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COVID-19 and People's Continued Trust in eHealth Services: A New Perspective

Abstract

Individuals' use of eHealth services has increased significantly. However, the recent pandemic of coronavirus disease 2019 (COVID-19) has resulted in a significant reallocation of health resources and supports. This study investigated the impact of service quality dimensions on individuals' continued trust in eHealth during COVID-19. A decision-making trial and evaluation laboratory (DEMATEL) approach was used to identify and analyse the causal relationships between service quality dimensions and individuals' continued trust in eHealth services. A total of 134 eHealth users (78 males and 56 females; aged 29-61 years) responded to the DEMATEL questionnaire. The results showed a variation in the impact of service quality factors on individuals' continued trust in eHealth services. This study found three core factors (responsiveness, assurance, and tangibility) that influence individuals' continued trust in eHealth services. Other secondary factors (e.g., content quality, reliability, efficiency, and hedonic benefits) were found to be primarily influenced by the core factors. The identified relationships in this study can aid the decision-making process of healthcare providers and increase the efficiency of healthcare delivery.

Keywords: eHealth, health psychology, health services, trust

1. Introduction

The recent advancement in eHealth services made it easier for people to monitor and manage various health-related needs [1 2]. People's use of eHealth systems has increased rapidly, especially during the COVID-19 pandemic. For example, eHealth systems are currently used to provide the public with health communication in relation to disease spread and control remotely [3]. People's trust in Information Technology (IT) services can be an important determinant of willingness to access health information on COVID-19 [4]. Yet in a study by Pramukti, et al. [5], it was found that COVID-19 information that was received from the internet and from medical staff can negatively influence individuals' psychological health and well-being.

Moreover, the shortage in the delivery of healthcare services during the COVID-19 pandemic has resulted in a significant reallocation of resources and supports [6 7]. The magnitude of this shortage can lead people to refrain from using health services, which may influence people's trust in using digital health platforms. This is because low trust has been frequently linked to people's likelihood of following recommendations given by health authorities during previous outbreaks of infectious diseases [8 9]. Soveri, et al. [10] reported the importance of maintaining individuals' trust in health providers as a means to ensure that individuals comply with the provided health services and support. The literature showed that trust in health providers is exhibited to be highly correlated with quality of health services [11].

Previous research highlights trust and trust in healthcare system as critical success factors responsible for peoples' preventive behaviors against infectious, chronic diseases, and risky lifestyles. In a study by

Lin, et al. [12], trust was generalized as an important factor that deterred people from suicidal tendencies during the COVID-19 pandemic. The reverse was found in a study conducted among students. The findings revealed that participants who had low confidence in the healthcare system had higher anxiety and suicidal ideation [5]. To reduce the negative impact of social media on the psychological well-being of people, previous research suggested studying trust as one of the significant factors contributing to people's use of health technologies/services [13].

By implication, the presence of trust and confidence in the health systems can potentially minimize the fear of COVID-19 and increase peoples' resilience for survival. Ahorsu, et al. [14] found a positive correlation between generalized trust and healthcare system which in turn influences peoples' willingness to get vaccinated against the COVID-19 virus. Similarly, Rad, et al. [15] found that trust in the healthcare system was one of the factors that would motivate the majority of healthcare workers who willingly accepted to be vaccinated against their unvaccinated counterparts. Another study also highlighted trust in healthcare system enabled people to translate positive attitude towards risk into preventive behaviors against COVID-19 [16].

Yet, people's perceptions of service quality may not be stable over time and that healthcare decision makers should be made aware of the implicit factors. Despite the fact that trust in a service during the COVID-19 pandemic has been the main concern among societies [17], there are limited studies describing how individuals' continued trust in a health service is currently conceptualized. This can be due to the limitation of

current statistical methods in handling complicated relations and bringing together a wide range of variables to solve weighing and selection problems in the form of cause-and-effect relations. Shiau, et al. [18] supported this assumption by addressing the needs for more advanced methodologies to understand, explain, predict, and manage pandemic crises such as COVID-19. To solve this challenge, Multi Criteria Decision Making (MCDM) can be applied to handle both qualitative and quantitative criteria and resolve the conflicts between the criteria and decision makers [19]. Decision Making Trial and Evaluation Laboratory (DEMATEL) is an example of MCDM that has been widely used to vitalize traditional methods [20]. Based on these observations, this study aimed at answering two main questions: "What are the service quality factors that most impact individuals' continued trust in eHealth services during the COVID-19 pandemic?" and "What are the relationships between these factors?"

It is hoped that the use of DEMATEL will be helpful in outlining potential causal relationships between service quality factors and individuals' continued trust in eHealth services. In addition, identifying the relationship between certain factors of service quality can assist decision makers take technology-related decisions to respond appropriately to health crises. Findings from this study can also help eHealth providers identify strategies to increase the efficiency of eHealth services and enhance the quality of care/life.

2. Literature Review

The literature reveals the importance of eHealth services (e.g., telehealth or telemedicine) in transforming healthcare through patient empowerment at a distance [21-24]. Understanding the recent shift in healthcare delivery in response to the COVID-19 pandemic is vital [25]. Despite the demonstrated utility of eHealth, issues relating to the quality of eHealth services and patients' trust remains contentious [26]. This assumption was supported by Chowdhury, et al. [27] who reported how patients' low perception of accessibility and poor service quality can potentially lead to low trust in telemedicine. However, the current evidence of a causal relationship between service quality and patients' trust in eHealth services is insufficient and more data from well-designed studies are urgently needed [28].

Scholars have devoted efforts to ascertain eHealth service quality dimensions based on the service quality measurement scale (SERVQUAL) developed by Delone and McLean [29] and Parasuraman, et al. [30]. The literature suggested that identifying specific eHealth service quality dimensions is key for generating sustained individuals' trust [31]. This is because a wider application of SERVQUAL may limit our understanding of how various factors influence the intended behaviors. Moreover, the unified theory of acceptance and use of technology model (UTAUT) has underpinned studies to determine factors that influence users' trust in eHealth [32 33].

Individuals' trust in technology has been widely argued to be the product of social relationships and cultural differences. This is because people of specific cultural values are likely to perceive the use of technology in a way different from other cultures. In addition, the lack

of trust in using specific technologies can be attributed to the cultural background of users [34]. Alzahrani [35] stated that individuals' cultural background can shape their trust in technology and their behavioral intention to adopt services in a particular context. Hence it can be concluded that trust in the quality of services can vary from one population to another in which understanding how certain variables of service quality relate to individuals' trust may increase individuals' use of eHealth services.

Although a number of quality assessment criteria has been introduced in the literature, a validated assessment of eHealth quality factors still varies widely. Akter, et al. [36] applied service quality factors to study users' perceptions of mHealth. The authors categorized service quality based on three dimensions, namely: platform quality, interaction quality, and outcome quality. These dimensions have proven robust in assessing the quality of eHealth/mHealth services [21 37-39]. Thus, given the wide application in empirical studies, this study applied Akter, et al. [36] classification of service quality for studying users' trust in eHealth services.

2.1 Trust in eHealth services

Trust in technology, and eHealth in particular, can be driven by the ability of the system to efficiently perform the task. According to Nesheva [40], users' willingness to exchange health information via eHealth systems is an ongoing challenge for healthcare providers. In addition, the cultural habit of specific populations can form a part in shaping people's trust to perceive the quality of services. For example,

Esmaeilzadeh [41] and Lupton [42] have argued that the exchange of medical information electronically moves beyond just a cognitive assessment of individuals' emotional belief in the system, thereby making trust an influential determinant of continued use of health technology. The concept of trust in technology has been characterized by many studies (e.g., [43]) as a trustor's willingness to be vulnerable to the actions of a trustee in view of expected future behaviors.

Our review of the literature suggests that trust in health applications may differ slightly from trust in technology in other domains (due to safety and health concerns of users) [44]. This is because trust in health services/systems is conceptualized as individuals' beliefs about the potential benefits accrued from using certain health technologies [22 45]. Many previous studies have explored how trust can influence individual behavioral intention and continued use of health technologies [45-47]. This includes the association between digital literacy of users and their trust in eHealth services [48].

According to Ehrismann and Stegwee [49], trust in eHealth services can be described based on benevolence, security, competency and effectiveness of the technology. Xie, et al. [50] sought to understand eHealth trust formation from the perspective of patients. The authors reported that factors related to situational normality, structural assurance, cognitive trusting base, perceived ease of use and self-efficacy are the main influencers of patients' trust in eHealth technologies. Esmaeilzadeh [41] examined antecedents of two forms of trust (cognitive and emotional) and their influence on patients' willingness to use and share health information. The author anticipated that the relationship between

perceived benefits, transparency of privacy policy and familiarity can promote trust among individuals.

Solem, et al. [51] combined evidenced-based and stakeholders' perspective to characterize the role of reliability, trustworthiness, content quality, personalization, feedback, behavioral tracking and self-assessment in developing user-centred eHealth intervention. Other studies highlighted the importance of maintaining confidence in eHealth systems by exploring issues such as tangibility and efficiency of health systems Bashshur, et al. [52]. Yet, the relationship between a range of service quality factors and individuals' continued trust in eHealth is not well understood, especially during the period of COVID-19. Thus, identifying the factors that promote users' continued trust in eHealth systems remain imperative [50]. From these observations, it can be said that the current understanding of people's continued trust in eHealth technology is insufficient, especially during natural disasters like COVID-19. Yet, a synthesis of what may contribute to individuals' continued trust in eHealth settings can be shaped based on three key quality dimensions, namely eHealth systems/platform quality (reliability, tangibility, efficiency, content quality), eHealth interaction quality (responsiveness, assurance, empathy), and eHealth outcome quality (hedonic benefit) [36]. These dimensions and their associated are described in the following sections.

2.1.1 eHealth system/platform quality

Continued trust and usage of eHealth systems are intricately linked with eHealth system/platform quality. Generally, platform quality of

information system is linked with technical structure and functionality of the system. The lack of these features may create uncertainty in the beliefs of individuals about the ability of the technology to perform as expected. The literature described system/platform quality via the following elements: reliability, tangibility, efficiency, and content quality.

The reliability of a system has been widely used to describe individuals' viewpoints about the quality of IS service [21 53]. Hadwich, et al. [31] identified reliability as a key determinant of eHealth service quality. In a related study, the term competency was used to denote the technical reliability of eHealth services [49]. Previous studies suggests a significant association between reliability and users' trust in technology [49 54]. For example, Cook, et al. [55] and Farrell [56] established that the trustee's reliability to set the boundaries of a trusted relationship.

In addition, the review of the literature showed the role of service tangibility (e.g., physical offices, equipment, personnel and communication materials) in affecting individuals' trust in the system [54]. Tangibility of the service is viewed as one of the substantial impediments to individuals' trust [21 57 58]. According to Boy [59], tangibility is a matter of trust that can lead to a sustainable use of technology. This is because service tangibility is considered a proxy for information that can bolster individuals' confidence when evaluating the benefits and physical attributes of the service [60]. In addition, the positive perception of service tangibility can reduce uncertainty and increase trust in a service among users [61].

Efficiency is another factor of service quality, which describes the technical performance of information system [29 30]. Service efficiency is commonly used to capture users' assessment of how valuable eHealth services can be [49]. It demonstrates users' perceptions in terms of saving money, time, and efforts in the provision of a service [62]. Some prior studies addressed the significant influence of system efficiency on users' continuous trust in eHealth technology. For example, Gadabu, et al. [63] noted a significant relationship between system efficiency and users' continuous trust in eHealth services. Service efficiency can produce a certain level of perceived effectiveness, which restore dissatisfied trust among users [64].

Meanwhile, content quality has been reported in the literature as a key determinant of users' continuous trust in health systems. It encompasses the extent to which health information is personalized, easy to understand, secure and appropriate for healthcare intervention [29 65]. Vervier, et al. [66] and Boon-itt [67] found that perceptions about information quality was the most important factor associated with users' trust in health-related systems. The foregoing suggests that the quality of eHealth content and its potential influence on users' continuous trust are critical and deserve further exploration. Based on these observations, we examined the impact of eHealth system/platform quality in terms of reliability, tangibility, efficiency, and content quality on individuals' continued trust in eHealth services.

2.1.2 Interaction quality

Interaction quality is an important determinant of trust [38]. It reflects the overall support delivered by the service provider [29]. Social exchange theory by Cook, et al. [68] pointed to the importance of exchanging positive and valuable information as a means for enhancing enhance individuals' trust and confidence. For example, it is anticipated that greater interaction quality can facilitate interpersonal and social bonding, which can also foster trust among people. In a healthcare context, this implies that greater interaction quality can result in a greater trust among eHealth users. Auh [69] used social exchange theory to explain the relationship between interaction quality and trust through the exchange of conversational and verbal information between the service provider and the customer. Key elements such as responsiveness, assurance, and empathy have been reported in the literature as the criteria for assessing service interaction quality [36].

Responsiveness has been described as an important quality criterion for promoting individual' trust in eHealth technology [70]. It refers to the readiness to respond to users' expectations regarding their usage of the system. Valentine [71] indicated that it is not a straightforward task to identify objective indicators for assessing perceived responsiveness of health systems. The literature showed how perceived responsiveness can further influence users' intention and continued use of health services through trust [54 72 73]. This is because, users' initial access to prompt quality care that satisfies their health needs is directly proportional to the trust value and continuous usage of specific eHealth services.

The quality assurance of services has also been identified to influence individuals' trust. Assurance describes the overall competence

of organizational resources [21 29]. In the context of this study, quality assurance refers to the ability of the eHealth system to inspire confidence in users that the service is trustworthy and safe. According to Xie, et al. [50], the presence of policies, laws, and guarantees can influence the initial trust formation process in the eHealth system. Thus, perceived assurance can be considered fundamental to users' long-term relationship to online services [74], and particularly trust [54]. Another study by Anshori [75] The showed that the quality assurance can positively influence individuals' trust in a service. Perceived quality assurance and trust can arise as a result of the needs and desires of users to gain information online [76]. Based on the foregoing, the potential relationship between assurance and trust formation of eHealth users was considered relevant to this study.

Empathy is another key factor of service quality which refers to providing an individualized attention and support offered by staff to patients. Previous studies demonstrated that empathic doctors who tend to listen to patients and offer emotional support can increase trust in the system. In addition, patients are likely to feel frustrated and disappointed if they could not perceive empathy from the medical staff [77]. According to Hadwich, et al. [31], physicians consider their empathic behavior as a significant predictor of eHealth service quality. The development of empathic understanding is challenging but important for the communication between health staff and patients [78]. Setyawan et al. (2019) argued that the empathic behavior of healthcare workers can generate mutual openness and wiliness to use the service, thus resulting in building a trustful and safe patient-doctor relationship. As such, this

study considered examining the impact of interaction quality in terms of responsiveness, assurance, and empathy on individuals' continued trust in eHealth services.

2.1.3 Outcome quality

User perception of system/service quality is important determinant of outcome quality. According to Akter, et al. [36], the overall benefits users accrue from using health services can constitute their perception of outcome quality. Many prior studies have (e.g., [79-81]) have supported the direct influence of outcome quality on individuals' trust in a service provider. The outcome quality of a service is one of the main features of patient-physician relationships and can be a possible determinant of patients' trust in the service received [82].

In an eHealth context, outcome quality can reflect the level of completeness and accuracy of information and how they support the health needs of the users. The literature suggested two outcome quality dimensions, namely: functional (pragmatic) benefit and emotional benefit [36 83]. Similar constructs, such as perceived enjoyment or intrinsic motivation, have been used in the literature to gauge users' perceptions of eHealth systems [84 85]. Specifically, hedonic benefits have been exhibited to impact individuals' trust in technology. Lupton [42] indicated that the utilitarian benefits of eHealth services, in particular the system's capacity to record and retrieve health records, can motivate individuals to develop positive feelings and trust in health

technologies. Xie, et al. [50] used calculative cost/benefits and self-efficacy to describe personal incentives that influence trust in eHealth technology among users. Gong, et al. [45] used perceived benefit to describe the functional outcome of eHealth technology service. Talukder, et al. [86] found that hedonic motivation was responsible for generating a positive perception among users when using healthcare technologies and services. Based on these observations, this study considered the role of hedonic benefits in influencing individuals' continued trust in eHealth services.

Despite previous efforts to improve the quality of healthcare services, a deficient understanding of the relationship between the eight dimensions of service quality mentioned above and users' continued trust in eHealth services still exists. The use of DEMATEL in this study would allow us to handle the inner dependences within a set of criteria, thus revealing various relationships between service quality dimensions and users' continued trust in eHealth services (as shown in Figure 1).

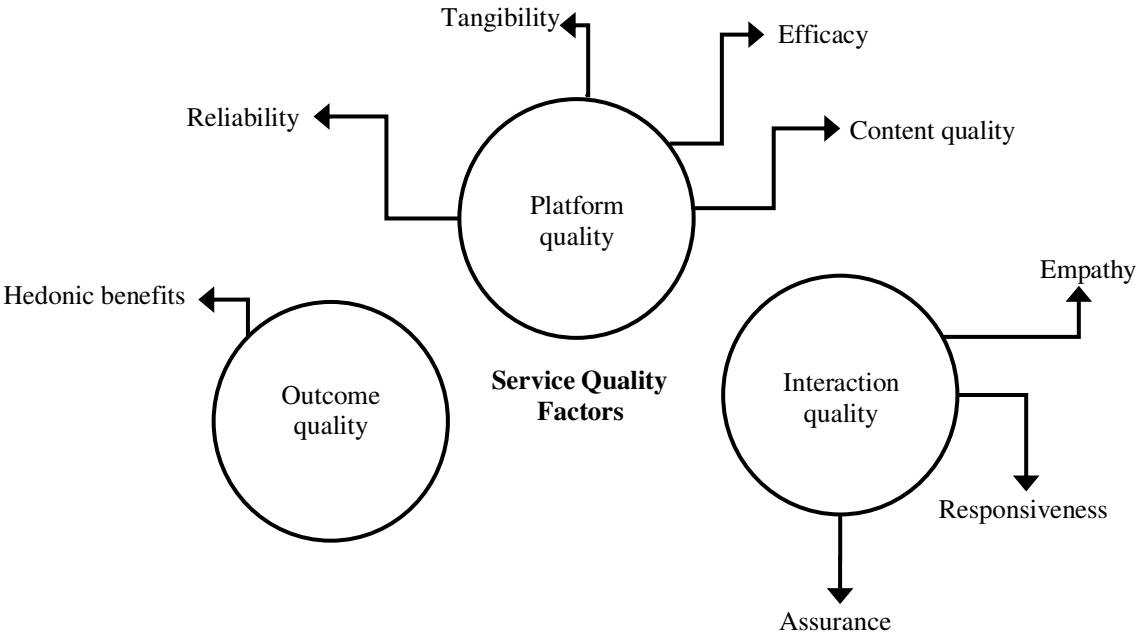

Figure 1: The examined service quality dimensions and factors

In the context of this study, the majority of eHealth services were made available freely through governmental channels.

3. Method

3.1 Sample and procedure

We examined the influence of service quality factors on individuals' continued trust in eHealth services during the COVID-19 pandemic. The identified factors form the literature (reliability, tangibility, efficiency, content quality, responsiveness, assurance, empathy, and hedonic benefits) were employed to construct a structured set of questions. This study applied a convenience sampling design to select the respondents. The selection of respondents was in part determined by the inclusion

criteria (availability or accessibility and willingness to respond). In addition, we had no access to all respondents with experience in using eHealth services during the COVID-19 pandemic, and hence, a smaller but representative sample of users was obtained.

In order to collect the required data, a questionnaire was developed in accordance with the requirements of the DEMATEL approach. Two DEMATEL experts were asked to validate the structure of the questionnaire presented in Table 2 (see the supplementary file for further details). The users of health services were obtained from the online health units of three universities. We also used the social media sites of these health units to encourage users to respond to the survey. The health unit in each university distributed the questionnaire link to its enrolled users. An email invitation was sent to individuals who had experience in using eHealth services, notably during the era of COVID-19. In order to ensure confidentiality of the respondents' data, the questionnaire did not contain any identifiers. After three attempts, a total of 134 eHealth users (78 males and 56 females) aged 29-61 years were recruited. Table 1 shows the demographic characteristics of the respondents. Since this study evaluated the current eHealth services in relation to the study factors, ethical approval was not deemed necessary. However, all participants gave written informed consent to participate in the study. The respondents were provided with an initial page before their survey starts, which contains a brief summary of the project and a downloadable participant information sheet. The respondents reported that they used eHealth services to perform contact tracing (n: 26), view health updates

(n: 79), receive health advice (n: 10), and manage health symptoms (n: 19).

Table 1: Demographic details of the respondents

Demographic	**Frequency**	**Percentage**
Gender		
Male	78	58%
Female	56	42%
Age		
25-34	12	9%
35-44	46	34%
45-54	68	51%
above 55	8	6%
Education		
No education	4	3%
Secondary/high school	17	13%
Undergraduate degree	93	69%
Postgraduate degree	20	15%
eHealth use		
Contact tracing	26	19.4%
View health updates	79	59%
Receive health advise	10	7.4%
Manage health symptoms	19	14.2%

The identified respondents were briefed via email about the aim of the study and their role in assessing the level of influence service quality factors has on their continued trust in eHealth services. A second email was sent to all respondents with a clear definition of each factor and an example of its application in the context of this study. A link to the online questionnaire was imbedded in the email sent to the respondents with instructions on how to identify the level of influence each service quality factor has on other factors as shown in Table 2. According to the Table,

we used a scale of 0 (no influence), 1 (very low influence), 2 (low influence), 3 (high influence), and 4 (very high influence) to assess the level of influence between the factors on individuals' continued trust in eHealth services. The period of distributing the questionnaire lasted from 23 October 2020 until early February 2021. We assessed the data for risk of non-response bias by comparing the means of the early and late responses using t-tests. The obtained p values (<0.5) from the t-tests corresponding to each variable in the study showed no significant differences between the means of the early and late responses. We also used the Harman's one-factor test to assess for common method bias by entering all the indicators into a principal component factor analysis [87]. The obtained variances for the examined constructs ranged from 15% to 19%, indicating no substantial common method bias. All the responses were coded individually in order to establish the relationship diagram, followed by the normalization step. The steps for generating the map are outlined in the next section.

Table 2: Example of the DEMATEL questionnaire

matrix	Reliability	Tangibility	Content quality	Responsiveness	Assurance	Empathy	Efficiency	Hedonic benefits
Reliability								
Tangibility			2					
Content quality								
Responsiveness						4		
Assurance								
Empathy								
Efficiency								
Hedonic benefits							0	

Instructions for filling out the index: 0 = No influence; 1 = Very low influence; 2 = Low influence; 3 = High influence; and 4 = Very high influence.

3.2 The DEMATEL approach

The DEMATEL method was originally developed by Battelle Memorial Association in Geneva. It was successfully used in many areas like healthcare decision making, e-learning evaluation, and technology utilization to establish a link between various factors [88]. In order to

generate the final diagram in relation to eHealth continued trust, we followed several steps as shown in Figure 2.

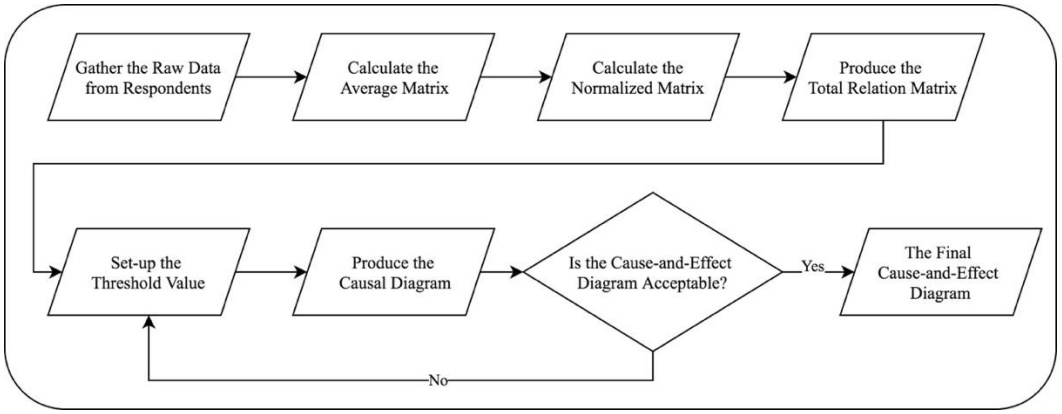

Figure 2: The DEMATEL steps

Our review of the literature resulted in the identification of service quality factors that can be linked to individuals' continued trust in eHealth services. These factors are outlined in Table 3 which we used to construct the diagram for this study.

Table 3: Service quality factors influencing individuals' continued trust in eHealth services

Factors	**Description**
F1	Reliability
F2	Tangibility
F3	Content quality
F4	Responsiveness
F5	Assurance
F6	Empathy
F7	Efficiency
F8	Hedonic benefits

Step 1. Calculating the direct relation matrix A

The direct relation matrix was calculated (see Table 4) by grouping responses from all respondents based on the relations between service quality factors presented in Table 3. The relation matrix *A* was estimated by averaging all responses based on the level of influence that the element *i* in the matrix row poses over the element *j* in the matrix column. This was represented in the form of a_{ij} which was originally established by calculating the $n * n$ matrix *A* as shown below:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots & \vdots & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

$$a_{ij} = \frac{1}{H} \sum_{k=1}^{H} x_{ij}^{k} \quad (2)$$

Here *H* refers to the number of users responded to the questionnaire.

Table 4: The averaged matrix

Averaged matrix	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.00	2.00	3.50	3.43	2.43	2.50	3.80	3.43
F2	2.90	0.00	3.78	3.29	2.30	3.10	3.00	3.87
F3	3.80	2.29	0.00	3.71	2.10	3.00	3.44	3.86
F4	3.80	3.20	4.00	0.00	2.43	2.60	3.80	2.71
F5	3.10	3.43	3.87	3.10	0.00	2.50	3.14	3.62
F6	3.41	2.14	2.29	2.45	2.71	0.00	2.00	3.10
F7	3.40	2.20	2.10	2.78	2.96	3.20	0.00	3.62
F8	2.89	3.20	3.90	2.14	3.14	3.38	3.74	0.00

Step 2. Normalizing the direct-relation matrix A

After calculating the direct relation matrix, we estimated the normalized direct-relation matrix *X* (see Table 4) by executing the following formulas:

Let $s = \max\left(max_{1\le i\le n}\sum_{j=1}^{n} a_{ij,}\ max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\ \right)$ (3)

Then $X = \frac{A}{S}$ (4)

Here, we calculated the sum of each row *j* of a matrix *A* based on the direct effects that factor *i* has on other factors. We used $\max\left(max_{1\le i\le n}\sum_{j=1}^{n} a_{ij,}\ max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\ \right)$ to represent the direct effect of each factor on other factors. By doing so, we were able to estimate the total-relation matrix *T*.

Table 5: The normalized cause-effect matrix

Normalized cause-effect matrix	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.00	0.08	0.14	0.14	0.10	0.10	0.16	0.14
F2	0.12	0.00	0.16	0.14	0.10	0.13	0.12	0.16
F3	0.16	0.09	0.00	0.15	0.09	0.12	0.14	0.16
F4	0.16	0.13	0.17	0.00	0.10	0.11	0.16	0.11
F5	0.13	0.14	0.16	0.13	0.00	0.10	0.13	0.15
F6	0.14	0.09	0.09	0.10	0.11	0.00	0.08	0.13
F7	0.14	0.09	0.09	0.11	0.12	0.13	0.00	0.15
F8	0.12	0.13	0.16	0.09	0.13	0.14	0.15	0.00

Step 3. Generate the total-relation matrix T

The normalized relation matrix *X* was applied in this step to produce the total-relation matrix *T*. This was achieved by executing the following formula:

$$X = \lim_{m\to\infty}\left(X + X^2 + \cdots + X^m\right) = \sum_{m=1}^{\infty} X^m$$

Where

$$\sum_{m=1}^{\infty} X^m = (X + X^2 + \cdots + X^m)$$
$$= X\,(I + X^1 + X^2 \ \ldots + X^{m-1})$$
$$= X\,(\,(I - X)^{-1}(I - X)\,(I + X^1 + X^2 \ \ldots + X^{m-1})$$
$$= X\,(\,(I - X)^{-1}(I - X^m)$$

$$T = X(I - X)^{-1} \qquad (5)$$

Here *I* is denoted as the identity matrix.

Step 4. Produce the causal map

We calculated the causal diagram/map for this study by denoting the sum of factors in the row and the sum of factors in the column independently as vector R and vector C (see Table 6). The relationship between R and C was used to construct the causal graph using (R + C) as the horizontal axis and (R – C) as the vertical axis.

Table 6: The total matrix

Total matrix	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.92	0.82	1.05	0.96	0.83	0.91	1.05	1.08
F2	1.08	0.78	1.10	0.99	0.86	0.97	1.07	1.14
F3	1.10	0.86	0.96	1.00	0.85	0.96	1.08	1.13
F4	1.12	0.90	1.12	0.89	0.87	0.96	1.11	1.11
F5	1.11	0.92	1.13	1.01	0.79	0.97	1.10	1.15
F6	0.93	0.73	0.89	0.82	0.74	0.71	0.88	0.94
F7	1.01	0.80	0.97	0.90	0.82	0.90	0.88	1.05
F8	1.08	0.90	1.11	0.96	0.89	0.98	1.09	1.00

Figure 3 shows the pairwise influence of each factor in the context of this study. The causal map was used to show the relationships between the influential factors of service quality and individuals' continued trust in eHealth services. It is also worth mentioning that the higher the value

of (R + C), the higher the degree of importance of a given factor in the decision-making process. However, if the value of (R – C) is greater than 0, then the value should dominate over other values. But if the value of (R – C) is negative, then the value can be dominated by other variables. Here we used the location of the result in the causal-effect plot to indicate whether a given factor is a cause or an effect.

$$R = [r_i]_{n*1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n*1} \quad (6)$$

$$C = [c_i]_{n*1} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1*n} \quad (7)$$

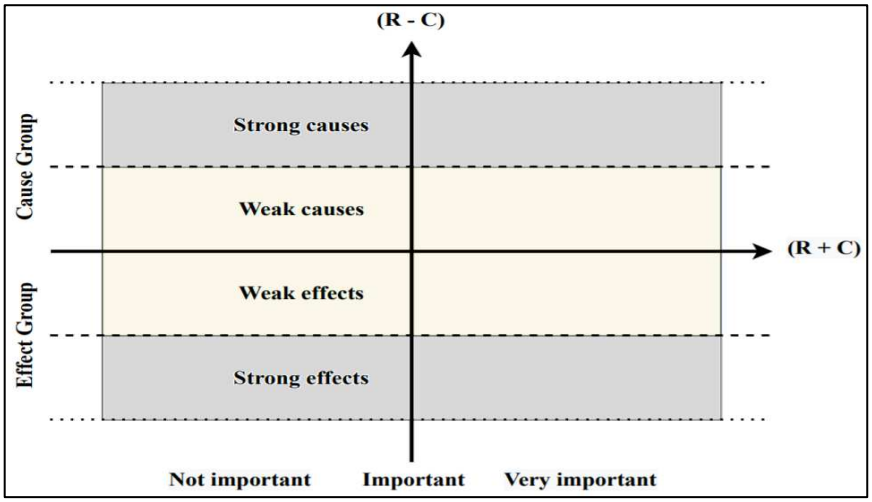

Figure 3: The causal map/graph

Step 5. Set up the threshold value (α) and produce the causal-relation map

A threshold value (α) was set up in the matrix *T* to determine potential structural relations among the factors while keeping the complexity of the whole causal-relation map at a manageable level. We only mapped the factors in an inner dependence matrix whose effect in matrix *T* was greater than the threshold value. The threshold in this study

was calculated by taking the mean and standard deviation (SD) of the values from the matrix *T*, and added one SD to the mean [89]. As such, we added the mean (0.97) and the SD (0.12) of the elements in total matrix *T* ($\alpha = 1.09$) to produce the final relations (see Table 7).

4. Results and Discussion

Our review of the literature indicated limited evidence about the impact of quality dimensions on users' continued trust in eHealth services, particularly during COVID-19. We unveiled eight service quality factors that can potentially contribute to individuals' continued trust in eHealth services (reliability, tangibility, content quality, responsiveness, empathy, assurance, efficiency, and hedonic benefits). The relationships between service quality factors were derived by summing and subtracting the raw (R) and column (C) values (see Table 7). Then, the obtained results were used to group the values of (R+C) and (R-C) into cause-and-effect scenarios based on the threshold value identified in Step 5. The final DEMATEL map, as shown in Figure 4, shows how certain service quality factors can influence individuals' continued trust in eHealth services. The main associations between the study factors were also examined. The interrelated lines in the DEMATEL map were used to outline the relationship from the influencing factor to the affected one. In addition, the two-way arrows (double-sided) was used as an indication of the mutual influence between the examined factors.

Table 7: The final relations

Factors	R	C	R + C	R - C	Group
F1: Reliability	7.62	8.34	15.95	-0.72	Effect
F2: Tangibility	7.99	6.72	14.71	1.27	Cause
F3: Content quality	7.96	8.33	16.29	-0.37	Effect
F4: Responsiveness	8.08	7.54	15.62	0.54	Cause
F5: Assurance	8.19	6.65	14.84	1.54	Cause
F6: Empathy	6.64	7.38	14.02	-0.74	Effect
F7: Efficiency	7.33	8.26	15.58	-0.93	Effect
F8: Hedonic benefits	8.01	8.60	16.61	-0.59	Effect

The results revealed that among the eight dimensions of service quality, only three factors were identified as causal factors and the rest were identified as effect factors. The main service quality factors associated with individuals' continued trust in eHealth during COVID-19 were responsiveness (F4), assurance (F5), and tangibility (F2) with values of 15.62, 14.84, 14.71, respectively. Service responsiveness appears to be at the top of the causal group, indicating that it is the primary causal factor among other service quality factors. The results additionally revealed that the factors of service quality in the effect group were hedonic benefits (F8), content quality (F3), reliability (F1), efficiency (F7), and empathy (F6) with values of 16.61, 16.29, 15.95, 15.58, and 14.02, respectively. In addition, if there was no link between any of the examined factors, then the cause/effect is independent from other factors. Accordingly, Figure 4 exhibits that the factor with the least effect on individuals' continued trust in eHealth was empathy (F6), with a value of -0.74. Based on the value of difference (R − C, presented in Table 6), the net causers in this study were assurance (F5), tangibility (F2), and responsiveness (F4), whereas hedonic benefits (F8), reliability

(F1), and efficiency (F7) were net receivers. Other factors, such as content quality (F3), hedonic benefits (F8), and reliability (F1), were net causers and receivers.

We found that the main causal factor of individuals' continued trust in eHealth services was responsiveness. The load on the health services caused by COVID-19 is expected to influence system/service responsiveness to patients/users. For example, the limited capacity in health management can hinder health professionals from responding to those who seek timely health information. This finding supports the recent work of Yuan, et al. [90] that indicated how the lack of eHealth planning can significantly influence users' perceived quality of the service. Our results add to previous studies (e.g., [91 92]) on the link between responsiveness of healthcare systems and trust in the service. Thus, it is recommended that healthcare decision makers integrate a cloud architecture to enable real-time responsiveness by reducing the latency that arises when senor readouts travels between devices and the cloud [93]. We also found that users' perception of eHealth responsiveness can contribute to their perception of its content quality. This can be explained by the nature of service responsiveness which similarly deals with assistive information and medical management that are closely related to the perception of content quality. Furthermore, content quality consists of content richness and continues update [94], which lead to the assumption that content quality may mediate the relationship between responsiveness and individuals' continued trust in a service. Individuals' perception of eHealth responsiveness was found to be linked with eHealth reliability. This can be justified by that both

responsiveness and reliability are considered a required functional structure of any service [95]. Yet, the influence of service responsiveness on users' perception of service reliability as a means to support their continued trust in eHealth has not been studied in depth in the literature. Such finding opens the door for more research in this new direction. eHealth responsiveness was proven to regulate individuals' perception of outcome quality. It is believed that hedonic benefits, such as knowledge about and experience with a service, can have a significant effect on individuals' trust [96]. Interestingly, this finding has not been reported or studied in the literature. Accordingly, we propose that hedonic and functional benefits should be linked to service responsiveness when studying continued trust in a service provider. The quality of eHealth responsiveness can potentially influence individuals' perception of service efficiency. According to Appannan, et al. [97], responsiveness of a system can be attributed to the process of taking actions efficiently to meet the specific needs of individuals. As such, delay in responding to user requests (not fulfilling their needs) can potentially influence their perceptions of service efficiency. This finding is in line with the work of Chakraborty [98] who addressed the importance of striking a proper balance between responsiveness and efficiency in a healthcare context.

Perceived assurance was similarly found to play a key role in influencing individuals' continued trust in eHealth services. Service assurance is considered as a main determinant of initial trust [99]. A possible explanation is that service assurance is infrequently perceived to be an important element to individuals at the pre-interaction stage

[100]. Yet, the impact of service assurance on users' trust can be higher at the post-interaction stage, mainly when users frequently use the service for disease-management and monitoring. Additionally, the finding implies that users may encounter a limited extent of service failures which can be imposed on the service provider. As such, to increase individuals' continued trust in eHealth through perceived assurance, healthcare providers should continuously monitor the performance of cloud services. This finding adds to previous research (e.g., [101 102]) on the relationship between assurance and trust antecedents in that it priorities the role of perceived assurance in influencing users' continued trust in the service. We found that perceived assurance of eHealth services can significantly contribute to individuals' perception of content quality. Interestingly, this study is the first of its kind to report such a relationship. On the basis of the results, the quality assurance of a service may lead to a higher level of participation and engagement with the content. Thus, providing assurance on the efficiency and effectiveness of eHealth can promote individuals' continued trust in the service. Another relationship between quality assurance and reliability was found in this study. Previous studies (e.g., [103 104] have indicated that assurance of service quality can somehow be related to the reliability of the service provided through various means such as privacy, security, access policies, and control mechanisms. Our finding on the importance of providing the necessary assurance in increasing the reliability of the system is similar to the work of Ahmed (2007). In a trust-based decision, we found limited evidence on how assurance gauges the reliability of service quality in the healthcare

context. This is stressed in the relationship found between assurance and efficiency of eHealth services. We are of the view that assurance can significantly contribute to the efficiency of eHealth services through continuous process optimization (resources and capabilities), mainly to react to changes by outlining source of conflicts between different services/functions [105].

The results further showed the role of service tangibility in promoting individuals' continued trust in eHealth services. This finding is unique in that many previous studies on e-service quality have solely examined the relationship between tangibility and continuous trust in healthcare systems. However, there is still a need to deeply explore this relationship, mainly during health crises. The results indicated a direct association between the tangibility of eHealth service and individuals' perception of its hedonic benefits. This significant impact is in line with the recent work of Nattuvathuckal, et al. [106] who addressed how ambience and equipment can directly affect hedonic value generation. Researchers like Rizomyliotis, et al. [107] indicated the importance of thoroughly explaining the process of how health services operate in order to improve individuals' perceptions of service tangibility. This includes offering users the necessary support to monitor treatment progress, which, as a result, can positively increase individuals' perceptions of the service's hedonic benefits. Our results demonstrated how changes in individuals' perceptions of eHealth tangibility can influence their perceptions of content quality. The literature revealed a very limited understanding about this influence and its relation to individuals' continued trust in eHealth. Yet, we argue that content quality can be

conceptually viewed as part of tangible benefits that would positively affect knowledge management systems success [108]. Furthermore, perceived tangibility was also found to influence individuals' perceptions of eHealth reliability. This result can be due to the fact that service reliability depends largely on various operational and environmental conditions. Such finding is supported by the work of Zhang, et al. [109] which reported a positive relationship between health service tangibility and service reliability. On the basis of these findings, the tangibility of eHealth services can be enhanced by increasing the reliability of system components through integrating appropriate distributed generation and earlier stage diagnostic modalities, especially in situations like COVID-19.

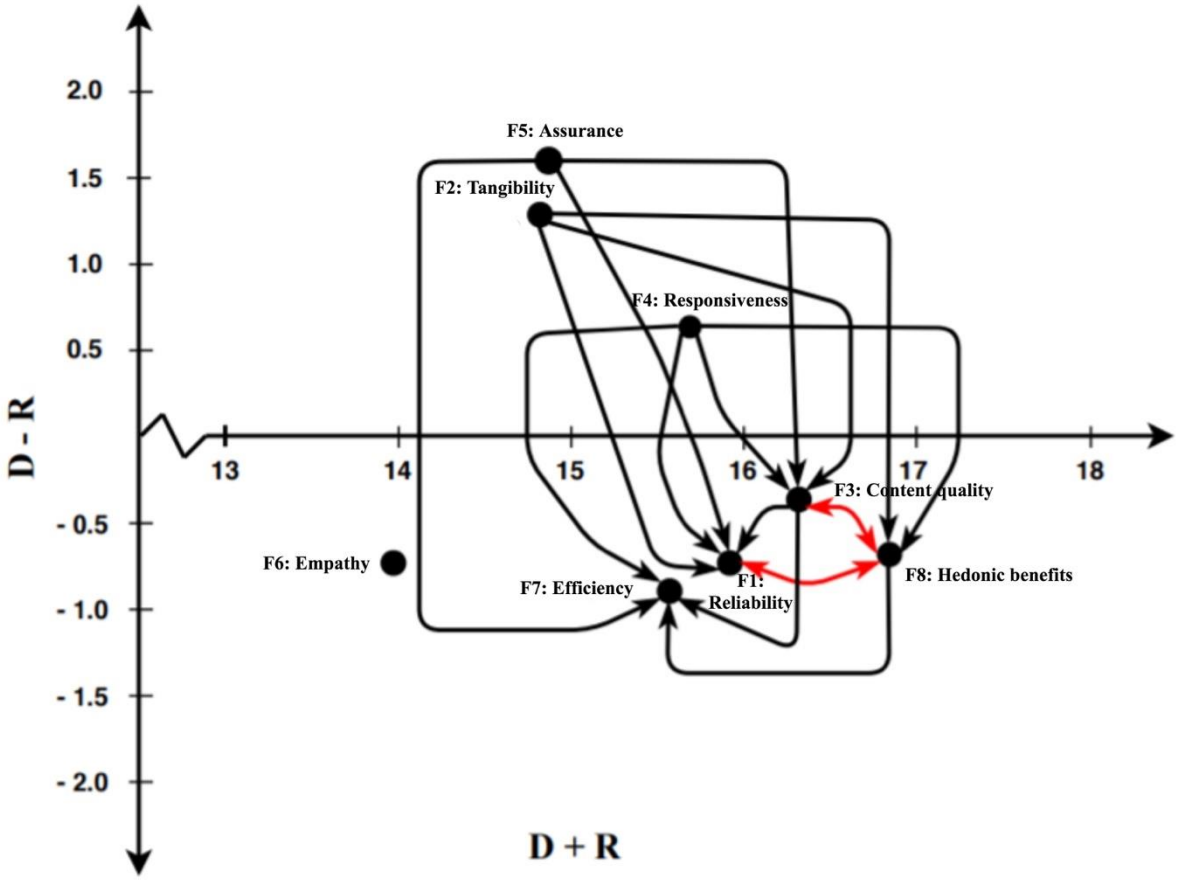

Figure 4: The DEMATEL map

From the above observations, this study suggests that there is a variation in the impact of service quality factors on individuals' continued trust in eHealth during the COVID-19 pandemic. Furthermore, the results revealed new relationships between service quality factors and individuals' continued trust in eHealth.

5. Implications

This study offers a number of practical and theoretical implications. From a practical perspective, the current study proposed new inter-relationships between service quality dimensions and individuals' continued trust in eHealth. For example, this study reported that perceived assurance of eHealth services can significantly contribute to individuals' perception of content quality. Such findings can aid the decision-making process of healthcare providers by taking early measures to increase the efficiency of eHealth services. In addition, the findings can help health authorities or providers decide on the importance of integrating cloud and distributed entities to facilitate the delivery of health services (disease monitoring, health management, and health inquiry), especially in emergency situations.

The findings contribute to the literature in several ways. First, unlike many previous studies assuming continued trust homogeneity on eHealth services, we generated a DEMATEL model to better understand various scenarios that are new to the literature and decision makers. Second, this work contributes to the theory of trust and information asymmetry by comparing the relative importance of different causal factors (responsiveness, assurance, and tangibility) in relation to the net causers (hedonic benefits, content quality, reliability, efficiency, and empathy). Third, our work adds to the theory of planned behavior by specifying which factor of service quality is more influential in promoting individuals' continued trust in a service provider, especially during disaster events or disease outbreaks. Through this, the study findings add to the theory of responsiveness and to empirical knowledge on the role

of assurance and tangibility in influencing other determinants of service quality. This study calls for the decision makers and business practitioners to work together to enrich the existing theories on technology utilization and provide more effective and efficient strategies and tools to eHealth users.

6. Limitations and Future Works

This study has some limitations that need to be addressed in future studies. First, the sample of this study was limited to eHealth users recruited using the convenience sampling method. It is believed that the use of a convenience sample in this study may influence estimates derived from the respondents' response to the questionnaire. In addition, convenience sampling can influence interpretability of the results. For example, our sample consisted of well-educated people. Thus, future studies may consider recruiting a more diverse sample of eHealth users to provide an in-depth understanding of the various relationships between service quality factors.

Second, the examination of service quality factors was limited to certain dimensions of platform quality, interaction quality, and outcome quality. This was mainly due to the evidence found in the literature. This study did not investigate the impact of cultural-related factors on users' use of eHealth services during Covid-19. Therefore, future research should explore how individuals of certain cultural backgrounds may perceive the service quality of eHealth services during health crises. Other factors of service quality can be further examined in the future to provide a wider picture of their impact on individuals' continued trust in

eHealth services. More attention to individuals' demographic background (e.g., age, gender, and online literacy) and their perceptions of eHealth service quality can be further investigated in the future. This can be achieved by using other data collection and analysis methods, such as Fuzzy DEMATEL, and comparing the results with the findings of this study.

7. Conclusion

The literature showed a limited knowledge of continued trust in eHealth services during the COVID-19 pandemic. The evaluation of continued trust criteria is a multiple criteria decision-making problem, which deals with different complex and interactive factors/dimensions. Therefore, we applied the DEMATEL method to examine and identify the causal relationships between service quality dimensions and individuals' continued trust in eHealth services. The application of DEMATEL in this study not only provides decision makers with a better understanding of the core factors affecting users' continued trust in eHealth services but also helps them identify the necessary associations to avoid unnecessary failure during disasters. The results showed that the main service quality factors associated with individuals' continued trust in eHealth were responsiveness, assurance, and tangibility, while the remaining factors were net causers. The identified factors and relationships can help health decision-makers, health authorities, and healthcare providers to assess the current service quality of eHealth systems/services and identify appropriate responses to challenges posed by COVID-19.

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