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Research article

The role of mGovernment applications in building trust during public crises: Evidence from the COVID-19 epidemic

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A B S T R A C T

Throughout the COVID-19 pandemic, China effectively contained the virus, resulting in increased public trust in the government. Mobile government (mGovernment) applications (apps) played a critical role in this improvement. This study aims to examine how mGovernment apps build citizens' trust in governments during public crises. The DeLone and McLean Information Systems Success Model (ISSM) is used to evaluate the quality of these apps. Public satisfaction serves as an intermediary variable, while public awareness of epidemic risks in sudden public relations crises acts as a moderating variable to explore the impact of mGovernment apps on government trust. Data analysis is conducted using SPSS Statistics 22.0 and AMOS 21.0. The study's results show that the system quality, information quality, and service quality of mobile government apps influence citizens' trust in governments through the mediating effect of public satisfaction. All three factors positively correlate with public satisfaction, with service quality having the greatest impact. Similarly, system quality, information quality, and service quality are positively correlated with public trust in governments, with system quality having the most noticeable influence. There is a strong correlation between public satisfaction and trust in governments, and the mediating effect of public satisfaction is significant. In addition, epidemic risk perception moderates the relationship between public satisfaction and citizens' trust in governments.

1. Introduction

In the 12th edition of the United Nations E-Government Survey, released in 2022, China achieved its highest ranking to date, placing 43rd out of 193 member states, demonstrating significant advancements in its digital transformation efforts [1]. As an extension of eGovernment, mobile government (mGovernment) uses mobile devices and applications, and wireless infrastructures, to provide citizens and organizations with information and services [2]. The use of mGovernment services has enhanced interactions among citizens, public institutions, and private organizations, proving crucial for government agencies in delivering services and communicating with their constituencies. During the COVID-19 pandemic, mGovernment apps played an increasingly important role in information disclosure. In China, local governments used mGovernment apps to release policy information, create epidemic prevention and control measures [3], and provide citizens with community services, such as epidemic consultation and discussion forums, which promoted interaction between citizens and their governments. In turn, this improved citizens' satisfaction with the government

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and strengthened the trust towards them.

For individuals, trust is a psychological state characterized by the acceptance of vulnerability based on positive expectations of others' intentions or behaviors [4]. For organizations, trust denotes a partner's expectation of the other party, wherein the expectation is that the other party will be trustworthy and act fairly [5]. In this context, government trust is defined as a type of public expectation of government departments where citizens believe that governments will act in a reliable and fair manner. Public trust in the government is essential for ensuring efficient governance [6]. The public's trust in government departments is a prerequisite for the smooth operation of the entire system. The higher public trust is towards government agencies, the easier it is for them to comply with the rules and regulations set by governments. Therefore, studying how to improve government trust has been the focus of much previous research [5]. Since the outbreak of COVID-19, trust has played an important role in strengthening citizens' relationships with governments and reducing widespread social anxiety and panic. The more trustworthy information shared by governments, the greater citizens accept and respond to epidemic prevention and management measures. In addition, greater trust in the government's efforts to control COVID-19 is strongly linked with increased adherence to preventive measures such as regular handwashing, avoiding crowded places, and practicing social distancing or quarantine [7]. Traditionally, factors like transparency, responsiveness, and effective service provision, have been critical in developing public trust. However, the COVID-19 pandemic intensified these challenges and led to a decline in government trust. In this context, examining the influencing mechanism of government trust in the context of COVID-19 is of great importance to help enhance government trust and quickly respond to such public crises, in future.

Previous research on the relationship between mGovernment affairs and government trust has also become a research hotspot. For example, a recent study posits that citizens' trust in governments and risk perception can affect their agreeance to download and use contact tracing applications [8]. However, existing studies on government trust in mGovernment affairs has several limitations. First, current research has mainly focused on the intention to use mGovernment affairs [2,9] while few studies have examined the mechanism of mGovernment apps to enhance government trust. Second, when studying the impact of mGovernment on government trust, the service quality of mGovernment is often considered as a single dimension [10]. However, mGovernment apps contain information, systems and services, which may have different effects on government trust. Third, although many studies have discussed the impact of mGovernment on government trust [11], few have examined how mGovernment apps affect government trust. Therefore, it is important to study the functional advantages and limitations of mGovernment in enhancing government trust in the context of the COVID-19 epidemic, and how to effectively use mGovernment apps to enhance public trust in the government. To sum up, the identified research gaps include limited understanding of the mechanism through which mGovernment apps enhance government trust, neglect of the diverse effects of other services contained within mGovernment apps on government trust, and insufficient examination of how mGovernment apps specifically affect government trust.

To address these research gaps, this study aims to examine the mechanism through which mGovernment apps enhance government trust. MGovernment apps are taken as the research object while the DeLone and McLean ISSM is used to evaluate mGovernment service quality, adding public satisfaction and epidemic risk perception as research impact mechanisms. The research model covers six variables: system quality, information quality, service quality, public satisfaction, epidemic risk perception, and trust in government, that are used to build a hypothetical model to explore the impact of mGovernment apps' services on government trust.

In contrast to previous research that has mainly investigated the factors that influence public satisfaction as the focus, this study examines the role of public satisfaction as a mediator variable. It aims to explore how public satisfaction acts as a link between the quality of mGovernment apps and the level of government trust. This study empirically studies the mechanism of how mGovernment apps affect government trust, which is not only conducive to the sustainable and healthy development of mGovernment apps in the future, but also helps the public better understand the role of mGovernment apps, thereby enhancing government trust.

The article is structured as follows: Section two provides a review of related literature. Section three introduces research hypotheses and the model. Section four explains the questionnaire design, data collection process, and statistical analysis methods. Data analysis and hypothesis testing are covered in section five, followed by critical discussion. Finally, the conclusion, implications, and limitations are summarized.

2. Literature review

2.1. Government trust during crisis

Government trust is the foundation of a government's credibility and legitimacy, and an important yardstick for evaluating the effectiveness of government governance. Much research exists that has examined the issues related to government trust, but there is yet a unified definition of its term, leading to some scholars providing their own definitions. Previous studies have defined government trust as the trust citizens have in governments [12] while, in later studies, researchers suggest that government trust is the public's belief that a government will perform its duties to a satisfactory degree [13]. In this study, government trust is defined as the public's expectation of governments, that is, the belief that government institutions can act in a reliable and fair manner.

In minimizing the spread of COVID-19, governments played a critical role in introducing Standard Operating Procedures (SOPs) and devising strategies to control the spread of the virus, while also ensuring the fulfillment of citizens' basic needs [14]. Trust in governments is an important factor in this context. Previous studies have extensively examined government trust and its influencing factors. In general, these factors can be divided into two types. First, studies focused on internal factors have explored the reasons why citizens' level of trust changes. For example, governments' professional ability and predictability [15,16], governments' impression management [17], governments concern for citizens, and their fairness in distributing information [18]. Extant research has well documented the strong correlation between government trust and perceived governmental performance. Moreover, studies have

demonstrated that during the COVID-19 pandemic, government communication was favorably linked to vaccination intent [19], adherence to public health guidelines [20], and trust in governments [21]. These principles also apply to trust in governments, which have a beneficial effect on public compliance with health policies [22]. Trust in governments is often influenced by the effectiveness of governmental management and service delivery, and vice versa. In this sense, trust in governments plays a crucial role in facilitating effective governance [6]. While other studies have highlighted external factors, for example, complexity of society [23], social security fairness [24], compliance to public health policies [7], and personal fear and anger, as well as other negative emotions, deeply affected government trust [25]. In sum, existing research that has explored the factors that affect government trust has mainly adopted a macro perspective, with less efforts being given on a specific entity. Therefore, this study concentrates mGovernment apps and examines the impact of their quality on government trust in the context of the COVID-19 epidemic.

2.2. Public satisfaction towards mGovernment during crisis

The effectiveness of information systems and their successful applications in political contexts hinges largely on sustained use, rather than just initial adoption [26]. Users' intentions to continue using an information system is influenced by a combination of factors, including their confirmation of expectations, satisfaction levels, and their instrumental and emotional perceptions [27]. Therefore, public satisfaction is an important determinant of the success of services offered on mGovernment portals [28], and public satisfaction with mGovernment may affect their satisfaction with the government [29]. Public satisfaction refers to citizens' expectations of the products or services provided by governments and the actual perceived value they receive. It is often connected with users' perceptions, which develop when the actual performance of a product or service matches their expectations [30]. In the context of this study, public satisfaction of mGovernment apps is regarded as whether the mGovernment app satisfies the users' needs for government services and if the users' experiences are consistent with their expectations. Among the factors pertinent to public satisfaction, service quality is an important one. It shows that information quality, system quality, network security, and system quality, improved citizen satisfaction [31,32]. A recent study indicated that user satisfaction plays a critical role in shaping their ongoing usage intentions for mGovernment services, with user trust being another significant factor. Previous studies also suggest that perceived quality and value have a substantial impact on both satisfaction and trust [33]. Similarly, another study highlighted that perceived responsiveness, transparency, and security are strongly linked to public trust in e-government services [34]. Some studies have further expanded this scope by identifying that the facilitating conditions, concerns for security and privacy, trust in mGovernment, and quality of information, directly influence the initial adoption of mGovernment services [35]. In addition, the DeLone and McLean ISSM has been widely adopted to explain why users are satisfied with mGovernment apps [36,37].

During public health crises, public satisfaction is essential for trust in governments. Although examining the influencing factors of public satisfaction during the COVID-19 pandemic has emerged as an important area of current research, empirical studies on public satisfaction in the mGovernment context are still limited. For example, a recent study found that authority control, political culture, and government performance awareness, were important factors for citizen satisfaction [32]. Some studies have also emphasized the important impact of mGovernment on public satisfaction [2,38], but few are centered on trust in governments. In addition, most previous research has used public satisfaction as a dependent variable to examine the factors that impact public satisfaction. Conversely, this study takes public satisfaction as an intermediary variable to explore what role it plays between the quality of mGovernment apps and government trust.

2.3. Risk perception in public crises

The COVID-19 pandemic exerted a high impact on public risk perception, including how individuals perceive and interpret the risks related to the crisis [39]. Risk perception is closely related to behavior changes. Existing behavior models confirm that people's risk perception level can lead to certain behaviors in specific health-related situations. A close association was observed between individuals' risk perception and their reported adoption of preventive health measures, a trend that was consistent across ten countries spanning Europe, America, and Asia [40]. Followed the efforts on defining risk perception [41,42], this study refers to risk perception as an individual's subjective judgment and assessment of the probability and severity of adverse results being caused by the risk of being exposed to COVID-19. Extant research on risk perception can be divided into two areas. The first string of studies center on the factors that affect risk perception. Researchers have identified various factors that affect individuals' level of risk perception. For example, prior disaster experience, family income and education levels, are significant for the formation of the perception of natural disaster risks [43]. While, another study found that government trust, confidence in governments' ability to respond to disasters, and attribution of responsibility sharing, played important roles in risk perception towards natural disasters [44]. In addition, studies have suggested that government trust has an impact on risk perception, positing that if citizens believe that key stakeholders can 'manage' or 'contain' the risks, they will feel safer and have a lower risk perception [45]. Recent studies have also shown that trust in governments can lead to a decline in risk perception [46,47].

Another string of studies have examined the consequences of risk perception behaviors. For example, it has been shown that by reducing citizens' risk awareness of stakeholders, such as risk managers or government agencies, it can increase their acceptance and cooperation with government policies [15]. A recent study into panic buying during health crises concluded that consumers with a high-risk perception of infection are more likely to participate in activities to protect themselves in order to reduce the risk of infection [48].

It is concluded that in studies examining risk perception and trust, trust is often seen as a factor that influences individuals' risk perception levels. This study, set against the backdrop of the COVID-19 epidemic, uses risk perception as a moderating variable to

examine its role in shaping government trust.

3. Research hypotheses and model

3.1. Hypotheses related to the quality of mGovernment apps and government trust

The DeLone and McLean ISSM emphasized the importance of IS success by synthesizing measures proposed by other consumer adoption of technology theories to propose their model. Its six interrelated dimensions include information quality, system quality, system usage, user satisfaction, personal influence, and organizational influence. This model seeks to provide a comprehensive understanding of information systems success by identifying and explaining the relationships between their most critical dimensions of success. It has been empirically tested and validated in later studies. In 2003, DeLone and McLean proposed the updated ISS model with the following additions, a) intention to use and b) service quality [49]. As a mature model for evaluating the success of information systems, the DeLone and McLean ISSM has been widely used in business administration [50], medical and health care [51,52], and other fields, to examine information systems and their influencing factors [53].

Compared with alternative consumer adoption of technology theories, such as the Technology Acceptance Model (TAM) [54] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [55], the updated DeLone and McLean ISSM allows for a more thorough evaluation of the success of mGovernment apps, considering various influencing dimensions. In this study, the quality of mGovernment apps is examined using three dimensions, namely: system quality, service quality, and information quality.

The system quality of mGovernment apps refers to users' perception of the functionality and characteristics of the applications, such as their speed of responsiveness, reliability, and security. Previous studies have shown that system quality is an important factor that affects government trust. For example, a study on the pre-factors affecting online group buying apps found that the quality of the system significantly affected users' level of trust [56]. In addition, empirical research has demonstrated that the higher the quality of mGovernment systems are, the higher the level of citizens' trust [57]. Therefore, this study posits that, during the COVID-19 pandemic, there was a correlation between the quality of mGovernment apps and citizens' trust in governments; that is, if the system's responsiveness, reliability, and security were high, citizens' level of trust in the government was also high. Conversely, if a user accesses an mGovernment app and it takes too long to access the required information or it cannot complete the user's request, this greatly reduces the user's experience and resultant trust in the government deploying the app. As a result, this study proposes the following hypothesis.

H1. The system quality of mGovernment apps has a positive impact on government trust.

The service quality of mGovernment apps refers to users' rational evaluation of their service attitude and level in the process of using mGovernment apps [58]. Previous studies have explored the relationship between service quality and government trust. For example, by improving mGovernment service quality, government employees are more responsible, resulting in an increase in citizens' trust towards governments [9]. It is further identified that the service quality of mGovernment affects the level of public trust in governments by enhancing public awareness and giving citizens greater personal control [59]. It can be assumed that, in the context of sudden public health crises, such as the COVID-19 epidemic, citizens are in a state of panic and helplessness and are, therefore, more sensitive to the quality of services provided by mGovernment apps. If the application provides a higher service attitude and level, then it can significantly increase citizens' trust in the government. Consequently, this study proposes the following hypothesis.

H2. The service quality of mGovernment apps has a positive impact on government trust.

The information quality of mGovernment apps refers to the public's perception of the timeliness, completeness, and accuracy of the information output by the mGovernment apps. A large amount of literature exists that proves that the quality of mGovernment information is a key factor in determining the resultant level of citizen trust. For example, the disclosure of government agency information allows citizens to better appreciate the motives behind government decision-making, thereby reducing their doubt and increasing their trust [60]. It also shows that the information services provided by mGovernment apps enable citizens to obtain relevant and timely information, facilitate public participation in government agencies, and thereby increase the trust of citizens [61]. In addition, the information quality of mGovernment apps affects the public's perception of transparency in government work. The higher the level of transparency perception, the higher trust citizens have in their governments [62]. Recent research highlights how transparency significantly enhances satisfaction among senior citizens with mGovernment services [63]. Similarly, current studies have found that government applications that provide citizens with information querying services make governments appear more transparent and, therefore, citizens are more aware of government actions, resulting in a higher level of trust [64,65]. It can be assumed that, in the context of COVID-19, mGovernment apps will disclose relevant information, truthfully, and accurately through their applications, which will play a pivotal role in establishing the government's image of integrity and enhancing citizens' trust in the government. As a result, this study proposes the following hypothesis.

H3. The information quality of mGovernment apps has a positive impact on government trust.

3.2. Hypotheses related to the mediating effect of public satisfaction

In previous mGovernment studies, researchers have regarded public satisfaction as a bridge that connects mGovernment services and affects citizens' trust in governments. Studies posit that the higher the service quality is of mGovernment apps, the increased citizen participation opportunities and increased satisfaction, thereby enhancing citizens' trust in governments [66]. In addition, a

customer satisfaction model was introduced to study citizens' satisfaction of US mGovernment websites and found that government trust is affected by public satisfaction [67]. Similarly, an empirical investigation of Canadian mGovernment platforms found that if public-centric mGovernment service quality can provide a user experience that meets public expectations, it can increase government trust [68]. Accordingly, during the COVID-19 epidemic, if mGovernment apps provided citizens with a high service and information quality, then the public can not only learn about the pandemic through the mGovernment app, but also take effective measures to avoid contact with confirmed cases or suspected cases to ensure personal safety. Moreover, since all online services in the government app are visible, all operations will leave traces in the system, which increases the transparency of the services provided [64]. These features can increase citizens' satisfaction, thereby increasing their resultant trust in governments [69]. Therefore, this study proposes the following hypotheses.

H4. Public satisfaction in mGovernment apps have a mediating effect on the relationship between system quality and trust in government.

H5. Public satisfaction of mGovernment apps has a mediating effect on the relationship between information quality and trust in government.

H6. Public satisfaction of mGovernment apps has a mediating effect on the relationship between service quality and trust in government.

3.3. Hypothesis related to the moderating effect of epidemic risk perception

Risk perception is an important topic in the contemporary risk society. It refers to citizens' perception and measurement of various external objective risks, with particular emphasis on individuals' intuitive judgment of the possibility of risk. Previous studies have shown that risk perception is achieved by adjusting individual cognitive mechanisms and actions. First, from the perspective of cognitive mechanism, in the face of sudden public health crises, citizens with high risk perception are more likely to attribute responsibility [44], taking the initiative to attribute the responsibility for risk mitigation to oneself, which will reduce part of the government's risk responsibility to a certain extent. Under the same government workload, citizens with high-risk perception will be better than those with low-risk perception and satisfaction with the government is higher. Second, from a behavioral perspective, risk perception is an important determinant of behavior change. Behavior models have confirmed that individuals' risk perception level can lead to certain behaviors [70]. For example, people with high perceived risk are more inclined to make preparations that are conducive to relieving the risk [71]. During the COVID-19 pandemic, citizens with high risk awareness are more likely to be determined to participate in activities to protect themselves in order to reduce risk of infection [72].

Active actions taken by the public can cooperate well with the work of government departments which are conducive to risk mitigation and exposure. When the public's perception of risk is low, there is a tendency to rely solely on government departments for risk prevention, leading to a lack of proactive risk mitigation measures by citizens and potential dissatisfaction with government departments. This highlights the critical role of risk perception in shaping public responses to health crises and the subsequent impact on citizen-government dynamics. The varying levels of risk perception can significantly influence the effectiveness of public health interventions and the overall success of risk mitigation strategies. Furthermore, the interplay between risk perception, citizen actions, and government responses underscores the complex relationship between public satisfaction and trust in government. Therefore, risk perception may play a moderating role in the relationship between public satisfaction and government trust. In this study, it is posited that compared to citizens with low-risk perception, citizens with high epidemic risk perception may be more likely to accept the mGovernment apps. During the epidemic, satisfaction derived from the value provided by mGovernment may in turn strengthen citizens' trust in the government. Therefore, this study proposes the following hypothesis.

H7. Epidemic risk perception has a moderating effect on public satisfaction and trust in governments.

3.4. Research model

The three variables of system quality, information quality, and service quality, proposed in the DeLone and McLean ISSM, were used to examine mGovernment apps, while public satisfaction was used as the intermediary between government trust and mGovernment apps' service. In the context of public health crises, such as COVID-19, epidemic risk perception was added as a moderating variable to jointly discuss the mechanism of mGovernment apps' services on trust in governments to ultimately understand the role of

Table 1
Summary of hypotheses.

	Research hypotheses
H1	The system quality of mGovernment apps has a positive impact on government trust.
H2	The service quality of mGovernment apps has a positive impact on government trust.
H3	The information quality of mGovernment apps has a positive impact on government trust.
H4	Public satisfaction in mGovernment apps have a mediating effect on the relationship between system quality and trust in government.
H5	Public satisfaction of mGovernment apps has a mediating effect on the relationship between information quality and trust in government.
H6	Public satisfaction of mGovernment apps has a mediating effect on the relationship between service quality and trust in government.
H7	Epidemic risk perception has a moderating effect on public satisfaction and trust in governments.

mGovernment from a broader perspective and help understand the formation mechanism of trust in governments. Through analysis of prior research, seven hypotheses were created which are summarized in Table 1.

To examine the relationship between the study's variables, a research model of the influence mechanism of mGovernment apps' services on citizens' trust in governments was constructed. Shown in Fig. 1, the model contains four variables i.e., independent variables, intermediate variables, moderating variables, and dependent variables.

4. Questionnaire design and data collection

4.1. Definition and measurement of variables

This study aims to examine the impact of using mGovernment apps' services from the perspective of citizens' trust in governments. Data is collected through questionnaire surveys. The item setting of the questionnaire variables is based on the background of the COVID-19 epidemic and the characteristics of the mGovernment apps and draws on the designs of questionnaires from previous literature. The questionnaire consists of two parts. The first collects demographic data about participants, including their gender, age, income, occupation, political profile, and whether they have previously used mGovernment apps. The second part studies the influencing factors of the model, involving six interrelated dimensions: system quality, information quality, service quality, epidemic risk perception, public satisfaction, and trust in government. Each survey item is measured using a 5-point Likert scale where "1 = completely disagree" and "5 = completely agree".

The variables of the questionnaire are defined based on the DeLone and McLean ISSM and the related literature on public satisfaction and government trust, as shown in Table 2.

4.2. Questionnaires survey implementation

Ethical approval was sought and approved by the College of Public Administration at Huazhong University of Science and Technology (Reference number: M201974886). In this study, wenjuanxin.com, one of the largest questionnaire-based survey platforms in China, was used to conduct the research. Simple random sampling was employed to ensure unbiased representation from various subgroups within the population. The questionnaire was distributed across various social media platforms from 2 to March 20, 2021, allowing anyone who saw the post to participate in the research. This approach ensures that social media users have an equal chance of participation. Citizens with basic knowledge of mGovernment apps and who have actively used mGovernment apps, at least once, were eligible for participation. This inclusion criteria was adopted to ensure that those chosen had relevant experience and knowledge related to mGovernment services. Individuals who failed to meet this criteria, especially those who had never used an mGovernment app prior to completion of the questionnaire, were excluded from the study. After screening, responses with duplicate IP address, completion time of less than 80 s, and those that selected "completely unclear" or "heard of, but never used" a mGovernment app, were removed from the sample. In total, 507 questionnaire responses were collected. Among them, 367 were valid accounting for 72.5 %. With an estimated population proportion of 0.5 for the attribute of interest and a margin of error of 6 %, a calculation was conducted to determine the minimum sample size based on previous research [76]. Additionally, a 95 % confidence level was applied, corresponding to a Z-score of 1.96, to ensure statistical reliability. The result shows a minimum of 267 participants were required. The actual number of participants meets this minimum requirement demonstrating adequate power for statistical analysis.
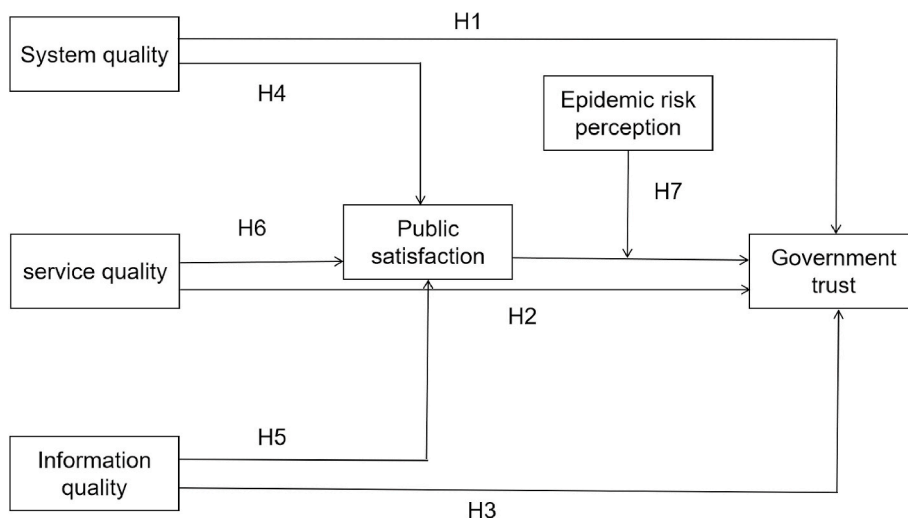

Fig. 1. Research model of the influence of mGovernment apps on citizens' trust in governments.

Table 2

Variable definitions and questionnaire item design.

Variable	Variable definition	Item content	Reference(s)
System quality	Citizens' perception of the responsiveness, reliability, and safety of the mGovernment app.	During the COVID-19 epidemic, the mobile government app services and its functionality could be used correctly. (SYQ1) During the COVID-19 epidemic, the mobile government app service I used could be accessed well, and it rarely crashed. (SYQ2) During the COVID-19 epidemic, the mobile government app service I used was very safe and protected my personal information well. (SYQ3)	[49]
Service quality	Citizens' perception of the attitude and level of service provided by the mGovernment app.	During the COVID-19 epidemic, the mobile government app I used to conduct online business was highly efficient and of high-quality. (SEQ1) During the COVID-19 epidemic, the online customer service of the mobile government app was excellent. (SEQ2) I will give an excellent appraisal of the mobile government app. (SEQ3)	[58]
Information quality	Citizens' perception of the timeliness, completeness, and accuracy of information output by the mGovernment app.	During the COVID-19 epidemic, I used the mobile government app to obtain timely and up-to-date information. (IQ1) During the COVID-19 epidemic, I used the mobile government app to obtain comprehensive, complete, and required information. (IQ2) During the COVID-19 epidemic, I used the mobile government app to obtain accurate and authoritative information. (IQ3)	[73]
Public satisfaction	The mGovernment app provides government services that are consistent with the expectations of users' feelings of affirmation, happiness, and satisfaction.	I am very satisfied with the online service level and efficiency of the mobile government app. (PS1) I am very satisfied with the entire use of the mobile government app. (PS2) Overall, I am very satisfied with the mobile government app. (PS3)	[36]
Epidemic risk perception	During the COVID-19 epidemic, citizens' intuitive feelings about their own infection of COVID-19, their cognitive judgment about their susceptibility to infection, and their perception of the severity of the virus.	I am worried about contracting COVID-19. (ERP1) I am sure that I will not be infected with COVID-19. (ERP2) I often search for and follow COVID-19 related information. (ERP3)	[74]
Government trust	Based on the services and information provided by the government, the public judge the ability and level of the government to assume responsibilities and achieve goals through their own belief system.	During the COVID-19 epidemic, the government and its staff were honest. (GT1) During the COVID-19 epidemic, the government was able to disclose accurate and reliable information to the public. (GT2) During the COVID-19 epidemic, the government and its staff were able to perform their duties, provide efficient administrative services, and solve any difficulties encountered by the public. (GT3) I trust the government most of the time. (GT4) I think that most of what the government has done is correct. (GT5)	[75]

Note(s): System Quality (SYQ), Government Trust (GT), Public Satisfaction (PS), Information Quality (IQ), Service Quality (SEQ), Epidemic Risk Perception (ERP).

4.3. Statistical analysis

The data collected was analyzed using SPSS Statistics 22.0 and AMOS 21.0. For descriptive analysis, SPSS 22.0 was used to identify the characteristics of participants, while AMOS 21.0 was used to perform Structural Equation Modeling (SEM). SEM was chosen due to its ability to analyze complex relationships between multiple variables simultaneously. This allows for the examination of both direct and indirect effects, making it suitable for examining the underlying mechanisms and pathways within a theoretical model. Using SEM, the study aimed to test and validate theoretical models by assessing the direct and indirect effects between variables. In addition, the mediation effects and moderated mediation effects were analyzed using AMOS 21.0 and Process Model 14, respectively. Process Model 14 is a powerful tool used for analyzing complex relationships and mechanisms in social science research, particularly in understanding how and when mediation processes are influenced by moderators. With Process Model 14, researchers can determine the processes and pathways involved in the study's hypotheses.

Overall, the statistical methods were selected to facilitate a comprehensive and nuanced examination of the relationships, mechanisms, and effects within the study's theoretical framework, contributing to a robust and insightful analysis.

5. Data analysis and results

5.1. Demographic characteristics of the respondents

Among the 367 participants, the proportion of male and female respondents was balanced, with females accounting for 52.86 % and males accounting for 47.13 %. With regards the age of participants, there were younger people that had previously used mGovernment apps with fewer elderly respondents. In terms of education level, nearly 80 % of respondents had a college degree or above, showing that young people with a higher education level engage more frequently with mGovernment apps. As for professions, participants had varied occupations, including working for government agencies, public institutions, private organizations, self-employed and others. As for the income of participants, people with an income of "below 2000 yuan" and "2000–5000 yuan" accounted for the majority. With regards political status, party members were the most, followed by the Communist Youth League members. See Table 3 for details.

AMOS 21.0 software was used for Confirmatory Factor Analysis (CFA) to test the adequacy of the research model in terms of its reliability, convergence validity, and discriminative validity. As shown in Table 4, the Cronbach's α and Combined Reliability (CR) values of each variable were all above 0.70, indicating that the reliability of the questionnaire is relatively high. The Squared Variance Extraction (AVE) of variables, such as system quality, information quality, and service quality were all greater than 0.5, indicating good convergence validity. Table 5 shows that the square roots of the AVE of the five variables were all greater than the correlation coefficients among the latent variables listed, indicating that the questionnaire had good discrimination validity. These results indicate that the questionnaire passed the reliability and validity test. Based on the collected data, the structural model was analyzed to verify the relationship between the variables and to verify the various items proposed and whether the hypotheses were valid.

5.2. Testing of the structural model

AMOS 21.0 software was used to create a SEM and to conduct model verification on the collected data. Table 6 shows the results and recommended values of the final structural model [77]. The results show that the SEM fits well and, therefore, hypotheses testing could be carried out. The hypotheses test results show that the quality of the mGovernment app, and the information quality and service quality output, are positively correlated with government trust ($\beta = 0.336$, $P < 0.001$; $\beta = 0.124$, $P = 0.005$; $\beta = 0.294$, $P < 0.001$), supporting hypotheses H1, H2 and H3. In summary, the path coefficients of these three paths all pass the significance test.

5.3. Testing for the model path

The maximum likelihood method of AMOS 21.0 was employed to estimate the path coefficients of the model to verify the relationship between the study's variables. Table 7 shows the path test results between the variables in the research model. All seven path coefficients were greater than 0 and the p-value was not greater than 0.005, indicating a significant positive correlation. This result indicates that the system quality, information quality, and service quality have a significant positive impact on public satisfaction. At the same time, system quality, information quality, service quality, and public satisfaction have a significant positive impact on

Table 3
Demographic information of questionnaire participants.

Demographic	Characters	Frequency●	Percentage (%)●
Gender	Male	173	47.13
	Female	194	52.86
Age	19 years old and below	17	4.63
	20–29 years old	276	75.20
	30–39 years old	39	10.63
	40–49 years old	23	6.27
	50 years old and above	12	3.27
Educational level	High school and below	15	4.09
	Junior college	57	15.53
	Undergraduate degree	165	44.69
	Master degree or above	130	35.42
Profession	Student	164	44.69
	Staff in government agencies or public institutions	65	17.98
	Staff in private companies	95	25.61
	Self-employed	35	9.54
	Other	8	2.17
Income	Below 2000 yuan	141	38.15
	2000-5000 yuan	98	26.70
	5000-8000 yuan	67	18.53
	8000 yuan or more	61	16.62
Political status	Member or Candidates of the Communist Party of China	150	40.87
	Communist Youth League Member	126	34.33
	The Masses	91	24.79

Table 4

Results of reliability and convergent validity.

Variable	Item	Standardized Estimate	AVE	CR	Cronbach's α
System quality	System quality3	0.866	0.697	0.873	0.802
	System quality2	0.849			
	System quality1	0.788			
Information quality	Information quality3	0.880	0.794	0.921	0.895
	Information quality2	0.875			
	Information quality1	0.918			
Service quality	Service quality3	0.758	0.597	0.816	0.914
	Service quality2	0.828			
	Service quality1	0.728			
Public satisfaction	Public satisfaction3	0.851	0.762	0.906	0.924
	Public satisfaction2	0.909			
	Public satisfaction1	0.857			
Government trust	Government trust5	0.833	0.660	0.906	0.967
	Government trust4	0.815			
	Government trust3	0.786			
	Government trust2	0.845			
	Government trust1	0.777			

Table 5

Discriminative validity.

	System quality	Information quality	Service quality	Public satisfaction	Government trust
System quality	0.835				
Information quality	0.048	0.891			
Service quality	0.044	0.044	0.772		
Public satisfaction	0.058	0.047	0.067	0.873	
Government trust	0.054	0.047	0.065	0.067	0.812

Table 6

Test results of model fit index.

	X^2	Df	P	X^2/DF	SRMR	GFI	IFI	TLI	CFI	RMSEA
Numerical value	296.770	109	<0.001	2.723	<0.05	0.913	0.960	0.950	0.960	0.069
Judgment criteria	N/A	N/A	<0.05	excellent	0.0365	>0.9	>0.9	>0.9	>0.9	<0.08

Note: SRMR: Standardized Root Mean Square Residual, CFI: Comparative Fit Index, GFI: Goodness of Fit, IFI: Incremental Fix Index, TLI: Tucker-Lewis Index, RMSEA: Root Mean Square Error of Approximation.

Table 7

Test results of model path.

Path	Unstandardized Coefficients	Standardized Coefficient	S.E	C.R	P
SYQ→PS	0.409	0.383	0.071	5.750	***
IQ→PS	0.162	0.167	0.050	3.246	0.001
SEQ→PS	0.452	0.410	0.069	6.564	***
SYQ→GT	0.368	0.336	0.068	5.406	***
IQ→GT	0.124	0.124	0.045	2.779	0.005
SYQ→GT	0.332	0.294	0.068	4.854	***
PS→GT	0.282	0.276	0.070	4.020	***

Note: *** stands for P < 0.001.

government trust. This means that hypotheses H1 to H7 are all supported. In addition, this demonstrates that the seven path coefficients of the model passed the significance test.

5.4. Testing for the mediation model

The Bootstrap method of AMOS 21.0 was used to test the mediation effect. Based on the collected data (N = 367), 5000 Bootstrap samples were drawn by repeated random sampling, thereby obtaining a 95 % confidence interval of the mediation effect. The results are as follows.

As for the mediating role of public satisfaction on system quality and government trust, the result demonstrates a significant mediating role. Specifically, Table 8 shows that the 95 % confidence interval (0.137, 0.613) of the direct impact of system quality on

Table 8

Test results of the mediation effect of public satisfaction.

	Multiplying coefficients		Bootstrapping			
	S.E	Coefficient	Bias-corrected 95 % CI		Percentile 95 % CI	
			LLCI	ULCI	LLCI	ULCI
SYQ→GT(c')	0.114	0.342	0.137	0.584	0.132	0.578
SYQ→PS (a)	0.118	0.389	0.137	0.613	0.153	0.624
PS→GT(b)	0.111	0.271	0.056	0.510	0.052	0.501
Mediating effect of PS(a*b)	0.056	0.106	0.019	0.245	0.014	0.230
Total effect (c)	0.098	0.448	0.239	0.623	0.257	0.636

Note: Standard Error (S.E), Lower Limit Confidence Interval (LLCI), Upper Limit Confidence Interval (ULCI).

public satisfaction does not contain 0, which indicates their relationship is significant. Meanwhile, the direct effect c' is also significant, and the mediating effect (a*b) has the same direction as the direct effect c'. Public satisfaction partially mediates the impact of system quality on government trust with the mediating effect accounting for 13.37 %.

With regards the mediating role of public satisfaction on information quality and government trust, the study's results demonstrates a significant mediating role. Specifically, Table 9 shows that the 95 % confidence interval (0.005, 0.331) of the direct impact of information quality on public satisfaction does not contain 0, which indicates their relationship is significant. Meanwhile, the direct effect c' is also significant, and the mediating effect (a*b) has the same direction as the direct effect c'. Public satisfaction partially mediates the impact of information quality on government trust with the mediating effect accounting for 14.74 %.

As for the mediating role of public satisfaction on service quality and government trust, the result demonstrates a significant mediating role. Specifically, Table 10 shows that the 95 % confidence interval (0.147, 0.625) of the direct impact of service quality on public satisfaction does not contain 0, which indicates their relationship is significant. Meanwhile, the direct effect c' is also significant, and the mediating effect (a*b) has the same direction as the direct effect c'. Public satisfaction partially mediates the impact of service quality on government trust with the mediating effect accounting for 13.52 %.

In summary, public satisfaction has a significant intermediary effect between system quality, information quality, service quality, and government trust. Therefore, hypotheses H4, H5 and H6 were supported.

5.5. Testing for the moderated mediation model

In this study, Bootstrap was used to test (sample size of 5000, 95 % confidence interval, PROCES model 14) the mediation model with moderation and moderating effect of epidemic risk perception. The system quality, information quality, and service quality were averaged to obtain the quality of the mGovernment app as the independent variable. As shown in Table 11, the eff1-3 adjustment variable gets bigger and bigger. The upper and lower limits of eff1-2 95 % confidence interval do not contain 0, which means that it is significant (lower limit = 0.117, upper limit = 0.414; lower limit = 0.060, upper limit = 0.348), and eff3 95 % confidence interval contains 0, which means it is not significant (lower limit = −0.013, upper limit = 0.299). From significant to insignificant, the mediation effect declines, indicating that there is moderated mediation, that is, with the increase in risk perception of the epidemic, citizens are more likely to take the initiative to mitigate risks and take positive actions, thereby increasing satisfaction in government agencies, which has an increasing impact on government trust.

Table 12 shows that after adding the epidemic risk perception into the model, the interaction term between the epidemic risk perception and public satisfaction has a significant positive effect on government trust ($\beta = -0.080$, $p = 0.005$), which indicates that the moderating effect is significant. Therefore, it is assumed that H7 is supported.

According to Fig. 2, participants with low emotional risk perception (M-1SD) have a significant positive predictive effect on trust in government in public satisfaction ($\beta = 0.283$, $p < 0.001$); however, they have a relatively high level of epidemic risk perception. For participants with high emotional risk perception (M+1SD), although public satisfaction has a positive predictive effect on trust in government, its predictive effect is small ($\beta = 0.154$, $p < 0.005$), indicating that as the level of epidemic risk perception increases, the predictive effect of public satisfaction on government trust is gradually reduced.

Table 9

Test results of the mediation effect of public satisfaction.

	Multiplying coefficients		Bootstrapping			
	S.E	Coefficient	Bias-corrected 95 % CI		Percentile 95 % CI	
			LLCI	ULCI	LLCI	ULCI
IQ→GT(c')	0.060	0.124	0.003	0.241	0.006	0.243
IQ→PS (a)	0.081	0.168	0.005	0.331	0.007	0.333
PS→GT(b)	0.111	0.271	0.056	0.510	0.052	0.501
Mediating effect of PS(a*b)	0.030	0.045	0.003	0.129	0.001	0.118
Total effect (c)	0.061	0.17	0.052	0.288	0.052	0.291

Table 10

Test results of the mediation effect of public satisfaction.

	Multiplying coefficients		Bootstrapping			
	S.E	Coefficient	Bias-corrected 95 % CI		Percentile 95 % CI	
			LLCI	ULCI	LLCI	ULCI
SEQ→GR(c')	0.086	0.290	0.132	0.468	0.124	0.456
SEQ→PS (a)	0.123	0.404	0.147	0.625	0.148	0.631
PS→GR(b)	0.111	0.271	0.056	0.510	0.052	0.501
Mediating effect of PS(a*b)	0.057	0.110	0.021	0.260	0.013	0.237
Total effect (c)	0.101	0.399	0.218	0.601	0.204	0.590

Table 11

Test results of the moderated mediation effects.

Effect result	index	Effect size	Boot SE	Boot CI	
				Lower limit	Upper limit
Regulated intermediary	eff1	0.260	0.074	0.117	0.414
	eff2	0.200	0.074	0.060	0.348
	eff3	0.139	0.080	−0.013	0.299
Moderated Intermediary Comparison	eff1-eff2	−0.061	0.023	−0.105	−0.017
	eff1-eff3	−0.121	0.045	−0.211	−0.033
	eff3-eff2	−0.061	0.023	−0.105	−0.017

Note: eff1 = M-1SD (mean-1standard deviation), eff2 = M (mean), eff3 = M+1SD (mean+1standard deviation).

Table 12

Tests on the moderating effects of epidemic risk perception.

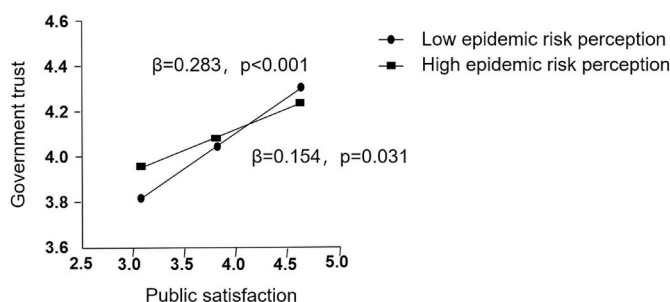| Effect result	Government trust					
	coefficients	SE	t	p	Boot CI	
					Lower limit	Upper limit
constant	0.206	0.383	0.537	0.592	−0.547	0.958
quality	0.498	0.067	7.489	<0.001	0.367	0.629
Public	0.493	0.109	4.517	<0.001	0.279	0.708
perception	0.331	0.109	3.043	0.003	0.117	0.544
Public*perception	−0.080	0.028	−2.848	0.005	−0.136	−0.025
R^2	0.592					
F	131.027					

Fig. 2. The moderating effect of epidemic risk perception in public satisfaction and government trust.

6. Discussion

6.1. System quality, information quality and service quality positively affect government trust

In previous research on the impact of mGovernment app on government trust, most studies have evaluated the service quality of mGovernment as a single dimension, such as information disclosure or government-citizen interaction. However, mGovernment apps have various service contents, and the impact of each service on government trust may vary. These results confirm that system quality, information quality, and service quality can affect government trust. This can be explained by the findings from previous research that

government trust reflects citizens' perception of government performance [78,79]. In general, citizens perceive government performance from their direct or indirect encounter with government provided services. During the COVID-19 epidemic, citizens' experiences with government-related services was critical for them to form understanding about government performance, i.e., how the government was fighting the spread of the virus and deploying proper strategies to control its spread. In this context, mGovernment apps acted as windows for citizens to obtain the latest information from their governments. If the mGovernment app demonstrated a high quality in terms of system quality, information quality and service quality, citizens perceived a high level of government performance and, thus, increased their trust in the government. Trust in governments is likely to boost citizens' confidence in fighting the pandemic, leading to greater compliance with government policies. In this vein, if governments actively engaged in crises response and well informed citizens through mGovernment apps, the increased government trust will definitely help the overall pandemic prevention and control [80].

First, the quality of mGovernment apps is an important factor that affects the experience of all citizens. If citizens have bad experiences with government applications, such as poor system compatibility, serious flashbacks after installation, and excessive access speed and response time, their satisfaction towards the app will not be high. In addition, they will relate their negative experiences with government performance and develop a low perception towards overall government performance, which will reduce their trust in governments. Taking Qingdao in China as an example, masks became an indispensable item in citizens' daily lives during the epidemic. Considering the high demand for masks, the Qingdao municipal government developed a new function in their mGovernment app for citizens to reserve masks. Citizens were able to make reservations on the mobile application to buy masks with their reserved information offline. However, the citizens of Qingdao were not happy about this. Many citizens responded that the system was broken and had delays in receiving the verification code. This demonstrated the instability of the system and slow response time, which impacted citizens' experiences, resulting in reduced citizen trust towards the government.

Second, since mGovernment apps in public crises act as authoritative platforms that release information about the development of the epidemic and the government's epidemic prevention measures in a timely manner, the government's epidemic prevention measures will be more transparent, and citizens will have a better understanding of the government's actions. Government transparency can effectively strengthen the trust of citizens. During the epidemic prevention period, the Chaoshan Municipal People's Government actively increased its epidemic prevention and control propaganda, launching the *Guangdong Provincial Affairs* small program for epidemic prevention and control service area, providing epidemic prevention and control videos, practical manuals, travel guides, etc., and efficiently assisting the Chaozhou epidemic in terms of information publicity. Similarly, Shanghai's *One Internet Access* platform launched the *One Internet Access* section for COVID-19 pandemic Prevention and Control in late January 2020. The establishment of the section increased citizens' understanding of the epidemic and increased their level of government trust. Meanwhile, mGovernment users who perceived a good service, will form a positive understanding of government performance and increase government trust. In response to the new needs of citizens arising from the COVID-19 pandemic, the Anhui Provincial Data Resources Bureau took advantage of its *Wanshitong mGovernment* app, which has a wide coverage, large number of active users, and authority, and acts immediately by organizing special teams to help citizens solve practical problems during the pandemic. This fast and convenient service helped build citizen trust for the government.

6.2. Public satisfaction serves as a mediating role on the effect of mGovernment app quality on government trust

Most previous studies have explored the impact of e-government on government trust from a macro perspective, with little analysis of the mechanism of mGovernment apps on government trust. In contrast, this study examined the mediating application of public satisfaction in the relationship between mGovernment apps' quality and government trust. The study's results show that public satisfaction has a strong correlation with government trust, and the mediating effect of public satisfaction is significant. During the COVID-19 pandemic, if citizens were satisfied with the information and interactive services provided by mGovernment apps, their trust in governments was also likely to be high. This finding is consistent with previous studies that demonstrate that government trust can be regarded as the most important result of citizen satisfaction [81], similar to the improvement of customer satisfaction which can increase income, positive word-of-mouth, and customer loyalty [82]. Those who are more satisfied with the government's ability to engage citizens in decision-making, effectively use resources and keep citizens informed, will have greater trust and confidence in their government [83]. As citizens' satisfaction with government performance increases, the probability of trusting them significantly increases, while the probability of trusting less and maintaining low trust decreases. In this sense, public satisfaction with governments' performance during the COVID-19 pandemic strengthened the public's support and trust in governments [32].

During the COVID-19 pandemic, Shaoxing City optimized its Zhejiang government service platform, *Zheli Office* (Shaoxing Station), and updated its special service area, launching epidemic prevention and control, social security, business environment and other applications, and launched 70 personal themed items, 28 corporate themed items, and implemented a *good and bad evaluation* mechanism for the quality of online government services. These services enabled citizens to evaluate their satisfaction of the service received. It showed that, in 2019, more than one million people used the Zheli Office app and its service quality satisfaction rate reached 98 %. This high satisfaction indicates that citizens' expectations were consistent with the actual perceived government performance. The trust and confidence of the government will also increase.

6.3. Epidemic risk perception serves a moderating role in the effect of public satisfaction on government trust

The study's results show that epidemic risk perception has a positive moderating effect on public satisfaction and government trust. Compared to citizens with low epidemic risk perception, public with high epidemic risk perception may likely feel the value of

mGovernment apps. The satisfaction generated will increase satisfaction with government departments, thereby enhancing overall trust in governments.

During the COVID-19 pandemic, citizens with a higher epidemic risk perception tended to have a clearer understanding of the distinction between government departments and their own self-identification, and took the initiative to assume the responsibility of mitigating the risk of COVID-19 [44]. At the same time, compared to citizens with low risk perception, individuals with high perception risk are more inclined to make preparations that help alleviate the risk of COVID-19 infection [71], such as learning about epidemic prevention and control measures, provided through videos displayed on mGovernment apps. Similarly, citizens with a higher awareness of the risk of the epidemic will also be more proactive in cooperating with the epidemic prevention measures of government departments, and show epidemic prevention behaviors, such as home isolation, frequent wearing of masks, frequent hand washing, and itinerary reporting. This sharp division of responsibilities and more proactive cooperation in epidemic prevention can not only relieve the epidemic prevention pressure of government departments, but also make the government epidemic prevention policies be implemented more smoothly, improving government performance and, thus, increasing citizens' satisfaction [32]. This increased satisfaction will ultimately lead to an increase in government trust.

7. Conclusions

7.1. Summary of findings

This study found that, during the COVID-19 epidemic, the system quality, information quality, and service quality of mGovernment apps affected citizens' trust in governments. Public satisfaction plays a good intermediary role in this, and the epidemic risk perception affects citizens' trust in governments. Public satisfaction and government trust have an obvious positive moderating effect. Therefore, based on these findings, during COVID-19 and other public crises, government departments should vigorously improve the three types of systems, information and services of mGovernment apps and pay greater attention to public satisfaction feedback. Meanwhile, they should strive to improve citizens' awareness of epidemic risks and ultimately improve the level of trust in the government. This study provides empirical research to support governments to tackling the above measures.

7.2. Theoretical contributions

This study highlights the influence of mGovernment app services on government trust during public health crisis. Focusing on the impact of mGovernment apps on government trust, the DeLone and McLean ISSM was used to assess the service quality of mGovernment apps, taking the effects of public satisfaction and epidemic risk perception into consideration. Specifically, a theoretical model was proposed that included system quality, information quality, service quality, public satisfaction, and epidemic risk perception to determine the formation of government trust in crises. The proposed model provided an integrated theoretical perspective to understand the mechanism of how mGovernment apps' services affect government trust.

7.3. Practical implications

MGovernment apps can overcome temporal and spatial limits, significantly aiding the government's epidemic prevention and control during public crises. The empirical research reported in this paper demonstrates that systems, information, and services are the three key aspects of mGovernment. In addition, efforts are required to raise public awareness of epidemic risks and, thus, increase public trust in the government. These initiatives are critical in building a responsive and effective governance that can adeptly addresses public needs and concerns, particularly during times of crises, such as the COVID-19 pandemic. This study, therefore, not only contributes to the future development of mGovernment apps, but also fosters a deeper public comprehension of the pivotal role of mGovernment apps, thereby enhancing government trust.

7.4. Limitations and future research directions

This study is not without limitations. First, the cross-sectional nature of the collected data, coupled with uneven distribution across various demographic factors such as age, education level, and professional background, may result in potential biases. Future studies should, therefore, address this by conducting a large-scale population survey with more balanced and representative data to validate the findings. Second, the relationship between mGovernment use and government trust may be mutually influential and future research should, therefore, examine their interactive dynamics, potentially employing longitudinal studies to capture the evolving nature of this relationship over time. In addition, regarding the measurement scale used in this study, future research should consider expanding it to a 7-point Likert scale to better capture the nuances and variations of the variables.

Ethics statement

This study has been approved by College of Public Administration, Huazhong University of Science and Technology (Reference number: M201974886).

Data availability statement

Data will be made available on reasonable request.

CRediT authorship contribution statement

Junze Wang: Writing – original draft, Supervision, Methodology, Data curation, Conceptualization. **Wei Zhang:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Pengyao Jiang:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Shen Zhao:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Richard Evans:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32476.

JW, WZ and RE conceived and designed the study, JW, SZ and PJ performed the survey and data collection, JW, WZ and PJ analyzed and interpreted the data, JW and SZ wrote the draft, WZ and RE contribute to the discussion and revision.

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