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Human-Centric Design Model to Enhance the Passenger Experience of Airport Smart Security System

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ABSTRACT

Many studies have overlooked the aspect of humans when it comes to the security system integration in an airport. Hence, this study aims to develop a human-centric smart security system at the Dubai International Airport (DXB) to enhance the passenger experience. This paper proposed a human-centric design model to assess passenger experience at the smart security gate in the DXB and uses the model to analyze the proposed model based on the feedback of passengers. The model is represented by the human-centric dimension of emotional/feeling, behavior, needs and requirements, usability, trust, cognitive, and ergonomics that has a relation with passenger experience. A survey was administered to 400 respondents who had experience using the airport security system at the DXB. Regression analysis was used to test the relationship within the model and establish a human-centric model. Usability tests were used to gain deeper insight and gauge a more in-depth opinion of the respondents. It was found that cognitive had a low influence on passenger experience, while most respondents viewed the model as very useful. The findings of the study will assist the airport industry and authorities in UAE airports to better position their security system and enhance the passenger experience.

Keywords:
Human-centric model; airport security; passenger experience; trust

1. Introduction

Airport, known as one of the most complex systems in the transportation sector, has become one of the dominant and preferred traveling options by most travelers. The statistics show that there were 420,870 planes registered in 2016, in these planes can accommodate around 250 or more passengers. This is an increment from around 373,534 in 2013, when aviation was relatively new [1]. This development has necessitated the existence of more than one airport in many world cities, including the United Arab Emirates (UAE).

The UAE airline has become one of the most preferred forms of transportation because it is faster and more comfortable than other modes of transportation. Moreover, in recent years, due to the

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competition in the aviation sector, the fact that air transportation has become more economical has also led to a serious effect on the preference for air transportation [2]. The number of passengers in domestic and foreign airlines in 2017 was approximately 88,242,099 in comparison to approximately 83,654,250 in 2016, 78,014,838 in 2015, and 70,473,893 in 2014 respectively. This shows that there has been a significant increment of approximately 25% until 2017 [2]. This increment increase of passengers has brought significant improvement in the airport and its current situation. Along with this, it has also triggered the need to design a new airport or extend the existing airports. Like other Emirates in the UAE, the Dubai International Airport has been built and expanded several times to fulfill the needs and an increasing number of international passengers [3].

Along with the development, the security infrastructure of the airport has become the other center of interest. This is because of the security processes and services involved in every phase of a passenger's travel life-cycle. However, these security processes and services often impinge on the passengers' experience. For instance, airport screening often causes long waiting lines at the screening points, leading to unpleasant experiences. A recent survey found that there is a need to improve and shorten the screening process. However, it may increase the security problems at the airport. As improving the passengers' experiences becomes of the utmost importance, there is a necessity to model and develop the security infrastructure of the airport, focusing on the needs, contexts, behaviors, and emotions of the passengers.

The airport needs to provide effective security infrastructure and environment for a better passenger experience. Positive and negative passengers' experiences in the airport process life-cycle will impact the entire travel experience. Negative experiences will impact on the reputation of the airport, which will lead to numerous losses to the airport business. The airport industry has to enhance the passengers' experience in achieving the aim of being the most memorable airport where passengers enjoy their experience of traveling [4].

Many studies have been reported on human-centric design that mention enhancing passenger satisfaction such as Airport Nepal [5], Melbourne Airport [6], China's High-Speed Rail (HSR) service [7], Jordan Airport [8], and Air Asia purchasing online ticket [9]. There is a shortage of literature on the study of human-centric design for passenger experience in the airport industry to replicate the findings in other industries such as manufacturing [10], military equipment [11], healthcare [12, 13], and product design [14].

Therefore, improving the passengers' experience is often the primary objective of the airport business to increase satisfaction and loyalty among passengers. Human-centric design (HCD) is a model that adopted from human-computer interaction technology is adopted in this study as a method to enhance the passengers' experience. It is because HCD is an approach that focuses on the user, their needs, and requirements to ensure the developed system is usable and useful from the perspective of users. As airport has high-end technology infrastructure, especially in the security unit. From 9/11 onwards, security has become a crucial part and led to prolonged security processing times for airport service [15]. Further, the additional screening of user belongings such as laptops and shoes has added anxiety for passengers [16]. It needs to be properly managed to meet passengers' expectations when they experience the security measures at the airport. It is necessary to consider the human perspective to model the airport security infrastructure to meet the physical and emotional expectations of the passengers.

However, many studies have overlooked the aspect of humans when it comes to the security system integration in an airport. In this study, the existing factors for the human-centric model from other industries are adopted such as cognitive [17], behavior [17], emotional [18], and need and requirements [10]. Trust, usability, and ergonomic are emerging variables in the literature, and considering them as new factors to a human-centric model can help better understand the passenger's experience at the airport [10].

It implies that there is a need for an improvement in the existing smart security system at the Dubai International Airport by developing a more human-centric design of the airport. Thus, in light of the identified challenges, it is argued that the development of a human-centric smart security system at the Dubai International Airport can improve the overall experience of the passengers, which subsequently provides a competitive advantage to the airport.

Also, this research extends the study by both Popovic *et al.,* [19] and Hong *et al.,* [20] on passenger experience and its consequences. It is found that the human-centric design model has been used in many domains of applications as it helps the developer to capture the requirements of users based on their needs and to ensure the developed system is usable and useful from the perspective of the users. However, this design model is still under-explored in the area of aviation or airport management. Most of the work also focuses on the value and requirements of products to be developed in terms of human emotion and behavior. Yet, there are lack of work to discuss and explore human-centric design in designing the security system of airports.

2. Human-Centric Design and Passenger Experience

Evolving from human-computer interaction technology, human-centric design (HCD) is an approach that focuses on the user, their needs, and requirements to ensure the developed system is usable and useful from the perspective of users. HCD has been applied in various domains of application such as maritime, aviation, and automobile. A study by Fancher *et al.,* [21], proposed to combine the concepts from human control, theory factors psychology, and vehicle dynamics, thereby contributing to the body of knowledge and understanding concerning human-centric approaches for designing and evaluating driver assistance systems. Conceptual and experimental results pertained to manual driving with the assistance of Adaptive Cruise Control (ACC) and Forward Collision Warning (FCW). The following human-centered aspects of driver-assistance systems were analyzed and presented: the looming effect; including rule-based and skill-based behavior in the design of ACC systems; using desired dynamics in controlling the driving process; braking rules that trade headway range for deceleration level; and collision-warning rules based on two different stress indicators. Hence, contextualized in the automotive industry, this approach is concerned with the aspects of driver assistance on brake systems in the automotive industry. Therefore, this approach is adopted for the smart security system of airports as it is believed could enhance the experience of passengers as it is a blended approach to developing technology with human concern. In addition to thus, the model proposed by Popovic *et al.,* [19] focuses on the overall processing starting from leaving the home until boarding, while the model proposed by IATA [22] concentrates on the usage of self-technology, such as biometrics for security process, online check-in that can be done at home, that contribute to effortless journey to improve the passenger's experience is also integrated to this approach.

The flow of passenger activities at the departure hall in this study is shown in Figure 1 and it is adopted from [19, 20]. This study focuses on the passenger activities at the airport's security process and the security activities are classified as a part of the processing activity as defined in [19-22]. From the work of Popovic *et al.,* [19] it is difficult to identify the discretionary activities during the security process.

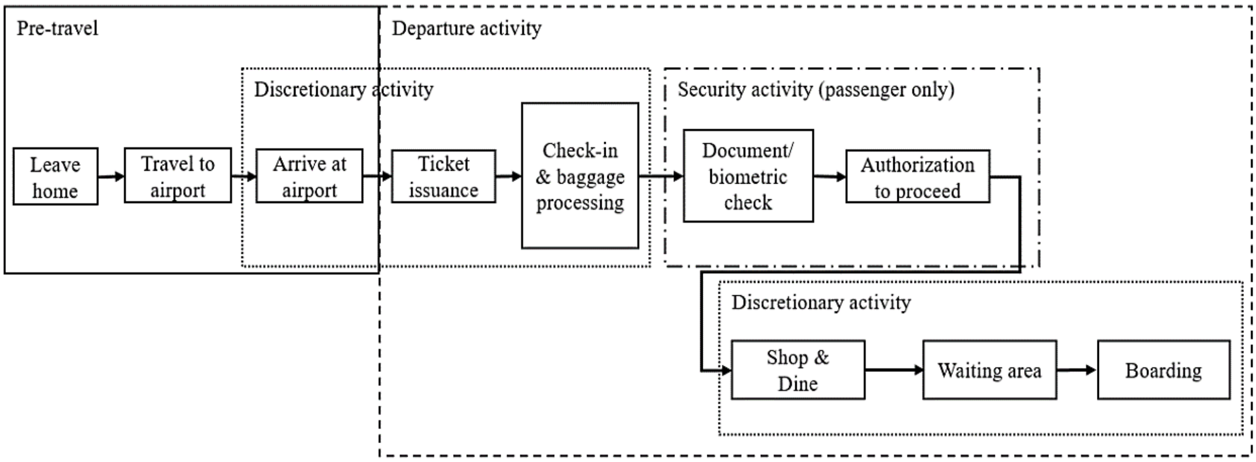

Fig. 1. The flow of passenger activity at the departure hall presented in this study has been modified from [19-22]

It is found that human-centric design can incorporate human perspective and technology for a better user experience. The smart airport security system in this study considers three aspects, which are: (i) the passenger, (ii) the process/service of the security system, and (iii) and facilities included in the system.

Factors that influence passenger experience, identified as the independent variables, include (i) emotion/feeling, (ii) cognitive/thought, (iii) behavior, (iv) needs and requirements, (v) usability, (vi) trust, and (vii) ergonomic. Meanwhile, passenger behavior, identified as the dependent variable has four dimensions, which are: (i) reliability, (ii) security, (iii) efficiency, and (iv) satisfaction. The first four factors are derived from the literature review, while the later three factors are based on the perception of the researchers. The development of the hypothesis in this research is described in the following paragraphs.

2.1 Emotion/Feeling and Passenger Experience

Airports are emotionally charged places. Passengers may feel a variety of emotions before boarding a plane, including anxiety, fear, excitement, and delight. Although emotions vary depending on the cause of travel, commercial flying is a stressful experience that ranks alongside events such as divorce or home purchase [*23*]. A study conducted by Yan and Huang shows that the characteristics of a building such as the layout have a positive relation with the user of the building [24]. Hence, we formulate the following null and alternative hypotheses:
$H1_1$: There is a significant relationship between emotion/feeling and passenger experience.
$H1_0$: There is no significant relationship between emotion/feeling and passenger experience

2.2 Cognitive and Passenger Experience

Cognitive is a psychological attitude of passengers in an attempt to create a sense of place before they leave the airport/destination [25]. Cognitive assessment can be traced to the theoretical roots of perceived value [26]. It is about the engagement of passengers towards the product or service received and its associated qualities. In the hospitality industry, by Shin and Back [27] showed the positive relation between cognitive engagement (how passengers process the product/service information), and the quality (what they process) can significantly influence the customers'

evaluation of the service experience. Similarly, Kim *et al.,* [28] identified cognitive attributes that have a positive relation with passengers' experience at the airline lounge. According to Popovic and Kirk [19] and Kirk [29], passenger activities in airline lounges is considered as discrepancy activity. Also, it is believed that cognitive has strong relation with emotional and sensory attributes, and it affects travellers' subsequent responses, such as their perception of well-being, satisfaction, word-of-mouth, and intention to revisit. Previous studies indicated that customers who feel a high level of cognitive experience are more likely to have a high level of experience [27, 28]. Hence, we formulate the following null and alternative hypotheses:
$H2_1$: There is a significant relationship between cognitive/thought and passenger experience.
$H2_0$: There is no significant relationship between cognitive/thought and passenger experience.

2.3 Behavior and Passenger Experience

Some literature uses the words behavior and emotion interchangeably [30]. It is believed that understanding passengers' emotions is vital because they are directly linked to their subsequent behavior, such as experience and behavioral intentions [28-31]. According to study from Fishbein *et al.,* [32] they defined behavioral intention is the tendency of people to act according to their convictions, when they are in a certain setting. Most of the hospitality literature, coined the behaviour with brand experience [27-33]. The behavioral experiences may happen during the process of participation in service production and delivery. Behavioral brand experience refers to how an individual interacts (physical actions) with a product, such as sleeping in a hotel bed. In the context of the airline industry, scanning biometrics on the boarding pass control gate is a behavioral experience. Based on a study by Jeon and Kim [34] showed that only positive behavior, affected by the environmental factors of airport services, had a significant impact on passengers' subsequent behavior. Finally, intellectual brand experience refers to thinking, stimulating curiosity, and problem-solving for example curiosity about the airport's intellectual facilities. Hence, we formulate the following null and alternative hypotheses:
$H3_1$: There is a significant relationship between behavior and passenger experience.
$H3_0$: There is no significant relationship between behavior and passenger experience.

2.4 Needs/Requirements and Passenger Experience

Customer requirements are defined as the desires or demands and expectations of consumers, i.e. what they feel a service provider should offer rather than would offer [35, 36]. In a highly competitive aviation industry, managers must find ways to make their service at the airport stand out amongst the others. To achieve this, managers must understand their customers' needs and then set out to meet (or exceed) these needs [37]. Further, some scholars found that the use of ICT has changed the passengers' expectations of the security airport system, that is it should offer to ease the journey and reduce ambiguity during the security process [37]. There has been a clear shift in the aviation industry on the importance of "passenger experience" [38-41]. However, this shift has not resulted in the inclusion of the true needs of passengers in the security process in the airport security system. Hence, we formulate the following null and alternative hypotheses:
$H4_1$: There is a significant relationship between needs/requirements and passenger experience.
$H4_0$: There is no significant relationship between needs/requirements and passenger experience.

2.5 Usability and Passenger Experience

Usability is the trade-off between performance, satisfaction, and cost related to the product/service assessed in the airport [42, 43]. To offer an easy journey to passengers, scholars believe that it should begin with the customer's experience, not with the ultimate product or technology [44]. Hence, we formulate the following null and alternative hypotheses:
H5$_1$: There is a significant relationship between usability and passenger experience.
H5$_0$: There is no significant relationship between usability and passenger experience.

2.6 Trust and Passenger Experience

Trust is a crucial element in any industry to build a long-lasting relationship. It serves as an important element in the long-term relationship between organizations and customers. Customer's decision to either switch to another provider or to proceed with a similar provider will be based on their previous experience; trust will gradually develop if the previous experience has been positive; and this will result in customer retention [45]. Based on the study by Bogicevic *et al.,* [46] developed some interesting insights concerning their research on the relationship among different types of airport technologies and travelers' confidence, enjoyment, and satisfaction. They argued that passengers' confidence benefits imply reduced anxiety and less perceived risk associated with experiencing the service [47]. The confidence benefits in a passenger is "a sense of knowing what to expect" and "what goes wrong should be taken care of" [48]. In addition, the confidence benefits have proved to be very important to customers as they shape their feelings of comfort, security, and confidence in the outcome of the service at the airport. In addition, trust is the result of passengers' expectation of trustworthiness in the expertise and intentionality of the product/service provider [49]. Hence, we formulate the following null and alternative hypotheses:
H6$_1$: There is a significant relationship between trust and passenger experience.
H6$_0$: There is no significant relationship between trust and passenger experience.

2.7 Ergonomic and Passenger Experience

Airport experience can affect passengers' overall travel experience, as long-distance travel experience frequently starts and ends at the airport. As a result, the experience of passengers at the airport will be of interest to all suppliers in the tourism supply chain. Caves and Pickard [50], addressed the satisfaction of human needs in airport passenger terminals by focusing particularly on the ergonomic components of space and wayfinding, and how these components affect passengers' feelings. Ergonomics facilitates the increase of the performance of a system by enhancing human-machine interaction. They identified the needs of aging passengers to improve the interaction between passengers and machines at the airport. Also, it provides the service strategies from the perspective of operators. Based on the study by Ardi *et al.,* [51] studied the effective way of finding Terminal 2 Soekarno-Hatta Airport. An effective way of finding is the interaction between human and environmental factors that results in a person moving successfully from their current position to the desired location at the right time. The study shows that the built environment elements and visual elements are necessary to improve the way finding of a passenger. Hence, we formulate the following null and alternative hypotheses:
H7$_1$: There is a significant relationship between ergonomic and passenger experience.
H7$_0$: There is no significant relationship between ergonomic and passenger experience.

3. Methodology

This study used a survey and the questionnaire has two main parts. The demographic section is in the first part and is designed to elicit information about age, gender, education level, traveling class, frequency of traveling in a year, and purpose of traveling. A total of 400 questionnaires were distributed randomly among the passengers and collected between November 2019 and January 2020 at Dubai International Airport. The second part consisted of the items measuring (i) emotion/feeling, (ii) cognitive / thought, (iii) behavior, (iv) needs and requirements, (v) usability, (vi) trust, (vii) ergonomic, and (viii) passenger experience. The items for the constructs can be seen in Appendix A. A five-point Likert-type scale, with a scale of one representing “strongly disagree” and five representing “strongly agree” was used to measure the items.

4. Result and discussion

4.1 Preliminary Analysis

The analysis started with the demographic and behavioural profile of the respondents. As shown in Table 1, the sample was relatively evenly split between males and females. Most of the respondents are in the age between 21 and 40 years old. Most respondents had a Bachelor’s degree (45.8%).

The behavioral profile of respondents shown in Table 2, revealed that they traveled in economic class and relatively infrequently (approximately 80% traveled between one and ten times a year by air) for government-related business (45.8%).

Table 1
Demographic profile of respondents

Variables	(%)
Gender:	
Male	59.5
Female	40.5
Age	
Below 20 years	11
21-40 years	58.4
41-60 years	23.5
Above 60 years	7.3
Education:	
Diploma	35.5
Bachelor	45.8
Master	2.5
Other	16.3

Table 2
Behavioural profile of respondents

Variables	%
Traveling Class:	
First class	29.3
Economic class	49.5
Business	21.3
Frequency of traveling:	
Less than 5 times in one year	49.5
5-10 times in one year	29.3
More than 10 times in one year	21.3

Table 2. Continued

Behavioural profile of respondents

Variables	%
Purpose of traveling:	
Company business or professional practices	35.5
Government related business	45.8
Visit family and friends	2.5
Studying	16.3

4.2 Reliability Analysis

Cronbach's reliability analysis is performed to measure the internal consistency of constructs. According to Hair *et al.,* [52], the appropriate alpha value of Cronbach is 0.60 and above. Table 3 outlines the findings of the reliability test, where the Cronbach's alpha range between 0.920 to 0.979. The variance suggests consistent and reliable scales used in this analysis. Based on the results obtained, the dependent variable which is passenger experience has a strong α coefficient of 0.932 based on responses of the data collection.

Table 3
Reliability analysis

No.	Variable	Items	Cronbach's alpha
1	Emotion/feeling	4	0.939
2	Cognitive/thought	3	0.979
3	Behaviour	3	0.973
4	Needs and requirements	4	0.920
5	Usability	4	0.963
6	Trust	3	0.954
7	Ergonomic	5	0.957
8	Passenger experience	4	0.932

4.3 Pearson Correlation Analysis

The strength between two or more constructs is measured through correlation analysis. This coefficient is a dimensionless measure of covariance, which is scaled with the end goal that it ranges from +1 to -1 [53]. Based on the data shown in Table 4, indicated that usability ($r = 0.493$, $p < 0.01$), cognitive ($r = 0.535$, $p < 0.01$), trust ($r = 0.678$, $p < 0.01$), need and requirements ($r = 0.495$, $p < 0.01$), behavior ($r = 0.656$, $p < 0.01$), ergonomic ($r = 0.466$, $p < 0.01$), and emotional ($r = 0.485$, $p < 0.01$).

Table 4
Pearson's correlation analysis

	P	E1	E2	B	N	T	C	U
P	1							
E1	.485**	1						
E2	.466**	.169**	1					
B	.656**	.320**	.462**	1				
N	.495**	.763**	.335**	.480**	1			
T	.678**	.396**	.366**	.604**	.551**	1		
C	.535**	.899**	.268**	.342**	.855**	.438**	1	
U	.493**	.371**	.424**	.308**	.356**	.327**	.402**	1

***. Correlation is significant at the 0.01 level (2-tailed).*
P: Passenger Experience; E1: Emotional/Feeling; C: Cognitive/Thought; B: Behavior; N: Need and Requirements; T: Trust; E2: Ergonomic; U: Usability

Subsequently, all factors have a significant and moderate relationship with passenger experience as suggested by [53]. Although these relationships are not extremely strong, they are still statistically meaningful and can provide insights into how these constructs are related to the passenger experience.

4.4 Regression Analysis

Regression Analysis was performed to investigate the relationship between dependent variables of human centric model namely, usability, cognitive, trust, need and requirements, behavior, ergonomic, and emotional and the dependent variable which is passenger experience. Table 5 displays the result of regression analysis between passenger experience and constructs of human centric model. Findings showed that usability ($\beta = 0.161$, $p < 0.000$), trust ($\beta = 0.377$, $p < 0. 000$) need and requirements ($\beta = 0.428$, $p < 0.04$), behavior ($\beta = 0.362$, $p < 0.000$), ergonomic ($\beta = 0.150$, $p < 0.050$), and emotional ($\beta = 0.532$, $p < 0.009$) have significant relationships with passenger experience. The adjusted R-square value of 0.636 indicated that 63.6% of the variation in passenger experience was explained by usability, trust, needs and requirements, behavior, ergonomic and emotional.

In this study, it is found that all new factors of human-centric model namely, usability, trust and ergonomic, have significant relationship with passengers' experience (Figure 2). In this human-centric model, the cognitive factor is ignored as it does not have significant relationship with the passengers' experience.

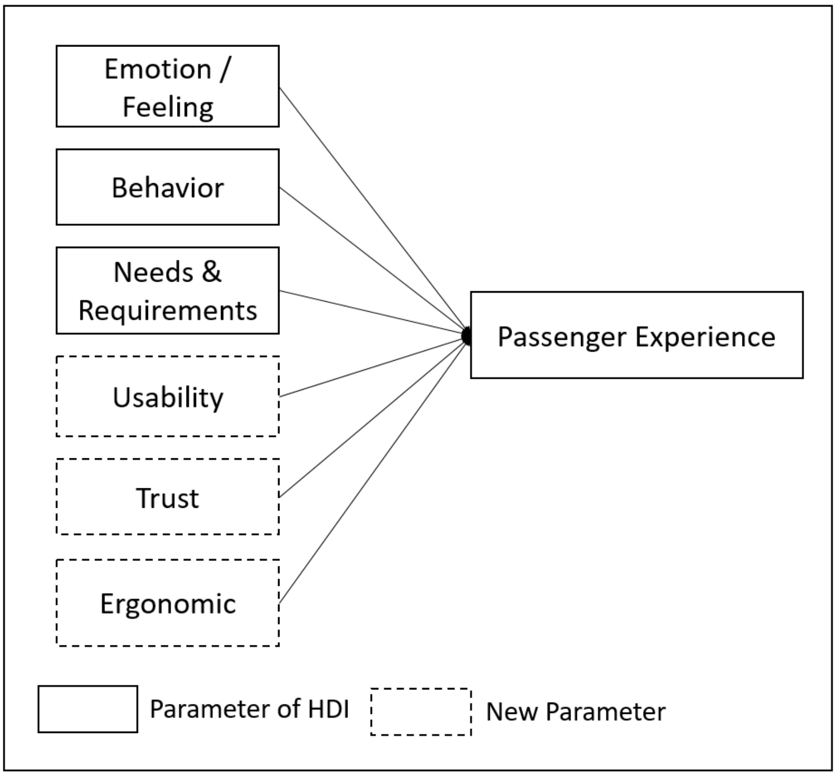

Fig. 2. Human-centric model for smart security system for Dubai International Airport

Table 5
Regression analysis of human-centric model on passenger experience

	Model summary			ANOVA		Coefficients		
	R	R^2	Adjusted R^2	F	Sig.			
	.815[a]	.664	0.636	24.029	.000[b]	β	t	Sig.
Ergonomic						0.150	1.891	0.050
Behaviour						0.362	3.902	0.000
Emotional						0.532	2.688	0.009
Cognitive						**0.036**	**0.230**	**0.819**
Trust						0.393	4.269	0.000
Needs and requirements						0.428	2.941	0.004
Usability						0.161	4.764	0.000

5. Conclusion

This paper demonstrates that humans have a high impact on the smooth operation of the airport. The results show that only one of the six factors do not have significant relationship with human-centred passenger experience, namely the cognitive or thought. Interestingly, three new factors have been introduced and used in the model: usability, trust and ergonomic, all of which have shown to have a positive impact on passengers' experience. Trust is the strongest independent variables against the dependent variable (passengers' experience) with the highest correlation value of 0.678. It is followed by behaviour (0.656), cognitive (0.535), need and requirements (0.495), usability (0.493), emotional/feeling (0.485), and ergonomic (0.466).

This paper focused on the direct relationship between human-centric factors and passenger experience. However, there are other factors that may influence the experience of passengers, such as the technological adaption factor, the service quality factor, and the environmental factor. Investigating these factors may bring more insights into future research. The ergonomic factor is also an interesting factor to study in detail. It is more fruitful if technical data are provided for the ergonomic analysis such as noise level, air temperature, and lightning which influence the experience of passengers.

Using alternative approaches, for example, case study research and a combination of both approaches (questionnaire and case study), may also be used to explore why and how the passenger experience can be improved. This would help to identify any pitfalls in the implementation of innovation and explore its success in achieving its intended objectives. In addition, a face-to-face approach while administering the survey may be useful in reducing any ambiguity in future studies.

In conclusion, future research needs to pay more attention to the model of smart airports, as the aim of UAE rulers is to have emerging technologies, and city technology efficiency as stated in The Smart Dubai Strategy 2021. Nowadays, the AI-driven technology integrated into the airport infrastructure could increase the passengers' experience [53] and needs to be developed in parallel with human contact.

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