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Performing Structural Equation Modeling in Public Transport Through COVID-19 Pandemic Time

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ABSTRACT

Traveling via public transportation is a better option than driving a private car and should be encouraged to reduce congestion, pollution, and fuel costs. However, due to COVID-19 pandemic, governments restrict the use of public transportation in order to limit infection spread. This study intends to identify travelers' attitudes and preferences for using public transportation during the COVID-19 epidemic using structural equation modeling (SEM). A questionnaire survey was created to analyze travelers' behavior, attitudes, perceived risk, and sense of responsibility when utilizing public transportation in Baghdad, Iraq. 234 complete responses were analyzed using the Structural Equation Modeling technique. The survey findings and measurement equations supported the relationship between observable and latent variables. The SEM results demonstrated that travelers' Perceived (PER) and Responsibility (RES) are favorably connected to Attitudes (ATT), whereas Behavior (BEH) towards public transportation is adversely related to Attitudes (ATT). To assess the confirmatory of measurement scale, confirmatory factor analysis (CFA) measurement was combined with nine Goodness-of-Fit measurements: Chi-square, Chi-square/df, RMR, GFI, AGFI, NFI, TLI, CFI, and RMSEA. This study highlights the findings of structural equation modeling research of using public transport through pandemic time in term of travel behaviors to improve the quality of service of public transport.

1. INTRODUCTION

During the COVID-19 pandemic, transportation has been the sector most severely impacted. Global spread of the COVID-19 virus leads WHO to declare a pandemic on March 11, 2020 [1]. This pandemic has changed the government's policy in order to reduce the faster spread of the COVID-19. These policies included the implement curfews and safer-at-home orders which affected on all economic activity and increasing unemployment rates. So that, the public transport services and ridership are having significantly effort to keep physical distancing continued until the danger from COVID-19 is outcaste. All this reason reduction the mobility on the streets which decrease the traffic volume during the pandemic lockdown [2]. The World Health Organization (WHO) recommended that it should keep 1m between people and don't touching the surface mainly in close areas to prevent virus transmission. Public transport identifies as a crowded space thus it is challenging to keep people within a social distance which makes public vehicles an excellent indoor environment for virus transmission. Using public transportation can increase the spread of viruses by a factor of up to six [3]. As a result, there was a worldwide drop in public transportation utilization during the COVID-19 pandemic [4]. In other wise, some people who are unable to drive, walk and cycle, public transport may be the best choice.

After a lot of cities reopen with hope to live without worry from virus, there is a pressing demand to take a quickly strategic to prevent completely lockdown. After the lockdown restrictions ease, the mobility shows a significant shift to private cars in cities after the experience of COVID-19 [5]. More private cars on the road would make cities to get a traffic jams which increased air and noise pollution, greenhouse gas emissions, obstruct walking and cycling, which make life difficult for people with lower-income who have not car [6]. Therefore, it should make some strategies as soon as possible for return the public transport system to transport sector under some restriction in order to confined transmission of virus.

The vehicle manufactures and the operators of public transport have a great effort to make space condition of public transport more safely by make door sensors, use hand sanitizer dispensers and redesign the internal seats for having physical barrier to reduce direct contact between the people [7]. Precautions, such as wearing face masks and maintaining the necessary physical distance, have been shown to reduce the risk of virus transmission [8]. It's worth noting that public transportation's physic social qualities-imposed limits on its use long before the COVID-19 [9]. Also, Aditjandra et al. [10] reported by development structural equations model that travel attitude characteristics and accessibility features of the urban area may change the use of public transport.

The researchers try to understand and predict travel modes and people behavior during and post the pandemic. Though there is research studying people's intentions to use public cars

in general, under restrictions, and when infected with COVID-19, the focus on alternative transportation modes during the pandemic has been lacking [11]. The study by Dzisi and Dei [12] took a prominent route in Kumasi, where researchers observed and analyzed the habits of over 850 of the city's most popular paratransit buses. While Ministry of Transport criteria were used to assess passengers' adherence to the policy on physical separation, the researchers counted the number of passengers on each bus to establish whether or not the policy on face masks was being followed. The results show that most buses adhere to the social distance regulations established by the Ministry of Transportation; nevertheless, the policy on face masks is only partially adhered to in most vehicles. Only around 12.6% of the vehicles had less than three passengers without face masks, and only about 21.3% of the buses had fewer than three passengers with face masks. COVID transportation policy and practice responses were aided by the introduction of the new concept of Responsible Transport [13]. What makes this concept novel is that it takes into account not just environmental factors related to sustainability, but also the health and well-being of individuals and communities. More than that, it highlights the role of the person as an independent, responsible agent in achieving socially desirable transportation outcomes. COVID-19 transportation policy and practice responses were aided by the introduction of the new concept of Responsible Transport. What makes this concept novel is that it takes into account not just environmental factors related to sustainability, but also the health and well-being of individuals and communities. More than that, it highlights the role of the person as an independent, responsible agent in achieving socially desirable transportation outcomes. Abdulrazzaq et al. [14] devised a methodology for people to use in order to make the transition from driving alone to taking public transportation. According to the results, an individual's mode of transportation selection is heavily influenced by their trip distance, daily trip frequency, trip duration, gender, age, and occupation. During COVID-19, Javid et al. [15] looked at how people felt about taking public transit on their travels. Using a questionnaire, researchers in Lahore, Pakistan, investigated passengers' knowledge, sense of duty, and moral duties toward adhering to safety standards and norms when using public transportation. The results of the structural equation model showed a favorable relationship between passengers' awareness of consequences and their willingness to take responsibility for their actions. Passengers' willingness to use public transit is significantly affected by their perception of the difficulty of complying with safety rules, such as wearing a facemask, using sanitizers, and maintaining a social distance. Travelers' preferences for public transportation may be significantly influenced by their level of familiarity, sense of duty, and trust in its use during a pandemic. During the pandemic, Abdullah et al. [16] constructed a binary logistic model to represent travel behavior in terms of individual modes (i.e., private cars, taxis, etc.) and public modes. It has been found that women are more likely than men to ride in public transportation vehicles of a different mode.

A conceptual model according to earlier studies has been proposed in this study. The concept of public transport user model are behavior, attitude, perception, and responsibility. Theoretically, the process in this study can provide a reference by employing model users' intentions to use public transport while adhering to the safety instructions during the COVID-19 pandemic in Iraq.

2. METHODOLOGY

2.1 Survey design and sampling strategy

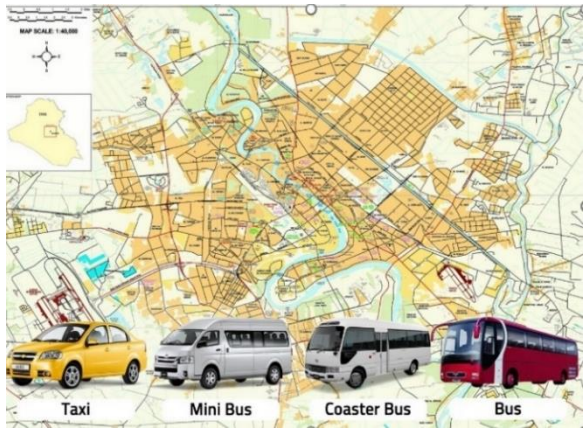

Figure 1. Type of public transport vehicles used in Baghdad city

As was mentioned earlier, one of the objectives of the paper was to investigate the incidence of citizen mobility within the spread of COVID-19 pandemic. As a result, the questionnaire was meticulously prepared in order to measure the travel pattern both during and after the COVID-19 pandemic. In order to acquire replies that could be relied upon, the respondents were given information regarding the aims of the study as well as instructions for filling out the questionnaire. The questionnaire underwent preliminary testing by specialists who belonged to the relevant study area. The comments made by these specialists were incorporated into the questionnaire in order to guarantee that each statement was clear and understandable to the respondents. Due to the social distance restrictions and the partial lockdown that was taking place in the country, it was not possible to conduct face-to-face interviews. The Likert-scale questions were introduced in the survey as a risk mitigation strategy: in case the answers to the open-ended questions were not really suited to the research goal, the responses to the rating questions could be used to inform reasonable perspective survey toward using public transport in pandemic incident. As such, the Likert questions offered a way to reduce possible loss of expert input. As such, Google form, emails, online websites, and social media messages were offered to the respondents. As a result, an online questionnaire was delivered to the target audience through personal connections, emails, and social media websites. Baghdad metropolis, which is the most populous of the provinces in Iraq, possesses socio-economic characteristics that are unique in comparison to those of other cities. The poll was conducted over the course of approximately one and a half months, beginning on April 17th, 2022 and ending on June 20th, 2022. During this time span, we were given a total of four hundred (400) responses. Figure 1 shows the type of public transport vehicles used in Baghdad city.

2.2 Questionnaire design

Both before and during the COVID-19 pandemic, respondents were asked about their travel patterns and the factors that influenced their mode preferences. The questionnaire was divided into two independent sections: (1)

socio-economic and demographic characteristics, and (2) travel patterns. In Table 1, the socioeconomic and demographic parameters that were examined were as follows: age, gender, location, education level, number of family members, monthly cost of travel, ownership of a cycle, ownership of a motorbike, ownership of a car, and employment status. There were questions in Section 2 concerning the mode of transportation that is most preferred for the purpose of traveling, as well as the primary reason that people do not prefer to use public transportation for the purpose of traveling, both before and during the COVID-19 pandemic, as listed in Table 2. In addition to this, it included questions regarding potential factors that could impact mode preferences both before and during the COVID-19 epidemic. It is hypothesized that people will pay more attention to pandemic-related items when choosing a transport mode because the virus spreads primarily through close contact with infected people or by getting in contact with an infected surface. Since this is the case, the hypothesis predicts that people will pay more attention to pandemic-related items. For instance, comfort and convenience might not be as important as preventing the spread of virus and keeping a healthy social distance during the pandemic. Therefore, elements that may affect mode choice during the pandemic have been identified, and respondents have been asked to place a priority on each factor while selecting a mode of transportation.

2.3 Proposed structural equation model framework

Because there is an immediate demand for information regarding the effects that COVID-19 has had on society, the primary findings of the data collection will be discussed in this paper in a manner that is mostly descriptive. The consequences on experiences, behavior, and expectations are broken down by background variables, such as age and area, wherever it is relevant to do so. In addition, this investigation makes use of the Statistical Package for Social Science (SPSS) for Windows version 26, which is available for purchase commercially. The statistics that were descriptive were given in terms of the number of replies.

Table 1. Socio-economic and demographic characteristics of the respondents

Category	Attribute	Percentage %
Gender	Male	57
	Female	43
Ethnic	Baghdad	41
	Other	59
Age	18-25 Years	68
	26-35 Years	24
	36-45 Years	5
	>45 Years	2
Level of Education	High School	26
	Bachelor's degree	58
	Post-graduate degree	16
Employment	student	67
	public sector	19
	private sector	8
	Self-employment	6
Household Size	1-3 person	14
	4-6 person	37
	more than 6 persons	49
Moving purpose in Baghdad city	Work	21
	Study	24
	Other	55
Means of transportation	private car	48
	public car	28
	other	24
Working time	Full time	37
	Part time	31
	Other	32
Working Days per Week	<3 Days	40
	4 Days	28
	5 Days	17
	6 Days	15
Required time reach to workplace	<10 minutes	14
	10-15 minute	18
	15-30 minute	11
	>30 minutes	46
Cost required to reach to workplace	100 000 Dinar	53
	100000-20000 Dinar	23
	more than 200000 Dinar	24
Why use the private vehicle	comfortable	67
	Safe	22
	Outward appearance	11
Factor that prevents you from using public vehicle	uncomfortable	27
	Traffic jam	11
	have a long time to reach for destination address	33
	poor public car service	29

Table 2. Descriptive statistics of items for all dimensions

Item Code	Statement	Five-Point Likert Scale 1*(%)	2*(%)	3*(%)	4*(%)	5*(%)
	Travel Behaviors for Public Transport					
Beh1	How often would you use public transport?	7 (3.0)	37 (15.8)	124 (53.0)	47 (20.1)	19 (8.1)
Beh2	Have you taken public transportation during the COVID-19 Pandemic?	2 (0.9)	10 (4.3)	64 (27.4)	98 (41.9)	60 (25.6)
Beh3	Public transport takes longer time than my private vehicle.	95 (40.6)	110 (47.0)	23 (9.8)	6 (2.6)	0 (0)
	Attitudes Towards Private Vehicles					
Att1	External appearance of the car is a major reason for using my own car.	9 (3.8)	82 (35.0)	64 (27.4)	74 (31.6)	5 (2.1)
Att2	Safety factor is one of the important reasons to use my own car.	63 (26.9)	112 (47.9)	39 (16.7)	20 (8.5)	0 (0)
Att3	Comfort factor is one of the important reasons to use my own car.	110 (47.0)	102 (43.6)	20 (8.5)	2 (0.9)	0 (0)
Att4	My own car is convenient and reliable to ride than public transport.	37 (15.8)	94 (40.2)	93 (39.7)	9 (3.8)	1 (0.4)
	Perceived Behavioral of Public Transport					
Per1	Public transport vehicles provide insufficient services during rides.	62 (26.5)	98 (41.9)	46 (19.7)	26 (11.1)	2 (0.9)
Per2	Public transport vehicles provide discomfort services during rides.	66 (28.2)	74 (31.6)	49 (20.9)	45 (19.2)	0 (0)
Per3	Traffic congestion is the main reason for not taking public transport vehicles.	92 (39.3)	92 (39.3)	33 (14.1)	16 (6.8)	1 (0.4)
Per4	Public transport vehicles considered inconvenient route for me.	69 (29.5)	116 (49.6)	41 (17.5)	8 (3.4)	0 (0)
	Responsibility Towards Public Transport					
Res1	Public transportation considers safety measurement during COVID-19.	25 (10.7)	14 (6.0)	75 (32.1)	58 (24.8)	62 (26.5)
Res2	How often would you use public transport considering the COVID-19 situation?	91 (38.9)	29 (12.4)	46 (19.7)	61 (26.1)	7 (3.0)
Res3	Do you keep social distancing when traveling in public transport during COVID-19?	60 (25.6)	86 (36.8)	51 (21.8)	18 (7.7)	19 (8.1)
Res4	Do you wear face mask when you are in public transportation during COVID-19?	77 (32.9)	59 (25.2)	82 (35.0)	9 (3.8)	7 (3.0)
Res5	Do you use hand sanitizer when you are in public transportation during COVID-19?	63 (26.9)	61 (26.1)	55 (23.5)	22 (9.4)	33 (14.1)
Res6	Do you take public transport when you have contacted with COVID-19 infected person?	2 (0.9)	2 (0.9)	2 (0.9)	74 (31.6)	154 (65.8)

A theoretical framework is required to investigate the causal relationship between the aspects of Public Transport that affects travel behavior, Attitudes, Perceived, and Responsibility toward public transport. Figure 2 shows the structural equation modelling structure as Squared Multiple Correlations (SMC).

SEM research design can provide standards and roadmap for the statistical examination of the relationships between several variables [17]. The SEM analytical framework, as shown in Figure 3, is used to interpret and communicate study results.

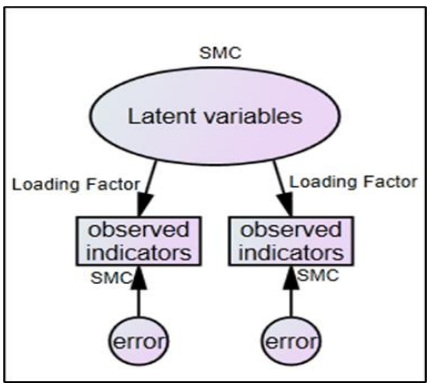

Figure 2. The structural equation modeling (SEM) structure

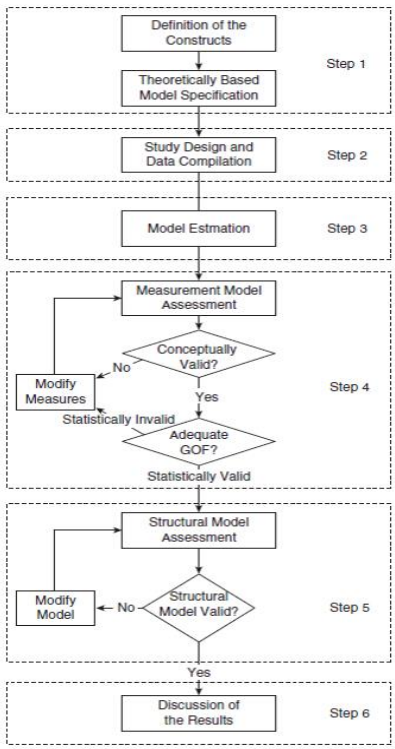

Figure 3. Structural equation model research process [17]

3. RESULTS

3.1 Reliability and validity measurements for SEM model

In order to determine the reliability of the dimensions and to examine the variables' degree of internal consistency, the Cronbach's alpha test was carried out. The fact that the Cronbach's alpha value for the Responsibility variables is less than 0.500 makes it unacceptable as a measure of reliability [18, 19]. The value was found to be 0.584. The item code Res1 was removed so that we could go within the range of the Cronbach's alpha test that is considered acceptable. After one item was removed, the values of all the variables and items that make up Cronbach's alpha lie between 0.623 and 0.692, as shown in Table 3. Following the completion of the reliability test, a multitude of additional tests can be carried out to validate the suitability of the factor analysis (FA) of the data sets. Kaiser-Meyer-Olkin (KMO) is a test that determines whether or not there was sufficient sampling, and factor loading identification and Bartlett's test of sphericity are tests that are used in the process of analyzing the dependability of each factor on its own. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were applied to the findings of the pilot study, and the results of both of these tests are shown in Table 4. This allowed for each of the 17 items on the questionnaire to be validated. The KMO measure of sample adequacy was found to be 0.688, which ensures the occurrence of significant partial correlations across the entire investigation. The requirement that the measure of sampling adequacy be more than 0.50 is a prerequisite for the criterion that was proposed by Hair et al. [20] to be evaluated to validate the existence of correlation.

Table 3. Reliability test results for pilot survey before and after items deleted

Variables (Scales)	Item Code	Mean Score	St. Dev.	Cronbach's Alpha*	Cronbach's Alpha if Item Deleted
Travel Behaviour for Public Transport	Beh1	3.58	1.315	0.623	0.492
	Beh2	3.89	1.148		0.060
	Beh3	4.26	0.737		0.761
Attitudes Towards Private Vehicles	Att1	3.05	1.415	0.692	0.425
	Att2	3.08	1.347		0.495
	Att3	3.06	1.421		0.402
	Att4	2.82	1.408		0.930
Perceived Behavioral of Public Transport	Per1	3.82	0.979	0.687	0.551
	Per2	4.05	0.779		0.646
	Per3	4.10	0.916		0.675
	Per4	3.69	1.081		0.598
Responsibility Towards Public Transport	Res1	2.50	1.244	0.484*	0.542*
	Res2	2.13	0.874		0.461
	Res3	3.64	1.179		0.358
	Res4	3.81	1.035		0.408
	Res5	3.42	1.351		0.333
	Res6	1.39	0.641		0.479

Table 4. KMO and bartlett's test for pilot study

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.688
Bartlett's Test of Sphericity	Approx. Chi-Square	450.099
	Degree of Freedom	45
	Significant	0.00

3.2 CFA measurement model

In order to validate the results of the measurement scale test, a confirmatory factor analysis (CFA) was carried out. During the course of the investigation, a total of 234 valid samples were found. In the context of the CFA, dimensions are referred to as latent constructs, whilst attributes are referred to as reflective indicators. In order to evaluate the measurement model, we looked at how well it suited the data overall, as depicted in Figure 4. In this analysis, nine goodness-of-fit indices derived from SEM-based research and the SEM references [20-22] were taken into consideration. In order to validate the results of the measurement scale test, a confirmatory factor analysis (CFA) was carried out. During the course of the investigation, a total of 234 valid samples were found. In the context of the CFA, dimensions are referred to as latent constructs, whilst attributes are referred to as reflective indicators. In order to evaluate the measurement model, we looked at how well it suited the data overall, as depicted in Figure 3. In this analysis, nine goodness-of-fit indices derived from SEM-based research and the SEM references [20-22] were taken into consideration. These indices are listed as follows:

1. P-Value;
2. Chi-square;
3. Chi-square/df (ratio of Chi-square to degree of freedom);
4. RMR (Root Mean Square Residual);
5. GFI (Goodness-Of-Fit index);
6. AGFI (Adjusted Goodness-Of-Fit index);
7. NFI (Normed Fit Index);
8. TLI (Tucker-Lewis Index);
9. CFI (Comparative Fit Index);
10. RMSEA (Root Mean Square Error of Approximation).

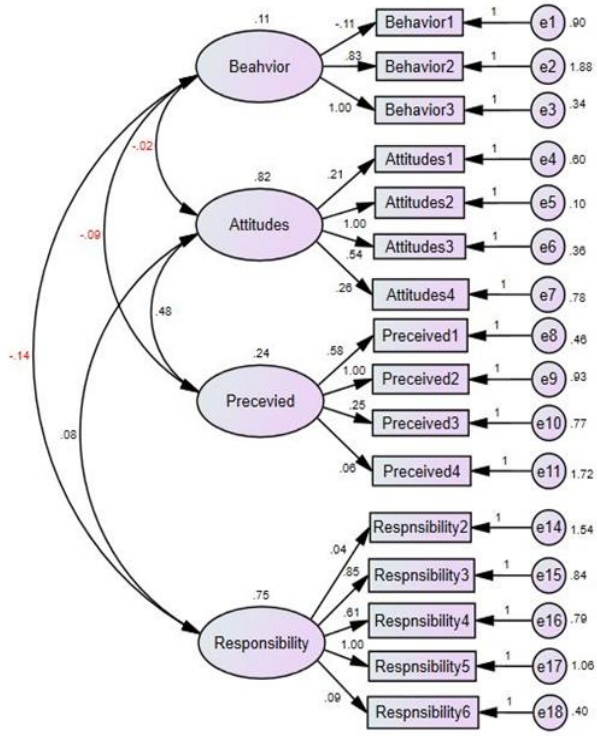

Figure 4. Structural equation model research process [17]

According to Figure 3, values that are more than 0.600 reflect the leading factors, providing evidence of convergent validity. Figures with an R^2 greater than 0.600 were found to be common for all indicators, which shows that definitive dependability has been reached. On the basis of the results of AMOS 24.0, this model is an adequate match because its indices have satisfied the requirements of a model fit, as indicated in Table 5.

Table 5. Fit indices for study SEM

Measure	Indices	Threshold Value [References]
Chi-square value		
df	99	
P-value	0.000	
Chi-square	311.887	P<0.05 [23]
Chi-square/df	3.15	Between 1.00 and 5.00 [23]
Goodness of Fit Index		
RMR	0.117	Close to 0 the better [24]
GFI	0.859	0.800 and above [24]
AGFI	0.807	0.800 and above [25]
Baseline Comparisons		
NFI	0.527	0.800 and above [26]
TLI	0.426	0.900 and above [27]
CFI	0.605	0.900 and above [24]
RMSEA	0.069	Between 0.03 and 0.08 [20]

According to Table 5, CFA was used to estimate the convergent and discriminant validities by using the AMOS 24.0 software. The overall goodness-of-fit indexes of the Confirmatory Factor Analysis (CFA) measurement model suggest a satisfactory fit. All measurements in Table 5 confirm that the structural model adequately fits the data, according to references [20, 23, 26, 27]. However, Baseline Comparisons refers to the models automatically fitted by Amos for every analysis which is not adequate due to not reaching thresholds.

4. CONCLUSIONS

Full descriptive analysis was done to all variables of the questionnaire after extensive data screening to respondents' answers to the questionnaire to fully understand the respondents' perspective for travel aspects for public transport in Baghdad city. Demographic analysis was discussed which shows that the respondents are 57% male and 43% female which represent a perfect combination of gender bias in this study. Public transport users from 18-25 years old were the major influence of the result of this study with 68% of all respondents. Further descriptive analyses for all variables were preformed to understand the respondents' perspective toward satisfaction, comfort, and reliability of public transport.

The generation and formation of theoretical based model of structural equation model as the study examined for the first time the effect of causal determinants of travel aspect for public transport in Baghdad city with regards to Travel Behaviors for Public Transport, Attitudes Towards Private Vehicles Perceived Behavioral of Public Transport, and Responsibility Towards Public Transport. CFA measurement was used with nine Goodness-of-Fit measurement to test the confirmatory of measurement scale: Chi-square, Chi-square/df, RMR, GFI, AGFI, NFI, TLI, CFI, and RMSEA. Most these measurements shown an acceptable threshold value when model was tested. AVE and C.R measurement for reliability and validity of model have also shown acceptable values which indicate that all determinants of SEM model have significant and positive causal relationship with factors.

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NOMENCLATURE

AGFI	Adjusted Goodness-Of-Fit index
ATT	Attitudes
BEH	Behavior
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
COVID	Coronavirus Disease
FA	Factor Analysis
GFI	Goodness-Of-Fit index
KMO	Kaiser-Meyer-Olkin
NFI	Normed Fit Index
PER	Perceived
RES	Responsibility
RMSEA	Root Mean Square Error of Approximation
RMSR	Root Mean Square Residual
SEM	Structural Equation Modeling
SMC	Squared Multiple Correlations
SPSS	Statistical Package for Social Science
TLI	Tucker-Lewis Index
WHO	World Health Organization