Investigating Users Attitudes and Perceptions Towards the Usage of Smart City Apps

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Abstract. The important role of citizens towards smart city success has been increasingly recognized by police makers, practitioners and academics. In light of this, smart apps are probably the most appealing smart city element to citizens, who are using these on a daily basis. Nevertheless, little was known about citizens attitudes and perceptions regarding the usage of smart city apps. In this paper, we reported the results derived from a questionnaire survey with 577 citizens in Guangzhou, China. The study investigated their use experience of smart city apps, in order to identify potential shortcomings of these apps and provide reference for their future optimization. The results show that Chinese citizens have high intention to use smart city apps, but they also have concerns about app service responsiveness, information accuracy, system reliability, perceived cost, and perceived risk.

Keywords: Smart city · Smart city app · User perspective

1 Introduction

With the advancement of urbanization and increasing urban population, the daily lives of urban residents and the public management of local infrastructure and services are becoming more and more complicate [1]. In response to the emerging "urban problems", the concept of "smart city" was proposed by IBM in 2008. A smart city utilizes the information to effectively integrate infrastructure, increases the participation of citizens in urban governance, and thus improves the efficiency of urban operations and residents' quality of life [1, 2]. The construction of smart cities has achieved initial results. With the help of smart technology, residents can carry out urban activities such as consultation appointments, parking inquiries, and real-time traffic inquiries without leaving home. China has proposed the development prospects of "smart society" construction [3].

The progress from a smart city to a smart society will completely change people's mode of production and lifestyle [4], which will inevitably require the full use of various urban data and ensuring the full coverage of city residents by smart services. This goal cannot be realized without the support of various smart city apps. Only through smart city apps can residents be connected with various smart infrastructures [5, 6] to enjoy the convenience of life brought by the smart environment. Governments of countries in the world have invested a lot of money in building smart city infrastructures. At

present, there are many apps supporting smart services, but the actual utilization is not optimistic. In China, researchers have found that residents' awareness and utilization of mobile medical apps are at a low level [7]. Government apps also have the problems such as uneven quality, poor functions, blind development, few users, and low user stickiness [8, 9]. There are also similar problems in foreign countries. The London government has invested a lot of money in building a smart parking system, but the supporting app is rarely used by residents [10]. The widespread application of smart technologies in cities will indeed facilitate residents' participation in urban governance, but inadequate use of these technologies by residents will be a waste of resources [11–13]. At present, smart city has a good momentum of technical development, but there is still a lack of humanities. Smart city is implemented by people, not technology [14], and technology is valuable only when it is embedded in the social environment [15]. Research on the use of smart services by residents is also an important subject in smart city construction.

At present, there have been related studies focusing on user behaviors under smart services. Researchers have used empirical research to build user adoption models of specific smart services in the context of smart cities, and explore factors that affect users' adoption of and intention to use services. These studies have provided a good theoretical basis for understanding users' adoption behavior in the smart city context. These models mainly clarify the relationships and influence paths of various factors. Although they can also provide a reference for the development and improvement of smart services, smart services can be improved and optimized in a more targeted manner by learning about the current user experience of smart services to find the gap between user needs and actual services. As such, this study differentiates itself from most previous studies by learning about the residents' use experience of and comments on smart city apps from multiple dimensions through questionnaires, and finding out the problems in the apps to provide references for its optimization. The next section outlines the literature on smart services and users, followed by discussion on research methodology. Then, the results of the study are discussed. The last section is the summary and outlook.

2   Related Work Between Smart City Services & Users

Smart city is a rich concept that involves all aspects of the city, so the services provided in a smart city are diverse [16]. The existing smart services and applications cover smart transportation, smart healthcare, and smart education, smart energy, smart public security, smart building management, smart waste disposal, etc. [10]. Most researchers believe that the construction of smart cities requires advanced information and communication technologies in order to provide more effective public information and services and thus a smarter city life for residents [10]. Accordingly, city managers overemphasize the fundamental role of smart technology in the construction of smart cities, and put more effort into building infrastructure to provide smart services regardless of time and location [17].

Although smart services have brought many innovative means to urban governance, substantial improvement of quality of life cannot be brought by sensors only [11–13]. The implementation of technology works only when it is accepted by end users. In this regard, ICT (Information and Communication Technology) companies focus on not

only sensor-based systems, but also the value of these systems for the communities they serve, as well as communication with residents [18]. Similarly, researchers have begun to pay attention to users' acceptance of information and communication technologies in the context of smart cities. Yeh [19] found that if a smart service is innovative and have high quality without unauthorized disclosure of privacy, residents will be willing to accept and use such a service. Research by Tony et al. [20] showed that residents' perceived usefulness and perceived ease of use of City113 app will affect their attitude towards it, and thus affect their intention to use the app. Daniel et al. [21] studied smart cards and found that the ease of use has a high positive effect on perceived privacy, perceived usefulness, and perceived security, and convenience plays a decisive role in continuance of users. In addition, research shows that users of smart city services value safety, security as well as information quality and service quality [22]. These studies mainly clarify the relationships and influence paths of various factors, providing a good theoretical basis for understanding user adoption behavior in the context of smart cities.

Smart phones are considered an ideal carrier for developing smart applications and services [23]. Smart apps will be an important medium for experiencing smart services. However, previous research shows that smart apps fails to achieve the desired result even if its development has cost a lot of money and energy of the government [7–10]. The low utilization has made smart apps useless. How to improve the acceptance of smart apps by residents is an important issue for the promotion of smart services. As mentioned above, most of the current related studies are based on user behavior theory, focus on the identification of the factors that influence the users' intention to use and clarify the mechanism of their interaction. However, smart services can be improved and optimized in a more targeted manner to increase the utilization rate by learning about the current user experience of smart services to find the gap between user needs and actual services. Different from previous research, this research surveys the residents through questionnaires to learn about their use experience of and comments on smart city apps from multiple dimensions and find out the problems in the apps.

3 Methodology

3.1 Questionnaire Design

As mobile applications, smart city apps are also information systems. Most of the user-perspective studies on information systems use Technology Acceptance Model (TAM) [24], Unified Theory of Acceptance and Use of Technology model (UTAUT) [25], and the Delone and McLean Model of Information Systems Success (D&M model) [26] or other theoretical models coupled with external variables to study multiple factors affecting user adoption of information system. The data collected by this research aims to reflect the experience and comments of residents in using smart city apps. A large number of studies [27–29] have proven that factors such as perceived ease of use, perceived cost, perceived risk, system quality, information quality, and service quality can affect users' intention to use information systems and their satisfaction. Relevant research on user adoption behavior has also proved that the above factors play an important role in user adoption behavior. Therefore, learning about users' comments on these dimensions is of great significance for the targeted optimization and improvement of the systems. In addition,

most of the above studies quantify these factors by examining the user experience during the use of the system, which shows that the above factors can be used to measure the user experience of the information systems.

In summary, by reference to the previous research and based on the characteristics of smart city apps, some factors were selected and refined to obtain user perception indicators of smart city apps in this research (Table 1).

Table 1. User perception indicators of smart city app

Indicator	Definition	Subdivision indicator	Source
Perceived ease of use (PEU)	The ease of use of smart city apps perceived by residents	1 Ease of use	Davis [24]
		2 Flexibility	
Perceived cost (PC)	Time, energy and economic cost perceived by residents for using smart city apps	1 Perceived financial cost	Luarn & Lin [27], Hu & Kettinge [28]
		2 Perceived effort	
Perceived risk (PR)	Risk perceived by residents in the use of smart city apps	1 Privacy risk	Featherman & Pavlou [29], Jacoby & Kaplan [30]
		2 Performance risk	
System quality (SYSQ)	Residents' evaluation of the system reliability of smart city apps	System reliability	Petter et al. [31], Zhou [32]
Information quality (IQ)	The accuracy and timeliness of information transmitted by smart city apps perceived by residents	1 Information accuracy	
		2 Information timeliness	
Service quality (SERQ)	The service quality of smart city apps perceived by residents	1 Service responsiveness	
		2 Service effectiveness	
Behavioral intentions to use (BI)	Residents intention to use smart city apps	Attitude toward using	Moon & Kim [33]

Questions in the questionnaire described the experience of using the apps from various dimensions in the form of statement (Table 2). Each indicator is measured using a Likert 5-level scale, and respondents answered the questions based on their real feelings in using smart city apps.

3.2   Selection of Sample

In this study, Guangzhou is selected as the representative of China's "smart cities" for a case study. In 2012, Panyu District and Luogang District of Guangzhou became the

Table 2. Design of questionnaire on user perception of smart city apps of Guangzhou

Indicator		No.	Content	Options
Basic question		Q1–Q5	Area of residence, gender, age, education level, income	N/A
Core problem	PEU1	Q6	The mobile smart city apps are easy to operate	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree
	PEU2	Q7	Smart city apps are easy to use most of the time and place	
	PC1	Q8	I think the economic cost of using smart city apps is high	
	PC2	Q9	I think the use of smart city apps costs a lot of time and energy	
	PR1	Q10	I worry about privacy leakage when using smart city apps	
	PR2	Q11	I think there is great risk in using smart city apps	
	SYSQ	Q12	Smart city apps generally have no problems such as crash, white screen or inability to open	
	IQ1	Q13	Smart city apps always send me accurate information	
	IQ2	Q14	I think smart city apps send timely information	
	SERQ1	Q15	The offline service of smart city apps can be well connected with the corresponding online service	
	SERQ2	Q16	The services provided by smart city apps make my life more convenient	
	BI	Q17	I have a positive and supportive attitude towards the use of smart city apps	

first pilot areas of China's smart cities. After several years of development, Guangzhou has a more mature strategic deployment in the construction of smart cities, developing a relatively complete social activity system. There are increasingly sound technical support systems to provide strong support for the construction of smart cities [34], and smart city services such as smart transportation, smart ports, and e-government have made great progress [35]. Guangzhou has won multiple awards at Smart China Annual Conference,

won the fourth place in the "Top 20 Cities in Smart City Construction" in 2017 [36], and won the Smart City Leadership Award in 2018 [37]. It can be seen that Guangzhou has made good achievements in smart city construction. To some extent, Guangzhou represents the current level of smart city construction in China. It is appropriate to select this city as a survey sample.

3.3   Questionnaire Distribution

The targeted sampling frame is the users of smart city apps in Guangzhou, China. The sample data is collected by means of online questionnaire filling and paper questionnaire distribution. In order to ensure that the collected sample data is comprehensive and can fully reflect the use of smart city apps by residents in Guangzhou, on the one hand, researchers spread the questionnaires by forwarding online; on the other hand, considering that the scope of online spread will be restricted by the breadth of the social circle, the research team distributed questionnaires offline in 11 districts of Guangzhou. Finally, the data collected online and offline were integrated and cleaned, and quantitative analysis was performed.

4   Data Analysis and Results

4.1   Sample Demographics

A total of 577 valid questionnaires were collected in this study. The sample data covered 11 districts of Guangzhou. According to the data released by the Guangzhou Statistics Bureau, the urbanization rate of Guangzhou by the end of 2018 was 86.38% [38]. It can be seen that the collected sample data is basically consistent with the distribution of urban and rural population in Guangzhou. The proportions of different genders are roughly equal. In terms of age structure, respondents aged 19 to 44 accounted for the largest proportion, and this age group is also the most frequent users of mobile applications. In terms of education level, undergraduates and above account for nearly 80% of the respondents, indicating that the users of smart city apps of Guangzhou are mainly people with higher education level. In terms of income, the respondents mainly have a monthly income of less than 5,000 yuan and 5,000 to 20,000 yuan; and those with a monthly income of more than 20,000 yuan are only a small proportion (Table 3).

4.2   Overall Situation of Users' Perception on Smart City Apps

According to the collected valid questionnaires, the arithmetic mean value[1] of the results of each question were calculated to obtain the residents' evaluation scores on smart city apps as a whole and each indicator (Table 4). The higher the score given by users, the higher the evaluation of smart city apps, and the better the user experience will be.

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[1] During data analysis, for the questions with positive meanings (Q6–Q7, Q12–Q17), the options "strongly disagree", "disagree", "neutral", "agree" and "strongly agree" are assigned scores of 1, 2, 3, 4 and 5 respectively; for questions with negative meanings (Q8–Q11), the scores are assigned reversely, that is, 5 for "strongly disagree" and 1 for "strongly agree" and so on.

Table 3. Sample demographics

Measure	Item	Percentage
Region	Urban	73.3%
	Rural	26.7%
Gender	Male	46.4%
	Female	53.6%
Age	≤18	10.9%
	19–44	78.3%
	≥45	10.7%
Education level	Senior high school or lower	21.7%
	Undergraduate	59.1%
	Graduate and above	19.2%
Monthly income	≤5000 yuan	48.0%
	5,000–20,000 yuan	47.5%
	≥20,000 yuan	4.5%

Table 4. Results of user perception measurement of smart city apps of Guangzhou

Indicator	Score (out of 5)	Question	Score (out of 5)	Order
BI	4.02	Q17 (Attitude toward using)	4.02	2
SERQ	3.89	Q16 (service effectiveness)	4.08	1
		Q15 (service responsiveness)	3.69	6
PEU	3.87	Q7 (Flexibility)	3.91	3
		Q6 (Ease of use)	3.82	5
IQ	3.77	Q14 (Information timeliness)	3.87	4
		Q13 (Information accuracy)	3.68	7
SYSQ	3.44	Q12 (System reliability)	3.44	8
PC	2.76	Q9 (Perceived effort)	2.83	9
		Q8 (Perceived financial cost)	2.82	10
PR	2.44	Q11 (Perceived financial cost)	2.65	11
		Q10 (Privacy risk)	2.23	12

Overall score 3.41

The overall score of smart city apps given by residents was 3.41, still far from the full score, indicating that smart city apps currently cannot bring the best user experience to

residents, and there is a great room for improvement. Among the subdivision indicators, "service effectiveness" in SERQ got the highest score, and the "privacy risk" in PR got the lowest score.

(1) BI

The score for BI was 4.02 (reflected by "attitude towards using"), which was the highest among the seven indicators. 79.4% of the residents had a positive and supportive attitude towards the use of smart city apps. Less than 1% of the residents held the opposite opinion, and the remaining 19.8% had a neutral attitude. From this point of view, smart city apps are highly accepted among residents, indicating that the development of smart city apps meets the needs of residents. At the same time, less than 30% of the residents with a positive attitude gave a score of 5, which shows that smart city apps need to be improved in many aspects although it is recognized by most residents.

(2) SERQ

The overall score given by residents on the SERQ of smart city apps was 3.89, which was relatively high. From the perspective of subdivision indicators, the service effectiveness got the highest score among all subdivision indicators. 81.8% of the residents agreed with the statement "the services provided by smart city apps make my life more convenient", indicating that smart city apps play a better role in the daily life of residents and bring convenience to them. However, in terms of service responsiveness of smart city apps, the score was 3.69. In addition to assisting residents with information inquiry and acquisition, smart city apps can also assist citizens in handling various affairs. When residents' requests can be quickly responded, it will improve the users' perception of effectiveness [22]. Therefore, ensuring effective response is an important dimension for improving the user experience. If a resident registers online to see a doctor, but he is told that there is no registration record at the hospital. The bad experience brought by this disconnection of online and offline information will greatly curb the enthusiasm of residents for using smart city apps. According to the survey results, there is still room for improvement in the service response of smart city apps.

(3) PEU

The overall score given by residents on the PEU of smart city apps was 3.87, which indicates that smart city apps perform better in this regard. In terms of each subdivision indicator, the ease of use got a score of 3.82, and the flexibility got a score of 3.91. An app can attract users and solve their needs only if it is easy to use, otherwise users may abandon it the first time he opens it due to tedious operations. According to the survey results, there is no big problem in the operation design of smart city apps, but there is still room for improvement. The residents gave a generally high score to flexibility. Smart city apps rely on smart phones, so they have good mobility and can be used anytime and anywhere. However, in some special scenarios, they may bring hidden safety hazards. For example, navigation apps are likely to bring unsafe driving behaviors [39]. In addition, most smart city apps need access to the Internet to obtain the latest real-time information, and the completeness of communication facilities will also affect their use.

(4) IQ

Smart city apps integrate city data to provide residents with basis for various information decision-making and convenient city services. Information is one of the core elements of smart city apps. According to the statistical results, residents gave a relatively low score of 3.77 on IQ, which is a key indicator of smart city apps. Among the subdivision indicators, the information timeliness scored higher, indicating that smart city apps can basically deliver real-time information to users in a timely and fast manner. Information accuracy scored lower. Ensuring information accuracy is an important foundation for smart city apps. Only based on accurate information can users make correct decisions. Without accuracy, no matter how timely the information is provided, it will not help users make decisions, and may even bring reverse results. At present, the information quality of smart city apps still have potential for improvement.

(5) SYSQ

The smart city apps' system reliability got a score of 3.44. Less than 50% of residents think that smart city apps generally do not have problems such as crash, white screen or failure to open. This reflects that the system cannot ensure its proper operation during the use of smart city apps. Although there are many smart city apps on the market, the statistics of mobile app store[2] show that most apps have fewer downloads and low software ratings except for some familiar applications, and many comments suggest that apps have problems such as "inability to open normally", "inability to log in", "connection failure", "crash", etc. It indicates that some smart city apps have the poor system stability, which will directly affect the user experience. Therefore, more attention should be paid to system stability in the smart city app development process.

(6) PC

There is a great gap between the score of PC and those of the aforementioned indicators. The perceived cost of smart city apps includes the effort and money spent on using the apps. Both subdivision indicators scored lower than the median score of 3, which shows that most residents believe that using the smart city apps will bring them higher costs. The use of smart city apps will inevitably consume a certain amount of time and energy, and sometimes users need to learn the corresponding knowledge in order to master the use method. Certain apps may also charge fees during the use, thus bringing burdens to residents and complicating matters that could have been done easily [40]. Seen from the survey results, residents currently have a poor evaluation of smart city apps in terms of the perceived cost.

(7) PR

PR also received a low score, ranking last among the eight indicators, and the "privacy risk" scored the lowest among all questions, indicating that residents are paying great attention to personal privacy when using smart city apps. Smart city apps are data-driven and will inevitably need to collect a large amount of user data. Most of people's information and behavior data will be recorded, and some smart city apps also require users to provide their real names and bind their bank cards. Therefore, the privacy and security of information can easily cause residents'

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[2] The data source is Android App Store.

concerns [41, 42], and solving security issues is vital to smart services [43]. The data shows that current residents' evaluation of smart city apps is low in terms of both privacy protection and security performance.

4.3 Users' Perception on Smart City Apps Under Different Demographics

Previous studies have shown that user groups with different socio-demographic charac- teristics may have different intentions to use technology products [44], and age, gender, or education level may all have an effect on this [45]. In addition to grasping residents' perception of the smart city apps as a whole, the study also horizontally compares the respondents with different socio-demographic characteristics in order to obtain different user groups' perception of the smart city apps. According to the results, the male and the female groups show no obvious differences in the choice of the answers to the questions, but differences are shown between the groups in the dimensions of area of residence (Table 5), education level (Table 6), age (Table 7), and monthly income (Table 8).

(1)   Difference between urban and rural residents

Table 5. Statistics of answers given by urban and rural residents (partial)

Question	Group	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Mobile smart city apps are easy to operate.	Urban residents	0.2%	3.1%	25.5%	53.0%	18.2%
	Rural residents	0.6%	3.2%	34.4%	48.7%	13.0%
The services provided by smart city apps make my life more convenient.	Urban residents	0.0%	1.4%	14.4%	54.6%	29.6%
	Rural residents	0.6%	1.9%	22.1%	52.6%	22.7%
Smart city apps always send me accurate information.	Urban residents	0.0%	4.3%	33.8%	47.5%	14.4%
	Rural residents	1.3%	5.2%	41.6%	40.9%	11.0%
I think the use of smart city apps costs a lot of time and energy.	Urban residents	1.9%	23.9%	35.2%	29.8%	9.2%
	Rural residents	4.5%	19.5%	48.1%	20.8%	7.1%
I worry about privacy leakage when using smart city apps.	Urban residents	0.9%	4.7%	30.7%	39.5%	24.1%
	Rural residents	1.3%	3.2%	41.6%	36.4%	17.5%

In terms of ease of use, the proportion of urban residents with a positive attitude was 71.2%, while that of rural residents was 61.7%, nearly ten percentage points lower compared with urban residents. At the same time, the rural residents who encountered problems such as crash and white screen on the apps accounted for 39%, 11.4% more than urban residents. This shows that in the operation and use of the smart city apps, rural residents perceive higher difficulty than urban residents, which may be because rural residents have lower education level than urban residents and accept new things slowly.

In terms of service quality and information accuracy, rural residents' evaluation of smart city apps is also lower than that of urban residents. Rural residents' perception of the service effectiveness of smart city apps is not as obvious as that of urban residents. The reason may be that the difficulties encountered in using apps have weakened their perception of the convenience to a certain extent. Urban residents who agreed with the statement "smart city apps always send me accurate information" accounted for 61.9%, while the proportion of rural residents was 51.9%, indicating regional difference in the quality of information provided by smart city apps. The reason may be that the infrastructures supporting smart city services in rural areas are inferior to those in urban areas.

Urban residents appear to be more sensitive than rural residents in terms of perceived effort and privacy leakage. 39% of urban residents think that it costs a lot of time and energy to use smart city apps, and this value has dropped to 27.9% in rural areas. Regarding privacy, 63.6% of urban residents are worried about privacy leakage when using smart city apps, while only 53.90% of rural residents are concerned about privacy leakage. Compared with rural residents, urban residents pay more attention to their time and energy costs and privacy security when using smart city apps, raising higher requirements for the use costs and security performance of apps.

(2) Difference among different education levels

Table 6. Statistics of answers given by respondents with different education levels (partial)

Question	Group	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The services provided by smart city apps make my life more convenient.	Graduate	0.0%	2.7%	11.7%	57.7%	27.9%
	Undergraduate	0.0%	0.6%	16.1%	54.8%	28.4%
	High school	0.8%	3.2%	21.6%	48.8%	25.6%
I have a positive and supportive attitude towards the use of smart city apps.	Graduate	0.0%	0.9%	18.0%	55.9%	25.2%
	Undergraduate	0.0%	0.3%	16.4%	59.2%	24.0%
	High school	0.8%	1.6%	30.4%	47.2%	20.0%
I worry about privacy leakage when using smart city apps.	Graduate	0.9%	4.5%	21.6%	41.4%	31.5%
	Undergraduate	0.9%	3.5%	33.1%	39.6%	22.9%
	High school	1.6%	6.4%	45.6%	33.6%	12.8%

Residents with undergraduate or high education level did not show outstanding group characteristics, and residents with a high school or lower education level showed differences in certain dimensions.

The group with a high school or lower education level had lower evaluations of smart city apps in terms of "service effectiveness" and "behavioral intention to use" than the other two groups. In terms of perceived effectiveness brought by smart city apps, 74.4% of the group with a high school or lower education level believed that the services provided by smart city apps make city life more convenient, while the proportions of graduate group and undergraduate group with the same opinion both exceeded 80%. In addition, more than 80% of graduate and undergraduate groups have a positive attitude towards the use of smart city apps, and this value dropped to less than 70% of the group with high school or lower education level. It can be found that, along with the low evaluation of service quality perception, the intention to use smart city apps among people with high school or lower education level also dropped. Compared with the groups with other education levels, the group with high school or lower education level includes respondents under the age of 18, who have insufficient knowledge of urban life, use smart city apps less frequently and thus have limited perception.

In terms of privacy, the respondents with a high school or lower education level do not pay as much attention as the other two groups. 72.90% of the respondents with graduate education level are worried about privacy leakage when using smart city apps, 62.50% of the respondents with undergraduate education level also hold the same opinion, and only 46.40% of respondents with high school and below education level are concerned about privacy leakage. With the improvement of educational level, people are more aware of information security, and will pay more attention to their privacy protection and the privacy protection function of apps.

(3)   Differences among different age groups

Table 7. Statistics of answers given by respondents of different age groups (partial)

Question	Group	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The services provided by smart city apps make my life more convenient.	≤18 years old	0.0%	1.6%	28.6%	47.6%	22.2%
	19-44 years old	0.2%	3.1%	27.0%	52.4%	17.3%
	≥45 years old	1.6%	4.8%	33.9%	51.6%	8.1%
I worry about privacy leakage when using smart city apps.	≤18 years old	1.6%	9.5%	42.9%	27.0%	19.0%
	19-44 years old	0.9%	3.8%	32.7%	39.4%	23.2%
	≥45 years old	1.6%	3.2%	30.6%	45.2%	19.4%
I have a positive and supportive attitude towards the use of smart city apps	≤18 years old	0.0%	0.0%	30.2%	46.0%	23.8%
	19-44 years old	0.0%	0.9%	18.8%	56.2%	24.1%
	≥45 years old	1.6%	0.0%	16.1%	64.5%	17.7%

Among the three age groups, the 19–44 age group did not show significant differences from the other two groups.

Regarding the ease of use of smart city apps, nearly 70% of people under the age of 44 have a positive attitude, while only 59.7% of those aged 45 and above have the same attitude. This shows that compared with other age groups, the middle-aged and elderly group have some difficulties in using smart city apps, and further optimization is needed to meet the requirements of this group.

The consciousness of privacy protection among people aged 18 or below is relatively weak. Only 46.0% of this group are worried about privacy leakage when using smart city apps, while more than 60% of the other two age groups are worried about privacy leakage. In addition, the group under 18 years of age hold a less positive attitude towards the use of smart city apps than the other two groups, which may be related to the fact that this group has not started an independent life and has less exposure to smart city apps.

(4) Difference among groups with different income levels

Table 8. Statistics of answers given by respondents with different income levels (partial)

Question	Group	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The services provided by smart city apps make my life more convenient.	≤5,000 yuan	0.4%	1.4%	19.5%	55.2%	23.5%
	5,001–20,000 yuan	0.0%	1.5%	14.2%	54.0%	30.3%
	≥20,000 yuan	0.0%	3.8%	7.7%	42.3%	46.2%
I have a positive and supportive attitude towards the use of smart city apps.	≤5,000 yuan	0.4%	0.4%	24.9%	54.2%	20.2%
	5,001–20,000 yuan	0.0%	0.7%	15.0%	59.5%	24.8%
	≥20,000 yuan	0.0%	3.8%	15.4%	38.5%	42.3%

The high-income group with monthly income of more than 20,000 yuan gave higher evaluation in some indicators than the other two groups. In terms of the service effectiveness of smart city apps, the respondents with monthly income of more than 20,000 yuan who choose "strongly agree" accounted for the highest proportion among the three groups. At the same time, the proportion of people who hold positive attitudes on this topic in this group is also higher than that of the other two groups. In addition, in terms of intention to use, the proportion of people who gave a score of 5 is also much higher than that of the other two groups.

5 Discussion and Conclusion

The purpose of this study is to investigate residents' perception and attitudes towards the use of smart city apps, so as to find out issues that should be focused on in the optimization of smart city apps. In addition to the planning and design of government agencies and technological innovation, the construction of smart cities is inseparable from the support and adoption by urban residents. Therefore, it is of great significance to study residents' views of smart city services. This can provide guidance for targeted

optimization of smart city apps. In this study, a Chinese city with good achievements in smart city construction has been selected a sample, and the survey results come from representative respondents among local residents. The study mainly draws the following conclusions:

(1) The overall evaluation of smart city apps by citizens is not very high. Although the data reflects residents' high intention to use smart city apps, some indicators got a low evaluation and there is still room for improvement.
(2) Among the multiple evaluation indicators, smart city apps got relatively high evaluation in terms of service effectiveness, perceived ease of use, and information timeliness and can basically meet the residents' requirements for use.
(3) Smart city apps got low evaluation in terms of service responsiveness, information accuracy, system reliability, perceived cost, and perceived risk, showing a great gap from residents' expectations. Smart city apps should be improved in these aspects.
(4) High-income residents and highly educated residents showed a higher intention to use smart city apps.
(5) In terms of ease of use, urban residents and high-income group have shown higher recognition, while the elderly group still has obstacles in the operation of smart apps.
(6) In terms of service quality and information accuracy, urban residents gave higher evaluation than rural residents.
(7) Urban residents, highly educated residents and adult group pay more attention to perceived risk and perceived cost.

6 Limitations and Direction for Future Studies

The indicators in this study were mainly extracted from previous empirical studies, so there are certain limitations in the construction of the indicator system. In addition, from the results of data analysis, it can be seen that the evaluations of smart city apps by different demographic groups shows differences. Since the data were collected from questionnaires and the questions in the questionnaires were closed, it was unable to find the reasons behind the difference. Further exploration can be made in this aspect in the future. In terms of research object, this study took all different types of smart city apps as a whole for the research. However, different types of smart services have different focuses, so whether this will lead to the differences in people's evaluations remains to be studied in the future.

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