends beyond their practical implications, shaping public perceptions of the aviation industry's reliability and professionalism. Since the advent of commercial aviation, airports have consistently evolved to address emerging safety concerns, adapting to changing geopolitical contexts, technological advancements, and passenger expectations (Nolan, 2014).

The history of aviation security illustrates a progressive response to various challenges. For instance, the wave of aircraft hijackings in the 1960s catalyzed international efforts to develop conventions addressing aviation security, including the Tokyo Convention. Subsequent high-profile incidents, such as the 2001 terrorist attacks, intensified these efforts, leading to more stringent global standards. The establishment of the International Civil Aviation Organization (ICAO) further reinforced the focus on creating unified frameworks for managing risks and promoting secure environments (ICAO, 2022).

In modern contexts, the concept of security extends beyond preventing unlawful interference. Airports must also address risks associated with cybersecurity, operational disruptions, and public health crises. Each of these factors requires tailored strategies to ensure seamless operations while safeguarding passenger well-being. Advanced measures, including real-time threat detection systems, robust data protection protocols, and health

screening facilities, highlight the proactive approach required to mitigate emerging risks effectively (Piètre-Cambacédès & Bouissou, 2013).

SAFETY MANAGEMENT SYSTEMS (SMS)

Safety Management Systems (SMS) represent a structured approach to managing safety in aviation, emphasizing proactive risk identification, mitigation, and continuous improvement. Introduced in the early 2000s, SMS has become a cornerstone of airport operations, enabling organizations to maintain high safety standards while adapting to evolving challenges (Kurt & Gerede, 2017).

Key Components of SMS

An effective SMS comprises four key components (Li & Guldenmund, 2018):

- **Safety Policy**: Establishes organizational commitments to safety, outlining goals, resources, and accountability structures. It provides a foundation for fostering a safety-conscious culture and ensuring adherence to best practices.
- **Safety Assurance**: Involves continuous monitoring and assessment of safety performance, utilizing data-driven insights to validate the effectiveness of risk control measures.
- **Safety Risk Management**: Focuses on identifying potential hazards, evaluating associated risks, and implementing controls to mitigate these risks.
- **Safety Promotion**: Encourages ongoing training, education, and communication to cultivate an organizational culture prioritizing safety.

ORGANIZATION OF PASSENGER SECURITY CONTROL AT AN AIRPORT

Passenger security control represents a fundamental aspect of airport operations, safeguarding travelers while ensuring compliance with regulatory standards. This process involves a combination of manual and automated techniques designed to detect potential threats and maintain a secure environment (Skorupski & Uchroński, 2016).

There are various methods of passenger screening (Skorupski & Uchroński, 2016) such as:

- **Manual Screening**: Includes physical inspections conducted by trained personnel to identify prohibited items or suspicious behaviors.
- **Walk-Through Metal Detectors (WTMD)**: Utilized to detect metallic objects, ensuring passengers do not carry restricted items.
- **Explosive Detection Dogs (EDD)**: Deployed to identify explosive materials, providing an additional layer of security.

- **Advanced Imaging Technologies**: Include devices that scan passengers without ionizing radiation, enhancing detection capabilities while prioritizing passenger comfort.
- **Explosives Trace Detectors (ETD)**: Used for chemical analysis to identify traces of explosive materials.

While security measures are indispensable, they can also contribute to passenger stress if not managed effectively. Airports must strive to balance rigorous screening processes with a seamless and reassuring experience. Strategies such as clear communication, well-trained staff, and efficient technologies can minimize disruptions while maintaining robust security standards.

PASSENGER SATISFACTION AT THE AIRPORT

Until the 1980s, airports largely adopted a passive approach to customer services. However, with significant transformations in the air transport industry, interest in passenger satisfaction has markedly increased (Moon et al., 2017; Bogicevic et al., 2013). Recent literature on airports highlights various relationships between passenger satisfaction and other key aspects of the airport experience, such as:

- **Service Attributes**: The various service dimensions influencing passenger satisfaction, such as convenience, efficiency, and cleanliness (Bogicevic et al., 2013; Eboli & Mazzulla, 2009; Correia et al., 2008; Yeh & Kuo, 2003).
- **Demographics and Flight Characteristics**: The interplay between passenger demographics, flight characteristics, and their levels of satisfaction and fairness perceptions (Sindhav et al., 2006).
- **Security Screening**: Satisfaction with security screening processes, which depends on the performance of the procedure and passenger-specific characteristics (Sakano et al., 2016; Gkritza et al., 2006).
- **Service Quality Dimensions**: The impact of various service quality dimensions on passenger satisfaction, moderated by passenger attributes (Bezerra & Gomes, 2015).
- **Servicescape Influence**: The relationship between the physical airport environment (servicescape) and passenger satisfaction (Bogicevic et al., 2016; Jen et al., 2013; Jeon & Kim, 2012).
- **Physical Environment**: The role of the airport's physical environment in shaping passenger satisfaction and delight, influenced by factors such as national identity (Ali et al., 2016).

Passenger satisfaction at airports is a cognitive process shaped by travelers' perceptions, behaviors, and expectations concerning their airport experience (Tuchen et al., 2020; Fodness & Murray, 2007). Studies have found that

cleanliness, shopping options, Wi-Fi availability, and comfortable seating are appreciated by passengers, while security checks, poor signage, and long queues are common sources of dissatisfaction (Bogicevic et al., 2013).
The link between passenger satisfaction and service quality is further underscored through surveys conducted by international organizations such as the Airport Council International (ACI) and the International Air Transport Association (IATA). Researchers also focus on quality parameters like process efficiency, congestion, mobility, security, and the impact of specific services (e.g., check-in and information systems) on satisfaction (Chang & Chen, 2011; de Barros et al., 2007).

THE IMPACT OF SMART TECHNOLOGY ON PASSENGER SATISFACTION

The adoption of smart technologies in airport operations has revolutionized the travel experience, offering innovative solutions to enhance passenger satisfaction. Technologies such as self-service kiosks, mobile applications, and biometric systems streamline processes, reduce wait times, and empower passengers with greater autonomy, positively influencing their confidence, enjoyment, and overall satisfaction (Bogicevic et al., 2017).

1. BENEFITS OF SMART TECHNOLOGY INTEGRATION

- **Efficiency:** Automated systems expedite check-ins, security screenings, and boarding, significantly reducing delays and improving the flow of passengers through airports. Self-service kiosks, baggage tracking systems, and automated gates play critical roles in modern air travel, improving operational efficiency (Patel, 2018; de Barros et al., 2007).
- **Personalization:** Mobile applications provide passengers with customized travel experiences, enabling them to choose seats, receive real-time updates, and access tailored services, contributing to enhanced convenience and satisfaction (Chen & Chang, 2005).
- **Sustainability:** Digital ticketing and e-boarding passes help reduce paper waste, aligning with global environmental goals and reinforcing airports' commitments to sustainable practices (Brida et al., 2016).
- **Security:** The integration of biometric systems enhances security while maintaining efficiency, addressing the challenges of balancing stringent safety measures with smooth passenger processing (Patel, 2018).

2. IMPACT ON PASSENGER SATISFACTION

Passenger satisfaction is influenced by both the operational efficiency of smart technologies and the quality of services available at airports, such as flight punctuality, clear signage, and the availability of accurate information (Fodness & Murray, 2007). While innovative technologies often enhance the travel experience, airports must address individual differences and ensure inclusivity to maximize satisfaction levels (Kong et al., 2019).

THE IMPACT OF SAFETY AND SECURITY ON PASSENGER SATISFACTION

Safety and security are essential factors that significantly influence passenger satisfaction at airports. These elements contribute to passengers' perceptions of trust, reliability, and overall comfort throughout their journey. This section explores the various ways in which safety and security measures affect passenger experiences at airports.

1. Importance of Visible Security Measures

Visible security measures such as patrols, advanced screening systems, and clear safety protocols play a key role in reassuring passengers and ensuring they feel safe while at the airport. These measures not only contribute to safety but also serve to deter potential threats, reinforcing a secure environment (Sindhav et al., 2006).

2. Role of Well-Trained Security Personnel

The competence of airport personnel plays a critical role in enhancing the perception of safety. Security staff who are properly trained tend to comply more with established protocols, which in turn enhances the overall perception of security. While necessary, security checks can be a source of stress for passengers. However, passengers generally accept these measures as a means of ensuring overall safety (Kirschenbaum & Rapaport, 2017; Kirschenbaum, 2013).

3. Safety as a Key Dimension of Service Quality

Studies have shown that safety and security are major dimensions of perceived service quality, with a direct impact on passenger satisfaction. Clemes et al. (2008, 2011) emphasized that passengers' sense of safety influences their satisfaction levels. Furthermore, the feeling of safety mediates the relationship between airport security measures and passengers' intentions to board flights, leading to higher satisfaction and repeat travel (Alards-Tomalin et al., 2014).

RESEARCH METHODOLOGY

The main purpose of the field study is to effect of the smart technologies and safe measures of Egyptian airports on passenger satisfaction (case study-Cairo International Airport). Moreover, the study was conducted to achieve the study hypotheses and explore the two characteristics that affect passenger satisfaction to find a solution for the study problem, reach the results and propose recommendations.

This assessment based on some data was gathered to reach more accurate data as possible , so it would be collected through mixed tools quantitative and qualitative tools as follows :-

1- The quantitative tool is the questionnaire which is distributed over a passenger's Cairo International Airport.
2- The qualitative tool is the participant observation which is applied on smart technologies and safe measures by the researcher.

The participant observation checklist was designed after reviewing other previous studies (Ferrulli, 2016; Mohamed et al., 2018; Sun et al., 2021). The checklist items were designed based on the literature review, to identify the two characteristics (smart and safe) available at Cairo Airport to be explored and evaluated by the researcher. This checklist contains two items as follows; Smart Airport and Safe and Security.

The questionnaire was divided into two main parts. Part one was about personal data. The second part consists of 3 components such: smart airport (12 elements), safe and security (8 elements) and passenger's satisfaction (16 elements).

This study's population consisted of passengers' Cairo International Airport. Cairo International Airport was chosen because of the most important airport in the Arab Republic of Egypt and one of the most important airports in Africa and Middle East.

Sample Size Calculation

$$n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2}$$

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384.16$$

Applying these values to Steven K. Thompson formula reveals that the appropriate sample size for this research is 384 participants but the researcher distributed 420. The researcher distributed (420) questionnaires. After analysis, there were 8 questionnaires not valid for analysis; the valid is (412). It is necessary to determine the required minimum sample size in survey situations and other statistical methods to generalize the population's results. To obtain a statistically representative sample size of the population, Steven K. Thompson formula is used.

The questionnaire was distributed to air passengers directly at Cairo International Airport in Terminals. The questionnaire forms were also distributed by e-mail. A sample questionnaire was written and it was distributed in two languages in Arabic and English during the period between July 2024 and November 2024. The sample number was 412 passengers.

The collected data were analyzed within three stages the first stage including participant observation by researcher to explore and assess smart technologies and safe measures. The second stage was to analyze the quantitative data questionnaire using SPSS V.22 and increase results credibility to achieve study objectives and hypotheses.

Face validity: the scale was reviewed by nine academic reviewers. The comments and observations of them have been considered before implementing the filed study.

Regarding the reliability: Reliability was evaluated using metrics such as Cronbach's Alpha and Composite Reliability (CR), with values ranging from 0.755 to 0.964, demonstrating strong internal consistency across the constructs.

RESULTS AND DISCUSSION

The results of data analysis obtained from the data collected from the respondents. The main purpose of this study is to measure of smart technologies and safe measures of Cairo International Airport on passenger satisfaction. In addition, the study focused on exploring the reasons that affect the improvement of these characteristics at the airport. According to the main objective of this study that achieving its objectives and hypotheses. Therefore, the researcher presented the results in two axes.

THEME ONE: RESULTS AND DISCUSSION FOR THE PARTICIPANT OBSERVATION

By answering the study's question (What are Smart technologies and safety measures available at Cairo International Airport), the researcher exploring

and assessing the Smart technologies and safety measures that are available at Cairo International Airport. The results of the observation showed the following (see table 1).

Category / Section	Items	N/A	Very Good	Good	Neutral	Poor	Very poor
Smart Airport	Smart Wallets	✓					
	Smart Lanes	✓					
	Positive Boarding	✓					
	Finger Print	✓					
	Smart Screen	✓					
	High-Tech Mirror	✓					
	Smart Gates (E-Gates)					✓	
	Sophisticated Motion Sensor Systems	✓					
	Self-Check-In Points					✓	
	Airport Mobile Applications					✓	
	Autonomous Robots	✓					
	Smart Wheelchairs	✓					
	Internet Of Things IOT					✓	
Safe and Security	Security Screening			✓			
	Airport Emergency Service Team			✓			
	Safety Infrastructure			✓			
	Airport Emergency Plan			✓			
	He Threat-Oriented Passenger Screening Integrated System (TOPSIS)	✓					

Table (1) Exploring and Assessing the Smart technologies and safety measures that are Available at Cairo International Airport.

The results presented in Table1 provide an insightful assessment of Cairo International Airport's performance across two key characteristics: smart and safe. Each characteristic is evaluated through specific items, revealing strengths and areas for improvement.

SMART AIRPORT

The findings indicate that Cairo International Airport demonstrates progress in adopting smart technologies, as features like **Smart Gates (E-Gates), Self-Check-In Points, Airport Mobile Applications, and the Internet of Things (IoT)** are rated "Good." However, certain aspects, such as **Smart Wallets, Fingerprint Scanners, and Smart Lanes**, are only "Neutral," suggesting limited functionality or availability. Advanced technologies like **Autonomous Robots and Smart Wheelchairs** also fall under "Neutral," highlighting the need to expand the use of cutting-edge innovations to enhance the passenger experience.

SAFE AND SECURITY

The safety infrastructure at the airport shows significant development, with items like **Security Screening, Emergency Service Teams, and Emergency Plans** rated as "Good." However, advanced systems such as **TOPSIS (Threat-Oriented Passenger Screening Integrated System)** are rated "Neutral," indicating room for improvement in adopting state-of-the-art safety technologies to ensure a seamless and secure passenger experience.

The findings underscore the airport's strengths in integrating **smart technologies and humanistic features** while demonstrating moderate performance in **sustainability and advanced safety measures**. To further enhance its global competitiveness, the airport should focus on improving underperforming areas, particularly in **smart technologies**, while maintaining its existing strengths. This balanced approach can help Cairo International Airport achieve higher operational excellence and passenger satisfaction.

As a result of the above, the first objective of the study was achieved, which was "exploring ***the smart technologies and safe that are available at Cairo International Airport ".***

THEME TWO: ANALYZING OF THE QUESTIONNAIRE

This theme presents the findings of the research study, which the effect of smart technologies and safe measures of Egyptian airports on passenger satisfaction. The data was analyzed using two advanced statistical tools: SPSS V.22 for descriptive and inferential analysis.

DEMOGRAPHIC AND TRAVEL-RELATED INFORMATION

This section provides an in-depth analysis of the demographic and travel-related characteristics of the study participants. The data is organized to offer

insights into the respondents' gender, age, education, and marital status, followed by an examination of their travel purposes, waiting times at Cairo International Airport, the number of return flights within the last year, and the nationalities of the tourists surveyed. These indicators not only reflect the diversity of the sample but also provide valuable context for understanding travel behaviors and patterns among passengers at Cairo International Airport.

DEMOGRAPHIC INFORMATION

Table (2) provides a detailed breakdown of the demographic characteristics of the study participants.

Table (2) Demographic Data

Demographic and Travel Information		Freq.	%
Gender	Male	206	50.0
	Female	206	50.0
Age	Less than 20	30	7.3
	21-40	222	53.9
	41-60	146	35.4
	More than 60	14	3.4
Education	High school or below	68	16.5
	Bachelor’s degree	208	50.5
	Postgraduate degree	136	33.0
Marital Status	Single	90	21.8
	Married	144	35.0
	Married with children	144	35.0
	Widow	34	8.3
Total		412	100%

The sample is evenly split by gender, with 50% male and 50% female respondents, ensuring a balanced perspective from both genders. The majority of participants fall within the age group of 21-40 years (53.9%), followed by those aged 41-60 years (35.4%), indicating that most respondents are in the prime working or traveling age. Regarding education, half of the respondents (50.5%) hold a bachelor’s degree, while a significant proportion (33.0%) has postgraduate qualifications, reflecting a highly educated sample. In terms of marital status, a notable portion of the participants are either married (35.0%) or married with children (35.0%), highlighting the presence of family travelers, while 21.8% are single, and 8.3% are widows.

DESCRIPTIVE STATISTICS

The descriptive statistics analysis offers a comprehensive overview of passengers' perceptions across key aspects of airport services, specifically focusing on smart technologies and safe measures. Additionally, passenger satisfaction with their overall experience at Cairo Airport was assessed, based on their responses to targeted statements reflecting these dimensions. This analysis provides valuable insights into how well the airport meets passenger expectations in various areas of service.

SMART AIRPORT

The descriptive statistics for the "Smart Airport" variable, as shown in Table (3), provide insights into passengers' perceptions of the airport's technological advancements. The overall mean score of 3.29 with a standard deviation of 0.507 indicates that passengers generally view the airport's smart features positively, although there is room for further enhancement.

Table (3) Descriptive Statistics for Smart Airport

	Statements	Mean	SD	Rank
1	The Airport Provides Smart Gates (E-Gates) in The Terminals	3.07	.922	10
2	Self-Check-In Points Are Operating Efficiently at The Airport	3.55	.890	3
3	Mobile Applications Are Activated and Active	3.61	.884	1
4	Providing Automated Services at The Airport	3.56	.889	2
5	Smart Technological Means Available at The Airport	3.23	.939	7
6	The Airport Uses The Internet of Things (IOT)	3.09	1.07	8
7	The airport offers fast and reliable Wi-Fi connectivity throughout the terminal.	3.53	.923	4
8	The airport uses digital signage for real-time flight updates and information.	3.50	.934	5
9	The airport provides seamless baggage tracking through smart technology.	3.01	1.07	11
10	The airport offers contactless payment options at all service points.	3.24	.961	6
11	Smart parking systems are available to improve the parking experience at the airport.	3.00	1.148	12
12	The airport uses AI-powered systems to enhance the overall passenger experience.	3.08	1.01	9
Smart Airport		3.29	.507	

The highest-rated feature in the table is the activation and functionality of mobile applications, with a mean score of 3.61, reflecting passengers'

satisfaction with this service. Similarly, automated services and self-check-in points are well-regarded, with mean scores of 3.56 and 3.55, respectively, highlighting the efficiency of these smart solutions in streamlining passenger experiences.

Wi-Fi connectivity and digital signage, which provide real-time flight updates, are also appreciated, as seen from their mean scores of 3.53 and 3.50, respectively. These features play a crucial role in ensuring that passengers stay informed and connected during their time at the airport.

However, certain aspects received lower ratings. For instance, smart parking systems and seamless baggage tracking were rated lowest, with mean scores of 3.00 and 3.01, respectively, indicating areas where improvements are needed to meet passenger expectations. Additionally, while contactless payment options and the availability of smart technological means scored moderately (Mean = 3.24 and 3.23, respectively), these features could be enhanced to provide more convenience to travelers.

The table also shows moderate satisfaction with the airport's use of the Internet of Things (IoT) and AI-powered systems (Mean = 3.09 and 3.08), suggesting opportunities for further development in these areas to create a more integrated smart airport experience.

In conclusion, as demonstrated in Table (3), passengers appreciate many of the smart features available at the airport, especially mobile applications, automated services, and self-check-in points. However, there is potential for improvement in areas such as parking, baggage tracking, and the implementation of advanced technologies to fully align with passenger expectations of a "smart" airport.

SAFE AIRPORT

The descriptive statistics for the "Safe Airport" dimension, as shown in Table (4), provide insights into passengers' perceptions of the safety and security measures implemented at the airport. The overall mean score for this dimension is 3.30, with a standard deviation of 0.574, indicating a generally positive perception of the airport's safety measures, though with some areas for improvement.

Table (4) Descriptive Statistics for Safe Airport

	Statements	Mean	SD	Rank
1	The airport seeks to reduce waiting time at security checkpoints.	2.82	1.03	8
2	The airport is concerned with emergency services.	3.34	.922	5

3	The airport uses modern technological devices for accurate security checks.	3.04	1.11	7
4	I feel that the security personnel are well-trained and professional.	3.52	1.00	1
5	The airport provides clear instructions and signage for safety procedures.	3.45	.984	3
6	The airport has visible security measures in place to ensure passenger safety.	3.43	.947	4
7	The emergency exits and procedures are easy to locate and understand.	3.51	.944	2
8	The airport regularly communicates safety protocols to passengers.	3.26	.914	6
Safe Airport		3.30	.574	

The highest-rated item in this category is passengers' confidence in the professionalism and training of security personnel, which ranks first with a mean score of 3.52. This suggests that passengers feel secure and reassured by the competence of the airport's security staff, a critical factor in maintaining a safe environment. Similarly, the visibility and clarity of emergency exits and procedures are rated highly, with a mean score of 3.51, indicating that passengers appreciate the ease with which they can locate and understand emergency protocols.

The airport's provision of clear instructions and signage for safety procedures is also positively rated, with a mean score of 3.45, reflecting passengers' confidence in the airport's efforts to communicate essential safety information. Additionally, visible security measures, such as surveillance and security personnel presence, were viewed favorably, with a mean score of 3.43, further emphasizing the importance of visible safety precautions in creating a secure atmosphere.

Conversely, reducing waiting times at security checkpoints is identified as the area with the lowest satisfaction, receiving a mean score of 2.82. This highlights that passengers may feel that the airport could improve its efficiency in this aspect to enhance their overall experience. Similarly, the use of modern technological devices for security checks received a moderate rating (Mean = 3.04), suggesting that while the airport employs advanced technologies, there may be room to increase passenger awareness of these efforts or to further enhance their effectiveness.

Emergency services (Mean = 3.34) and regular communication of safety protocols to passengers (Mean = 3.26) are rated moderately, indicating that while passengers recognize the airport's efforts in these areas, there may be opportunities to improve the visibility and frequency of safety communications and to further develop emergency response capabilities.

In conclusion, Table (3.11) illustrates that while passengers generally feel safe at the airport, particularly in terms of staff professionalism and the visibility of security measures, there are opportunities to reduce waiting times at security checkpoints and enhance the effectiveness of technological security solutions to improve overall passenger satisfaction with airport safety.

PASSENGERS SATISFACTION

The descriptive statistics for "Passenger Satisfaction" presented in Table (5) offer valuable insights into various aspects of passengers' experiences at the airport. The overall mean score for this category is 3.11, with a standard deviation of 0.471, indicating a moderately positive level of satisfaction among tourists, though several areas require attention for improvement.

Table (5) Descriptive Statistics for passengers Satisfaction

Statements		Mean	SD	Rank
1	I am satisfied with the overall cleanliness of the airport.	3.50	.918	2
2	The airport staff is friendly and helpful.	3.47	.923	4
3	The check-in and security processes are efficient and timely.	3.19	.810	9
4	I am satisfied with the courtesy and helpfulness of the check-in staff.	3.54	.885	1
5	I am satisfied with the wait-time at security checkpoints.	2.95	1.061	13
6	The thoroughness of the security screening meets my expectations.	3.35	.999	6
7	I feel safe and secure while at the airport.	3.20	.854	8
8	I am satisfied with the availability and quality of food facilities.	3.49	.970	3
9	I am satisfied with the availability and quality of stores at the airport.	2.96	1.09	12
10	The availability of banks, ATMs, and currency exchange services meets my needs.	3.36	.970	5
11	I am satisfied with the cleanliness of the airport facilities.	3.18	.943	10
12	The thermal comfort within the airport is satisfactory.	3.03	.965	11
13	The acoustic comfort within the airport is satisfactory.	2.81	1.04	15
14	I am satisfied with the availability of washrooms and toilets.	2.87	1.00	14

15	I find the flight information provided through mobile applications to be helpful and accurate.	3.33	1.10	7
16	I am satisfied with the presence of green spaces at the airport.	1.48	.787	16
Passenger Satisfaction		3.11	.471	

The highest-ranked statement, with a mean score of 3.54, reflects passengers' satisfaction with the courtesy and helpfulness of the check-in staff, suggesting that personal interactions with airport employees leave a strong, positive impression. Similarly, satisfaction with the overall cleanliness of the airport ranks second, with a mean of 3.50, highlighting the importance of maintaining a clean and hygienic environment for a positive customer experience. The availability and quality of food facilities are also highly rated, with a mean of 3.49, indicating that food services meet tourists' expectations.

In terms of staff behavior, the friendliness and helpfulness of the airport staff received a favorable score of 3.47, reinforcing the importance of customer service in shaping tourists' satisfaction. However, some logistical aspects, such as the efficiency of the check-in and security processes, are rated lower, with a mean score of 3.19, indicating that passengers see room for improvement in streamlining these procedures.

Passengers express moderate satisfaction with the availability of financial services, such as banks, ATMs, and currency exchange, which is reflected in a mean score of 3.36. Additionally, the thoroughness of security screening meets passengers' expectations, scoring 3.35, which suggests that while security is thorough, it may be perceived as timely or necessary for safety.

Conversely, several areas reveal dissatisfaction among tourists. The lowest-rated item, with a mean of 1.48, concerns the availability of green spaces at the airport, indicating a significant gap in this aspect, which could enhance the overall ambiance and environmental appeal of the airport. Similarly, acoustic comfort within the airport is poorly rated (Mean = 2.81), suggesting that noise levels may negatively impact passengers' experience. The availability and cleanliness of washrooms and toilets also ranked low, with a mean score of 2.87, pointing to a critical area that needs attention for improvement.

Other notable areas for improvement include wait times at security checkpoints (Mean = 2.95), as passengers may perceive delays in this process as detracting from their overall satisfaction, and the availability and quality of stores at the airport, which also scored relatively low (Mean = 2.96).

In conclusion, Table (5) illustrates that while tourists are generally satisfied with the cleanliness of the airport and the courtesy of the staff, there are notable areas of concern such as green spaces, washroom availability, and

acoustic comfort. Addressing these areas could significantly enhance the overall tourist experience and satisfaction at the airport.

TESTING THE STUDY HYPOTHESES

The hypothesis testing section of this study aims to examine the relationships between various variables related to airport attributes and passenger satisfaction. This analysis is crucial to understanding how different factors such as airport characteristics (Smart Airport, Safe and Security Airport) influence passengers' overall satisfaction and perceptions.

Table (6) Testing the Study Hypotheses

	Hypothesis	Path Coefficient	P	Result
H1	There is a significant relationship between the attributes of Smart Airports and passenger satisfaction.	0.293	.000	Accepted
H2	There is a significant relationship between the attributes of Safe and Security Airports and passenger satisfaction.	0.432	.000	Accepted

The results presented in the table indicate the following:

1. **H1, H2:** All hypotheses related to the relationship between various airports attribute (Smart, and Safe & Security) and passenger satisfaction **were accepted**, with significant positive path coefficients, indicating that these attributes significantly influence passenger satisfaction.

DISCUSSION OF RESULTS IN LIGHT OF PREVIOUS STUDIES

The results of this study highlight the critical role of the airport two characteristics namely (**Smart Airport** and **Safe Airport**) in enhancing passenger satisfaction.

1. Smart Airports

The **Smart Airport** dimension also demonstrated a positive effect on satisfaction, albeit to a lesser extent than humanistic services. Passengers particularly appreciated mobile applications, self-check-in services, and automated processes, which streamline their experience and reduce wait times. This aligns with **IATA (2019)**, which found that passengers increasingly expect airports to offer smart technologies that enhance convenience and efficiency. Moreover, **Bogicevic et al. (2017)** emphasized that features like e-gates and real-time flight updates via digital signage

contribute to a smoother, more efficient airport experience, which is crucial for passenger satisfaction.

Nevertheless, some aspects of smart airport technologies, such as parking systems and baggage tracking, were rated lower, indicating areas where further improvements are needed. **Zhao et al. (2020)** highlighted that while Internet of Things (IoT) and AI-powered systems have the potential to revolutionize airport operations, their implementation is still in its early stages, and passengers may not yet fully benefit from these innovations. Therefore, airports should continue investing in smart technologies while ensuring that these solutions are user-friendly and accessible to all passengers.

2. Safe and Security Airports

In terms of safety and security, passengers valued the presence of visible security measures and well-trained personnel. This finding is in line with **Barros et al. (2014)**, who demonstrated that airports with effective and visible security procedures tend to have higher passenger satisfaction. The feeling of safety is paramount in airport environments, and passengers appreciate the professionalism and competence of security staff, as shown in this study.

However, as noted by **Scholtz (2019)**, long wait times at security checkpoints can detract from the overall experience. This study similarly found that while passengers appreciated the security measures in place, they were less satisfied with the time spent waiting at checkpoints. Airports should, therefore, focus on optimizing security processes to balance thoroughness with efficiency, potentially through the use of more advanced technologies that speed up the screening process without compromising safety.

CONCLUSION

The main purpose of this study is to examine the impact of two pivotal characteristics—smart and safe—on passenger satisfaction at Cairo International Airport. This major aim has sub- objectives. For this sake the mixed approach methodology was used to conduct the study mixed techniques. The first is the quantitative approach which is the distributed questionnaire (420) questionnaires. After analysis, there were 8 questionnaires not valid for analysis; the valid is (412). Whereas the qualitative approach which is represented in the participant observation checklist was designed through literature review, in order to find out the two characteristics available and not available at Cairo Airport for assessing by the researcher.

Major Findings of the Study

- The airport showed progress in adopting smart features, but their implementation is limited. While tools like E-Gates, self-check-in kiosks, mobile applications, and IoT technologies are present, advanced systems like fingerprint recognition, smart wallets, and autonomous robots are largely absent. Moreover, the limited awareness of these technologies among passengers hinders their full utilization.
- Security measures were one of the airport's strengths. Passengers appreciated the professionalism of security personnel, visible safety protocols, and emergency response systems. However, the lengthy and complex security procedures, coupled with outdated scanning technologies, were noted as areas for improvement.

RECOMMENDATIONS

Based on the results and findings from the study regarding Cairo International Airport, the following detailed and clear recommendations are proposed to enhance its two main characteristics (smart and safe) and to improve overall passenger satisfaction. As the present study recommends as follows:

Official Authorities Responsible For Managing the Airport (Egypt Air-Public Relations- Station Staff-Marketing Department- Security Department – IT Departments- Facilities and Sustainability Teams-Training Department).

1- Smart Airport Recommendations

- **Expand Technological Implementation:** Invest in advanced technologies such as fingerprint recognition, smart wallets, and positive boarding systems. These tools can streamline processes and reduce waiting times for passengers.
- **Enhance Mobile Application Features:** Include real-time transportation schedules, airport maps, flight notifications, and facility guides to increase passenger convenience and engagement.
- **Improve Awareness of Existing Systems:** Launch campaigns to educate passengers on using self-check-in kiosks, e-gates, and other smart tools. Provide on-site assistance and tutorials for a smoother experience.
- **Focus on Connectivity:** Enhance Wi-Fi speed and reliability throughout the airport and integrate the Internet of Things (IoT) to optimize operations and improve passenger convenience.

2- Safe and Secure Airport Recommendations

- **Modernize Security Systems:** Introduce biometric verification systems, AI-driven scanning technologies, and advanced security infrastructure to reduce procedural complexities while maintaining high safety standards.
- **Streamline Security Processes:** Optimize security checkpoints to minimize waiting times and improve passenger flow without compromising safety.
- **Enhance Communication of Safety Measures:** Regularly update passengers on safety protocols through announcements, digital screens, and brochures.
- **Emergency Preparedness:** Train staff for efficient emergency response and ensure that emergency plans and exits are clearly visible and accessible.

Table (7) Action Plan for Enhancing Cairo International Airport's Smart and Safe Dimensions

Dimension	Objective	Proposed Actions	Responsible Parties	Timeline	Measurable Outcomes
Smart Airport	Enhance the adoption and functionality of smart technologies.	- Implement advanced tools like fingerprint recognition, smart wallets, and autonomous robots.	Airport Management, IT Department	12-24 months	Increased passenger efficiency and satisfaction ratings.
	Improve mobile applications.	- Add real-time flight updates, transportation schedules, and facility maps.	IT and Marketing Departments	12 months	Improved app ratings and usage statistics.
	Enhance connectivity and digital features.	- Upgrade Wi-Fi infrastructure and introduce IoT-based services.	IT Department	12-18 months	Faster Wi-Fi speeds and improved digital service adoption.

Safe Airport	Modernize security infrastructure.	- Introduce biometric verification systems and AI-driven scanning technologies.	Security and IT Departments	12-24 months	Reduced wait times and improved security ratings.
	Streamline security processes.	- Optimize checkpoint layouts and reduce procedural redundancies.	Security Department	6-12 months	Shorter waiting times at security checkpoints.
	Enhance emergency preparedness.	- Conduct regular emergency drills and train staff on advanced response protocols.	Security and Training Departments	6-12 months	Improved readiness as measured by emergency drill outcomes.

FURTHER RESEARCH

The findings of the current study give rise to some areas for future studies to expand on the limitations we encountered during the current study. The first such area is about

1. Expand the scope to include other airports for comparative analysis.
2. Investigate the role of emerging technologies like blockchain and AI in enhancing airport operations.
3. Explore cultural and demographic factors influencing passenger satisfaction across different regions.

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