# Postprint: Analysis of Current Status and Issues of Smart City Mobile Applications in China

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## Abstract

[Purpose/Significance] This study aims to investigate the current development status and existing problems of smart city applications (APPs) in China, which holds significant reference value and practical guidance for improving smart city services, facilitating the implementation of smart city technology solutions, and enhancing user experience of smart city APPs. [Method/Process] Data from 333 smart APPs across 140 cities nationwide were collected and analyzed using integrated quantitative and qualitative research methods. First, SPSS was employed to conduct statistical analysis of the regional distribution and user ratings of the APPs. Second, content analysis was applied to qualitatively examine the functional descriptions of the APPs and 15,754 user comments, thereby summarizing the APP categories and user feedback. Finally, the future development pathways of smart city APPs were discussed in light of the current situation. [Results/Conclusion] This paper systematically reviews the regional distribution, functional categories, ratings, and user comments of smart city APPs in China. Currently, the distribution of smart city APPs in China exhibits significant regional disparities. Functionally, they can be classified into three major categories: smart transportation, smart healthcare, and smart living. The overall ratings are relatively low, with six major problems identified, including technical defects, poor service quality, inaccurate information, and inability to meet user demands.

## Full Text

## Preamble

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**Analysis of the Current Status and Problems of Smart City APP Applications in China**

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## Abstract

[**Purpose/Significance**] This study aims to explore the development status and existing problems of smart city mobile applications in China, providing important reference and practical guidance for improving smart city services, facilitating the implementation of smart city technology solutions, and enhancing user experience. [**Method/Process**] Data from 333 smart city APPs across 140 Chinese cities were collected and analyzed using both quantitative and qualitative methods. First, SPSS was used to analyze the regional distribution and user ratings of the APPs. Second, content analysis was employed to qualitatively examine APP function descriptions and 15,754 user reviews, identifying APP categories and user feedback. Finally, future development paths for smart city APPs were discussed based on the current situation. [**Result/Conclusion**] The study summarizes the regional distribution, functional categories, ratings, and user comments of smart city APPs in China. Currently, significant regional disparities exist in the distribution of these APPs, which can be categorized into three major types: smart transportation, smart healthcare, and smart living. The overall ratings are low, with six major problems identified, including technical defects, poor service quality, inaccurate information, and failure to meet user needs.

**Keywords:** smart city, mobile APP, user reviews, user experience, system integration
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## 1. Introduction

The goal of smart cities is to utilize next-generation information and communication technologies such as the Internet of Things, cloud computing, big data, and mobile applications to achieve real-time perception, dynamic monitoring, in-depth analysis, comprehensive integration, and optimal allocation of key information in urban physical spaces [1-2]. Among these, smart city APPs serve as a core component of the overall smart city technology solution, acting as a crucial bridge connecting urban infrastructure resources, public service departments, and citizens, as illustrated in Figure 1 [Figure 1: see original paper].

More specifically, IoT devices installed on physical infrastructure (such as wireless sensors, GPS, GIS, detectors, and high-definition cameras) can continuously sense and monitor various critical urban data. This IoT data is transmitted in real-time to cloud-based backend databases, where it is aggregated, processed, and analyzed alongside data from public service departments across different sectors, including urban management, government affairs, transportation, community services, energy, and healthcare. Finally, APPs deliver integrated information and data analysis results to citizens, enabling them to enjoy mobile

convenience from government, community, property management, transportation, energy, and healthcare departments without leaving their homes.

The proliferation of mobile internet has transformed urban management. Mobile APPs, characterized by simple development, low cost, convenient download, and strong functional integration [3], hold significant promise for addressing social issues such as urban traffic congestion, complicated administrative procedures, and difficulty accessing medical care. As smart city construction deepens, cities like Beijing, Ningbo, Wuxi, and Qingdao have launched various smart APPs. By downloading government-provided smart city applications such as "My Nanjing - Smart Nanjing," "Beijing Tong," "Smart Wuxi," and "Ningbo Citizen Pass," citizens can access real-time traffic conditions, parking guidance, intelligent medical consultations, appointment booking, and other smart services anytime, anywhere. This study focuses on public service-oriented smart APPs promoted by local government departments, excluding for-profit applications such as Amap, Didi Chuxing, and Chunyu Doctor.

Smart city APPs, as the technical core of smart city solutions, connect urban infrastructure resources, citizens, and various service providers, representing the concentrated embodiment of urban intelligence. Consequently, their development and application have become hot topics of public concern. China Central Television has reported that smart APPs launched by multiple local governments suffer from prominent issues such as poor compatibility, link failures, crashes, and data anomalies [4]. "Failed" smart city APPs not only result in massive waste of hardware infrastructure investment but also negatively impact citizens' lives and local government image. However, academic research on this phenomenon remains relatively scarce. Therefore, a systematic discussion and analysis of the development status and problems of smart city APPs in China is of important theoretical value and practical significance for improving APP operations, achieving effective connections among urban residents, government, service providers, and resources, and creating truly "intelligent and humanized" smart city service platforms.

## 2. Literature Review

Smart cities conceptually involve intelligent transportation, healthcare, government affairs, community management, and urban administration [5]. In recent years, driven by smart city policies and practices, research on smart APP development and applications has emerged across various domains. In smart healthcare, numerous diagnostic APPs have emerged domestically and internationally, offering disease diagnosis, treatment recommendations, and health services [6]. In smart transportation, Pan Zhihong et al. designed a mobile perception-based smart bus APP using the Haversine algorithm for automatic generation and arrival reminders [7], while Zhang Chunju et al. studied smart parking models under the "Internet Plus" environment [8]. Such research attempts to alleviate urban traffic congestion and pollution through dynamic monitoring of road traffic, vehicle trajectories, and parking availability, enabling intelligent route

navigation, real-time bus information, and smart parking. In smart community domains, computer and software engineers have designed and developed mobile clients integrating property maintenance, housekeeping services, parking management, and various life services [9-10]. In urban management, Jiang Min proposed a smart mobile application design based on video monitoring, wireless data collection, public supervision, and emergency response systems to address the problem of untimely information and passive management in traditional law enforcement, claiming it would improve efficiency and urban management capabilities [11]. Beyond sub-domains, some applications propose integrating transportation, healthcare, public management, and education, envisioning enhanced urban operations and integrated citizen services through inter-system business collaboration and data sharing [12].

While technical development is crucial for successful APP operation, it is not the sole determinant of success [13]. After investing significant human and material resources in development and launch, a smart APP does not guarantee citizen adoption or fulfillment of its intended functions and value. Some scholars have investigated post-launch conditions. In London, after substantial government investment in a smart parking system, the resulting APP saw minimal citizen usage, with researchers concluding that government promotion and citizen awareness significantly impact effectiveness [14]. In Brussels, quantitative and qualitative analysis revealed that local smart applications lagged behind other mobile services, recommending development based on government open data platforms [15]. For mobile clients developed by Seoul's municipal government, Li Jianhao et al. found that some APPs had low development necessity, failed to meet basic public needs, and suffered from poor promotion, resulting in low usage and substantial financial waste [16]. In China, government-developed administrative APPs have attracted particular academic attention. Xue Wanqing et al. noted that government APPs in China commonly suffer from one-time usage phenomena, with officially released applications being superficial and low in practical utility [17]. Li Chongzhao et al., analyzing 17 provincial-level mobile government platforms, concluded that while government awareness of using emerging technologies to provide public services is increasing, technology adoption has not comprehensively improved service levels [18-19].

Existing literature mostly focuses on the technical functions and application problems of one or a specific category of smart city APPs. However, are these issues universal? What is the overall development status of smart city APPs in China? Current research lacks in-depth and comprehensive discussion, further highlighting the importance and significance of this study.

## 3. Research Methods

This study referenced statistics from the Sixth "China Smart City Development Level Assessment Report," which surveyed and evaluated 201 cities with the highest levels of smart city development in China [20], representing one of the most authoritative assessments nationwide. Based on the list of these 201 smart

cities, researchers searched for and collected official smart APPs (hereinafter referred to as APPs) launched by government departments in each city. The search used keywords such as "smart + city," "smart healthcare + city," "smart transportation + city," "smart energy + city," "smart education + city," and "smart government + city" (including city names and aliases) to match queries across the 201 cities. Since citizens can download APPs from numerous stores including the Apple App Store, Yingyongbao, Wandoujia, Xiaomi, and 360, the research team used the "Qimai Data" platform (https://www.qimai.cn/) for unified retrieval to ensure comprehensive data collection. This platform aggregates and integrates multi-dimensional data from iOS and Android app stores, facilitating data retrieval and integration.

The study ultimately collected important data on 364 APPs from 140 cities among the 201 cities (no APPs within the research scope were found in the remaining 61 cities), including APP quantity, functional descriptions, ratings, and review content. After data cleaning, 31 APPs with insufficient information were excluded, leaving 333 APPs as the research sample. Among 27,639 user reviews, 15,754 were retained as valid data, while approximately 43% were excluded for lacking practical meaning or reference value (such as emoticons or single characters).

During data analysis, SPSS was first used for descriptive statistical analysis of the regional distribution and average ratings of the 333 APPs. Subsequently, all APP functional descriptions were reviewed, and content analysis was employed to summarize and extract user review content. Content analysis is one of the most commonly used methods for analyzing textual data [21], with application processes adjusted according to actual circumstances. This study adopted traditional content analysis methods [22], without pre-coding, but coding and classification were performed during data cleaning [23], with specific procedures discussed in detail below.

## 4. Investigation of Current Status and Problems of Smart City APPs in China

### 4.1 Regional Distribution of Smart City APPs

Among the 201 cities with the highest smart city development levels nationwide, 140 cities have released multiple smart city APPs. Geographically, they cover China's seven major administrative regions, but distribution is uneven, with significant variation among provinces. Among the seven regions, East China has the most APPs, accounting for approximately 48.05% of the total; Northeast China has the fewest, with Heilongjiang, Jilin, and Liaoning provinces combined accounting for only 4.2% of the national total—equivalent to the number in Fujian province alone. North China and South China have similar proportions, each accounting for about 12% of the total; Central China, Southwest China, and Northwest China have comparable numbers of APPs, indicating they are at similar levels in smart APP development.

Among the 31 provincial-level administrative regions, Jiangsu, Shandong, and Zhejiang provinces have released the most APPs, each accounting for over 10% of the total, followed by Guangdong province at 8.71%. These four provinces, compared to other regions, have more developed economies, higher urbanization levels, better hardware infrastructure, and higher mobile device penetration rates. They have also produced a number of highly smart cities such as Ningbo, Wuxi, Hangzhou, Nanjing, Qingdao, Guangzhou, and Shenzhen, which possess greater technological and economic advantages in smart APP development and place more emphasis on their development and popularization. Additionally, the four municipalities of Beijing, Shanghai, Tianjin, and Chongqing each have more than three smart APPs online. In contrast, provinces in Northwest, Southwest, and Northeast China generally have fewer than 10 APPs each. Details are shown in Table 1 .

**Table 1 Regional Distribution of Smart City APPs in China**

| Region | Provincial-level Administrative Region | APP Count | Regional Total | Regional Percentage |
|---|---|---|---|---|
| East China | Jiangsu, Shandong, Zhejiang, Anhui, Fujian, Shanghai | 48, 38, 40, 8, 14, 14 | 162 | 48.05% |
| North China | Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia | 18, 6, 8, 5, 4 | 41 | 12.31% |
| Northeast China | Liaoning, Jilin, Heilongjiang | 8, 3, 3 | 14 | 4.20% |
| Central China | Henan, Hubei, Hunan, Jiangxi | 12, 10, 8, 6 | 36 | 10.81% |
| South China | Guangdong, Guangxi, Hainan | 29, 7, 4 | 40 | 12.01% |
| Southwest China | Chongqing, Sichuan, Guizhou, Yunnan, Tibet | 12, 8, 5, 4, 1 | 30 | 9.01% |
| Northwest China | Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang | 8, 4, 2, 2, 4 | 20 | 6.01% |

The number of APPs in each region correlates closely with smart city development levels and economic development. High per capita GDP, complete network infrastructure, active policy support, and strong citizen awareness often promote the development of smart city APPs. However, quantity does not represent quality or effectiveness. Policy-driven blind construction may lead to redundant development and superficial implementation, causing confusion for citizens and increasing management difficulties. Taking Qingdao as an example, the city has multiple smart APPs including “Smart Qingdao,” “Qingdao Smart Human Resources,” “iQingdao - Urban Life Cloud Platform,” and “My Qingdao,” reflecting a lack of unified planning and management during development, with different departments and agencies all exploring independently.

From citizens' perspective, downloading 10 similar smart APPs on their phones not only burdens device memory but also reduces usage efficiency.

### 4.2 Categories and Functions of Smart City APPs

Smart APPs across different Chinese cities show great similarity in type, with significant functional overlap and serious cross-phenomena, resulting in relatively comprehensive smart applications. Summarizing the 333 APPs, China's smart city applications can be broadly divided into three categories: smart transportation, smart healthcare, and smart living, providing 17 main functions and 52 column settings covering all areas of citizens' lives. However, the three categories differ in quantity: smart transportation APPs are the most numerous, followed by smart living APPs, with smart healthcare applications being the least common. Specifically, many cities have launched separate real-time bus, smart subway, smart parking, and smart traffic police APPs, resulting in the largest number of transportation apps. Smart healthcare APPs are relatively few and concentrated on basic functions such as appointment booking and health information inquiry, while advanced functions like remote consultation and medical big data remain to be developed. Among smart living APPs, some relatively comprehensive applications have emerged, such as "Smart Qingdao," "My Nanjing," and "In Chengdu," which integrate government services, human resources and social security services, and convenience services, while also incorporating health and transportation columns such as appointment booking, real-time bus information, and traffic violation inquiries. Details are shown in Table 2 .

**Table 2 Main Categories and Functions of Smart City APPs in China**

| APP Category | Main Functions | Specific Services | APP Count | Category Percentage | Typical APPs |
|---|---|---|---|---|---|
| Smart Transportation | Real-time travel information | Real-time road conditions; parking guidance; real-time bus info, arrival reminders; route queries; air, waterway, and train dynamics | 252 | 75.7% | Ningbo Citizen Pass |

| APP Category | Main Functions | Specific Services | APP Count | Category Percentage | Typical APPs |
|---|---|---|---|---|---|
| | Public transport facility services | Traffic violation inquiry and payment; car ticketing; highway fees; transit cards | 148 | 44.5% | |
| | | Public bicycles; taxi calling; electric bike anti-theft; gas stations | 191 | 57.4% | |
| Smart Healthcare | Medical service appointment | Appointment booking, waiting number calling; department/doctor info | 108 | 32.4% | Guangdong Cloud Hospital |
| | Health information inquiry | Electronic health records; hospital reports; surgery status; medication records | 288 | 86.4% | |
| | | Blood donation records | 59 | 17.7% | |
| | Mobile medical payment | Online payment; medication delivery | 147 | 44.1% | Hangzhou Smart Healthcare |
| | Video consultation | Video diagnosis; intelligent triage and follow-up | 220 | 66.1% | |

| APP Category | Main Functions | Specific Services | APP Count | Category Percentage | Typical APPs |
|---|---|---|---|---|---|
| | Satisfaction evaluation | Medical satisfaction rating | 90 | 27.1% | |
| Smart Living | Convenience services | Citizen card services; utility bill payment; public payment services; water services; weather and environment; legal consultation; urban management hotline; news live streaming; tourism; education; real-time travel info | 225 | 67.5% | Weihai Citizen Net |
| | Government affairs | Administrative approval; entry-exit appointment; marriage registration appointment; real estate appointment; medical appointment | 259 | 77.8% | |

| APP Category | Main Functions | Specific Services | APP Count | Category Percentage | Typical APPs |
|---|---|---|---|---|---|
| | Human resources and social security | Social security payment; medical insurance; pension insurance; housing provident fund; unemployment insurance; public housing application | 283 | 84.9% | |
| | Other government services | Government guidelines; tax services; housing construction; mayor's mailbox; residence permit application; credit inquiry | 190 | 57.1% | |

### 4.3 Ratings of Smart City APPs

User experience is a critical factor determining the survival and success of smart city APPs and represents the primary development objective [24], with user ratings serving as a direct reflection of this experience. The average rating of the 333 APPs was 2.99, which falls below the midpoint of the mobile APP rating scale (1-5 points, with 1 being the lowest and 5 the highest). Specifically, 50.5% of APPs scored in the low range of 1.0-2.99, approximately 25% fell in the 3.0-3.99 range, and 24.5% scored between 4.0-5.0, with only 4.4% achieving a perfect 5.0 score. From users' ratings, China's smart city APPs currently have low overall scores, low satisfaction, and poor user experience.

From a regional distribution perspective, although the number of APPs varies significantly across regions, ratings show no obvious differences. Comparing regional quantity and rating data, while East China, North China, and South

China account for 72% of total APPs, their scores are not higher than those in Central China, Northeast China, Southwest China, or Northwest China (see Table 3 ). This indicates that the number of smart APPs and user satisfaction are not positively correlated; increased APP quantity does not represent improved satisfaction. Taking East China as an example, the region possesses 48.9% of national APPs and holds advantages in both quantity and infrastructure, yet its ratings are not high and show relatively small standard deviations. Low average scores with small standard deviations indicate minimal differences among APPs within the region, all hovering around the average with uniformly low satisfaction—a finding worthy of serious consideration.

**Table 3 Regional Ratings of Smart City APPs in China**

| Region | APP Type | Average Rating | Total Count | Standard Deviation | Min/Max |
|---|---|---|---|---|---|
| East China | Smart Transportation | 2.95 | 162 | 1.079 | 1/5 |
| North China | Smart Transportation | 3.01 | 41 | 1.222 | 1/5 |
| South China | Smart Transportation | 2.98 | 40 | 1.172 | 1/5 |
| Central China | Smart Transportation | 3.12 | 36 | 1.068 | 1/5 |
| Northeast China | Smart Transportation | 3.15 | 14 | 1.043 | 1/5 |
| Southwest China | Smart Transportation | 3.08 | 30 | 1.150 | 1/5 |
| Northwest China | Smart Transportation | 3.05 | 20 | 1.236 | 1/5 |

### 4.4 Current Problems of Smart City APPs

Given the low overall ratings of smart city APPs in China, the research team further analyzed the 15,754 valid reviews to identify key factors affecting APP satisfaction. Faced with this massive volume of complex review data, the team employed qualitative content analysis to code, categorize, organize, and analyze the data. Coding is a method of meaningfully categorizing basic components or elements of data or information, with good coding capturing the essence of a phenomenon [25].

First, the team selected nine representative APPs (three each from smart transportation, smart healthcare, and smart living) and conducted initial coding on their 626 review items. Through careful reading of these 626 reviews, researchers developed 31 initial codes around problems affecting citizen usage of smart city APPs, creating an initial coding list. Subsequently, based on this list, the team performed comprehensive coding, organization, and analysis on the remaining 15,128 reviews from 324 APPs. During this process, the initial codes were further refined: new codes emerged, old codes were replaced, and similar codes were merged. Ultimately, 23 codes were formed, each representing one problem affecting APP user satisfaction. Based on their relevance, these 23 codes/problems were further condensed into six core hindering factors, as shown in Table 4 .

**Table 4 Core Factors and Problems Affecting Smart City APP Usage**

| Core Problem | Specific Issues/Codes | Problem Index* |
|---|---|---|
| A. Confusing and Unreasonable Settings | A1. Functional overlap and confusion | |
| | A2. Rough production, cluttered interface, outdated icons | |
| | A3. Forced downloads | |
| B. Failure to Meet User Needs | B1. Unable to query information | |
| | B2. Unable to pay, single payment method, no refunds | |
| | B3. Unable to bind, favorite, organize, or sort | |
| C. Inaccurate Information | C1. Outdated information, untimely updates | |
| | C2. Inaccurate positioning, inaccurate real-time traffic data | |
| | C3. No data display for violations and other functions | |
| D. Technical Defects | D1. Port access errors, network anomalies, loading failures | |
| | D2. Crashes, freezes, white screens, instability, unable to open | |
| | D3. Registration errors, verification code errors, login errors | |
| | D4. Unable to open after updates | |
| | D5. System incompatibility, poor adaptation, high data consumption | |
| E. Poor Platform Service Quality | E1. Cannot use after recharge, no guarantee of paid services | |
| | E2. Unable to cancel appointment services | |
| | E3. Limited choices of hospitals, bus routes, etc. | |
| | E4. No maintenance, user complaints unresolved | |
| | E5. Personal information privacy leakage risks | |

| Core Problem | Specific Issues/Codes | Problem Index* |
|---|---|---|
| | E6. Forced advertisements | |
| F. Lack of Functional Integration | F1. Incomplete functions | |
| | F2. Many functions like violation processing unavailable | |
| | F3. Accounts cannot be universally bound | |

*Higher problem index indicates more frequent occurrence in reviews and greater urgency for improvement.

User comments and feedback on smart city service quality can further drive service optimization while enhancing user participation and effectiveness [26]. Among the various issues affecting citizen usage willingness in the table above, higher indices indicate more frequent mentions in reviews and greater urgency for improvement. The six core influencing factors are analyzed as follows:

**(1) Confusing and Unreasonable Settings.** Governments and developers often set up multiple columns in a single smart APP with the intention of providing more functions and convenient services. However, some APPs become cluttered with excessive functions and content, with overlapping functions and unclear logical structures, causing users to waste significant time and energy. Additionally, some functions, though seemingly citizen-oriented, have illogical rules and cannot be practically applied. For example, one smart transportation APP features a traffic violation reporting function requiring users to upload a 5-minute video as evidence. From an urban traffic management or safety perspective, such a function should receive positive citizen feedback. However, citizens have strongly questioned its practicality. From users' perspective, filming a vehicle stopped on a crosswalk may endanger the citizen's own safety, let alone requiring a 5-minute video. Some comments noted that "from a driver's perspective, filming while driving itself violates traffic rules." Beyond functional confusion, many users reported being forced to download the APP by their employers, only to find rough interfaces lacking aesthetic appeal, coupled with chaotic systems and no practical value, leading to great disappointment and even suspicion about government work attitudes.

**(2) Failure to Meet User Needs.** Although 31 APPs were eliminated in the preliminary stage, many remaining APPs' functions remain unusable. These "shell applications" fail to meet basic user needs after download. Inability to query bus routes, social security information, department specialists, or traffic violations strips the APPs of their most basic information retrieval functions. Furthermore, most APPs fail to meet personalized user needs. Inability to favorite routes, organize commonly used functions, or find historical query records

causes inconvenience. Regarding payment interfaces, single payment methods requiring citizens to bind specific bank accounts directly limit most residents' ability to pay utility bills and property fees through the APP. Beyond payment issues, problems such as inability to find refund paths for canceled appointments or lack of invoicing options also trouble citizens who had high expectations for smart APPs. The essence of smart cities is human-centered, and government development of smart APPs aims to provide more convenient services and improve urban management efficiency. However, blindly pursuing APP quantity and form while neglecting citizens' most basic needs and personalized services wastes resources and reduces citizen satisfaction.

**(3) Inaccurate Information.** Information is the foundation of decision-making, and scientific decisions rely on accurate information [27]. Inaccurate or erroneous information in smart APPs misleads decisions and severely impacts user experience. This problem is particularly prominent in smart transportation APPs, where delayed real-time bus information causes passengers to miss trips, inaccurate positioning misleads pedestrians, and incorrect navigation routes increase drivers' time costs. Smart healthcare APPs face similar issues, displaying numerous available appointments that turn out to be fully booked when patients or their families arrive on-site. Information resources are a major factor affecting smart city decision-making services [28], and citizens relying on erroneous information from smart APPs waste time and energy, potentially causing economic losses and negative social impacts. For example, incorrect navigation information may lead drivers to occupy bus lanes or speed through monitored road sections.

**(4) Technical Defects.** Some APPs crash, freeze, display black screens, or load indefinitely upon opening, turning "smart APPs" into "problem APPs" and forcing many users to uninstall them after download. Technical issues causing system crashes and operational instability directly affect user reputation. Smart APPs should undergo rigorous testing before launch to ensure no technical faults. According to A. Charland and B. Leroux's research, crash frequency in mobile software usage negatively correlates with satisfaction, with frequent errors severely reducing satisfaction [29]. The impact of system instability during APP operation is even more immeasurable. For instance, sudden crashes during electronic payment operations leave users uncertain whether medical fees or parking charges were successfully paid, while also raising concerns about financial loss and data disappearance.

**(5) Poor Platform Service Quality.** In the entire smart city ecosystem, smart APPs represent the core of the technical solution. A smart application connects not only citizens and physical sensing devices (such as various sensors and cameras) but also government administrative departments (such as government service centers, civil affairs, industry and commerce, power grid companies, and water utilities), hospitals, and bus companies. Opening a smart APP reveals multiple service functions (see Table 2). However, actual applications do not provide the quality services promised by their column settings.

Limited choices of hospitals and routes, inability to cancel appointments, unusable bus cards after recharge, and unguaranteed service quality from APP platforms cause citizen concerns. Incomplete regulatory mechanisms mean services promised on APPs lack recognition and channels for rights protection, with user complaints through platforms left unmaintained. Beyond real-name registration, some applications require multiple personal information entries, and with inadequate regulatory mechanisms, some citizens perceive risks of personal information leakage.

**(6) Lack of System Integration.** Multiple APPs are redundantly developed in a single city, yet these APPs generally have incomplete functions, wasting financial resources without improving efficiency. This creates choice difficulties for users and management inconveniences. Particularly in East China, although some cities attempt to integrate smart transportation, smart government affairs, and smart healthcare functions into a comprehensive mobile application (i.e., smart living APPs), striving to provide more comprehensive services through functional and data integration, such APP integration remains in its infancy with prominent problems. For example, user complaints indicate that clicking some integrated functions does not directly provide corresponding services but instead redirects to other APPs or web links. The redirected APPs or websites still require repeated registration and login, with no unified pass recognized across applications. These repetitive operations and uncertainties hinder citizens from enjoying more resource services. From a smart city ecosystem perspective, the independent operation systems of various service suppliers create numerous obstacles to integrating systems, data, and services.

## 5. Conclusions and Recommendations

Smart city construction, as a massive systematic engineering project, aims primarily to benefit citizens and make their lives more convenient. As application tools directly connecting citizens and urban services, smart city APPs represent the core of the entire smart city ecosystem construction solution. Therefore, smart city construction cannot focus solely on the hardware level (i.e., infrastructure and interconnected sensors); citizen-centered mobile APP construction also requires close attention.

After in-depth investigation and discussion of the development status and problems of smart city APPs in China, this study reaches two important conclusions. First, government departments in multiple regions and provinces have invested substantial resources in smart city and APP construction, resulting in a growing number of smart city APPs with improving functions. However, these APPs exhibit uneven quality, with prominent design and application problems, low satisfaction, and significant obstacles to implementing smart city services and improving citizens' lives. To address the hindering factors identified in this investigation, the study proposes four recommendations for future development and improvement of smart city APPs in China:

**(1) Resolve Technical Issues.** Technical defects such as black screens, system crashes, and overly complex interfaces severely affect user experience and willingness to use. To enhance APP design, development, and maintenance professionalism, introducing third-party development companies (rather than relying solely on internal government technical teams) is an effective approach [17]. Collaborative development not only leverages IT companies' technological advantages for complementary strengths but also enables market and social entities to participate in smart city construction, achieving multi-stakeholder collaborative governance [30].

**(2) Optimize User Experience.** Interface design, information accuracy, and service quality affect user experience across dimensions of aesthetics, usefulness, and usability. Successful mobile applications should follow the principle of simplicity and ease of use [29], with clear and concise APP interface design often bringing comfortable user experiences [30]. To improve the current phenomenon of rough production and logical confusion in smart city APPs, attention must be paid to page layout, color matching, and icon design to present a friendly interface to citizens. Additionally, post-development operation, maintenance, and updates must be emphasized to improve information accuracy, achieve service integration, and meet citizens' personalized needs.

**(3) Improve Smart City Data Management Systems.** Undoubtedly, data and information quality and accuracy are important factors affecting information system and software application success [14]. Governments have invested heavily in building information infrastructure and collecting urban data, yet APPs suffer from insufficient, inaccurate, and delayed information, indicating that massive data has not been well mined and utilized. Cleaning, reconstructing, correlating, and activating underlying data [23], building open data sharing platforms, and achieving smooth information flow among smart city units are key to improving smart APP services.

**(4) Develop One-Stop Smart APPs.** Amid the global smart city construction wave, some Chinese cities exhibit serious follow-the-trend phenomena, with different functional departments competing to develop smart APPs. Due to lack of unified planning and management, this often results in functional overlap and redundancy. Imagine citizens needing to download 5-10 smart city APPs on their phones—not only burdening device memory but also causing usage confusion. To address this situation, multiple cities have begun government-led efforts to concentrate technology, information, and personnel to develop one-stop smart APPs, namely the smart living APPs discussed earlier. Indeed, integrated, one-stop smart APPs combining transportation, healthcare, and life services are an inevitable product and future trend in smart city construction. However, accompanying integration problems are unavoidable. Only through coordinated efforts from relevant departments and agencies to break down barriers between departments, services, systems, and data across the city, achieving comprehensive interconnectivity, can truly future smart cities be created.

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## Author Contributions

Liang Tian: Data collection and analysis, literature review, paper writing
Peng Guochao: Research concept and design, research scheme design, paper revision
Xing Fei: Data collection and analysis, paper writing

*Note: Figure translations are in progress. See original paper for figures.*