ISSN:2958-0420 Contents lists available at JJOAS-N

Jordan Journal of Applied Science - Natural Science Series
Applied Science Private University

Research Article *Vol. 20*

The Perception of Pharmacists and Pharmacy Students on the Future of Smart City Healthcare Technologies in Jordan: A cross-sectional study.

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A R T I C L E I N F O

Article history:

Received 12 Jul 2026

Accepted 04 Nov 2026

Published 09 Nov 2026

DOI: https://doi.org/10.35192/jjoas-n.v20i1.186

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A B S T R A C T

Background: Pharmacists' views on smart city healthcare technologies are essential to successful implementation, as they shape smart city design to meet pharmacists' needs and preferences. This study evaluates Jordanian pharmacists' and pharmacy students' perceptions and attitudes toward using smart city healthcare technologies.

Methods: This web-based, cross-sectional study used a questionnaire disseminated in Jordan between June and September 2024. The sample size was 523.

Results: Most participants recognized the influence of smart city healthcare technologies in improving pharmacy practice by boosting the efficiency of the pharmacist's role (94.5%), increasing access to real-time patient data (94.3%), facilitating better infrastructure for electronic pharmacy services, including digital prescriptions (96.4%), and easing collaboration with other healthcare providers (95.4%). At the patient level, 94.5% of participants believed that smart city healthcare technologies could augment outcomes and reduce costs. However, only 48.6% expected an obvious improvement in patients' adherence to their medications. On the other hand, more than half of participants anticipated better health for citizens, job creation, and lower living costs. 43.9% of participants believed that implementation and maintenance costs were the most common obstacle to applying smart city healthcare technologies. Female participants were more likely to agree that such services are easy to use ($p = 0.02$), but this association was not significant after adjustment.

Conclusion: Pharmacists and pharmacy students in Jordan believe that smart city healthcare technologies will be valuable and advantageous to pharmacy practice. However, effective implementation will require addressing key challenges, including implementation and maintenance costs, data security, and interoperability.

Keywords: Smart city, Pharmacy student, Pharmacy Practice, Jordan.

Introduction

Smart city development is built on the implementation of modern information and communication technologies, such as artificial intelligence (AI) and the Internet of Things (IoT) (1). These technologies can innovatively ease the collection and management of data (2). Attention to smart cities has increased as a response to a rising global population and the expanding demands for enhanced quality standards (3). Since 2018, the world's population has resided in urban areas, and this proportion is anticipated to rise further by 2050.Currently, urban areas consume 75% of natural resources, generate 80% of greenhouse gases, and threaten the ecosystem(4,5). A smart city impacts several types of technologies to facilitate data collection, management, and analysis (6). The rising dependence on these technologies is motivated by the rapidly increasing volume of data, leading us into an era of 'big data'. This reliance does not end there; it extends to a dependency on novel solutions evolving from the incorporation of technology and modern sciences within smart cities (7). As a result, various healthcare ecosystems, including hospitals, insurance companies, pharmacies, and physicians, are actively working on implementing these technologies to employ big data, reduce costs, improve services, and streamline processes (8).

Information Technology (IT) resources have benefited nearly every industry, including healthcare and pharmaceuticals. AI has already been implemented in diverse applications, like supporting medical staff in ailment diagnosis and treatment (9). In smart cities, community pharmacies play a crucial role in providing effective, cost-efficient, and safe medication. They provide a range of

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healthcare services, such as gathering patients' clinical data, re-dispensing reused medicines, utilizing diagnostic tools, generating automatic alerts regarding medication precautions/ contraindications, patient follow-up, and reminders for routine exams (10, 11).

Smart cities can provide high-quality, effective medical services and care. Targeted examinations and trend analysis can improve medical services by using various technologies, including electronic health records (EHRs), the Internet of Medical Things (IoMT), mobile cloud computing (MCC), and machine learning applied to vast amounts of diverse data (12). In addition, smart cities can offer safe and smart transportation of pharmaceutical products, preventing health issues caused by incorrectly delivered and/or fraudulently replaced products (11). However, it is essential to understand that smart cities are not applicable without challenges. The implementation of efficient platforms and MCC decisions to share online information between stakeholders is a setback which requires overcoming (12). If these challenges are solved, more mature decision-making and engagement of citizens can be attained (12). Jordan has committed to the digital transformation of government and society through national platforms, e-payment and paperless services, and has recognized the importance of cloud computing, AI and the IoT (13, 14).

Therefore, community pharmacies in Jordan must reposition themselves to meet the needs and infrastructure of modern smart cities. However, most literature on smart city healthcare has focused on physicians, nurses or the public in high-income settings, and pharmacists and pharmacy students in the Middle East and North Africa remain underrepresented, despite differences in health -system resources, regulation and digital infrastructure. To our knowledge, this is the first study to address this question in Jordan. This study therefore assessed pharmacists' and pharmacy students' perceptions of smart city healthcare technologies and identified the profession-specific benefits and barriers to their implementation.

Methods

Study Design and Study Population

This is a web-based cross-sectional study that evaluated pharmacists' and pharmacy students' perceptions of smart city development in Jordan. The research was conducted between June and September 2024. Respondents were eligible if they were 18 years or older. In addition, pharmacists must hold at least a diploma (assistant pharmacist) or bachelor's degree in pharmacy and reside or work in Jordan, or be undergraduate pharmacy students enrolled at a Jordanian university in their third year or above.

Participants were enrolled using non-probability convenience and snowball sampling. Participants were asked to confirm their understanding, eligibility, and consent. The survey was created and structured using Google Forms®. Participants provided electronic informed consent by ticking the required consent box, and only those who consented could proceed with the questionnaire. Participation was voluntary and unpaid, and participants could stop at any time without giving a reason. The research team collected no names, email addresses, or other identifying information, stored responses anonymously, and accessed them only for analysis. The survey was distributed via several social media platforms, including email, WhatsApp, and Facebook, targeting pharmacists and pharmacy students with access to the online survey.

Sample Size

Sample size was predicted using the Epi Info program. Assuming an expected proportion of 50%. The minimum sample size was calculated assuming a 95% confidence level, a design effect of 1.0, and a 5% margin of error (15). Therefore, the ideal sample size was 384 participants. Considering the non-response rate, 10% of the estimated sample size was added. Hence, the final sample size was calculated to be 422 (15).

Questionnaire Design

The study questions were adapted from several survey instruments used in similar studies to measure perceptions and attitudes about smart cities (16, 17). The first part of the questionnaire covered questions about demographic information. The second part included questions designed to measure participants' perceptions of how smart cities affect pharmacists' roles. The third part measured participants' perceptions of how smart cities affect patients' healthcare. The final part measured participants' perceptions of smart cities and the obstacles they may face during application and development. Community and clinical pharmacists assessed the face and content validity of the survey. A pilot study was conducted with ten participants, who were not included in the analysis. Cronbach's Alpha was used to evaluate internal consistency reliability, which produced a coefficient of 0.8, showing good instrument reliability.

Statistical Analysis

Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS), Version 26.0 (IBM Corp., New York, USA). Qualitative data were displayed as frequencies and percentages. Associations between participants' demographic properties and their perceptions of smart city healthcare technologies were examined using Pearson's chi-square test. Both the demographic variables and the response variable were dichotomized prior to analysis. Age was grouped as (≤ 29 years versus ≥30 years), educational level as (bachelor's degree or below versus postgraduate degree), and years of experience as (no practice experience versus any practice experience). Where any expected cell count was below five, Fisher's exact test was applied. p <0.05 was considered statistically significant. The two ordinal items were reported descriptively and were not included in the association analysis.

Results

Demographic Properties of the Participants

In total, 356 women (68.1%) and 167 men (31.9%) participated and completed the questionnaire, and most were 29 years old or younger (415; 79.3%). Of the 523 participants, 192 (36.7%) were undergraduate pharmacy students and 331 (63.3%) were pharmacy graduates; overall, 275 (52.6%) owned a bachelor's degree, and 37 (7.1%) owned a postgraduate degree. Table 1 displays participants' demographic properties. Most participants heard about smart cities through social media (186; 35.6%) and through their education (118; 22.6%), as presented in Table 2.

Table 1. Demographic Properties of the Participants, N=523.

Characteristics	N (%)
Gender	
Female	356 (68.1)
Male	167 (31.9)
Age	
20-29	415 (79.3)
30-39	69 (13.2)
40-49	26 (5.0)
≥ 50	13 (2.5)
Educational Level*	
Assistant pharmacists	19 (3.6)
Bachelor	275 (52.6)
Master	30 (5.7)
PhD	7 (1.3)
Years of Experience	
Students	192 (36.7)
Graduate, not yet employed	36 (6.9)
< 1	9 (1.7)
1-5	177 (33.8)
> 5	109 (20.8)

Table 2. Participants' sources of information about the smart city concept .

Source	N (%)
Social media	186 (35.6)
Education	118 (22.6)
From the questionnaire	97 (18.5)
Lecture or conference	42 (8.0)
Continuous education program	35 (6.7)
Friend	34 (6.5)
Television/ radio	11 (2.1)

The Influence of Smart City Healthcare Technologies on the Role of Pharmacists

Pharmacists and pharmacy students perceived smart city medical services as important and useful. Most participants (494; 94.5%) indicated that smart city healthcare technologies increase the productivity and efficiency of pharmacy healthcare workers. It will also offer pharmacists better and more rapid access to patient data (493; 94.3%).

Furthermore, most participants (504; 96.4%) believe a smart city will provide better infrastructure for digital prescriptions and electronic pharmacy services, such as a computer program that facilitates counting and purchasing pharmacy products. Among the key benefits identified by pharmacists and pharmacy students is improved collaboration between pharmacies and other healthcare providers, which a smart city can support (Table 3).

The Influence of Smart City Healthcare Technologies on Patients and the Quality of Healthcare Process

The results revealed that 475 participants (90.8%) expected smart city technologies to improve patient adherence, including 254 (48.6%) who expected adherence to improve greatly and 221 (42.3%) who expected to improve somewhat. Most participants agreed that using such smart services in pharmacies can shift decision-making from prescription-based treatment to patient-centered care (494; 94.5%), improve management of patients' healthcare needs (502; 96.0%), and improve management of pharmacists' time (495; 94.6%). In addition, 494 (94.5%) agreed that smart city technologies could enhance healthcare outcomes and reduce healthcare costs. Regarding telepharmacy, 467 participants (89.3%) rated smart city technology as very (188; 35.9%) or moderately (279; 53.3%) effective in providing telepharmacy services, 48 (9.2%) as slightly effective, and 8 (1.5%) as not effective (Table 4).

Table 3. The Influence of Smart City Healthcare Technologies on the Role of Pharmacists.

Question	N(%)
A smart city can improve the efficiency of the pharmacist's role	
Yes	494 (94.5)
No	29 (5.5)
Smart cities will impact the number of staff pharmacists	
Yes	478 (91.4)
No	45 (8.6)
Smart cities will provide better access to real-time health data for pharmacies	
Yes	493 (94.3)
No	30 (5.7)
Smart cities can facilitate better collaboration between pharmacies and other healthcare providers	
Yes	499 (95.4)
No	24 (4.6)
Smart cities will offer better infrastructure for digital prescriptions and electronic pharmacy services	
Yes	504 (96.4)
No	19 (3.6)

Table 4. The Benefits of Smart City Healthcare Technologies on Patients and the Healthcare Process.

Question	N(%)
The influence of specific smart city technologies on patient adherence	
Greatly improve adherence	254 (48.6)
Somewhat improve adherence	221 (42.3)
No change in patient adherence	34 (6.5)
Somewhat decreased adherence	11 (2.1)
Greatly decrease adherence	3 (0.6)
Smart city technologies could enhance healthcare outcomes and reduce healthcare costs	
Yes	494 (94.5)
No	29 (5.5)
The smart city technology will be effective in providing telepharmacy services	
Yes; very effective	188 (35.9)
Yes; moderately effective	279 (53.3)
Yes; slightly effective	48 (9.2)
No; not effective	8 (1.5)
Using such smart services in pharmacies can shift decision-making from physician-based to patient-centered care	
Yes	494 (94.5)
No	29 (5.5)
Using such smart services in pharmacies can allow for better management of patients' healthcare needs	
Yes	502 (96.0)
No	21 (4.0)
Using smart services in pharmacies allows for better management of pharmacist time	
Yes	495 (94.6)
No	28 (5.4)

Participants' Perception Towards Smart City

In contrast, general participants believe smart city applications will face all previous obstacles (76.4%)" now reads: "When asked about the obstacles facing smart cities, participants cited the cost of implementation and maintenance (54; 10.3%), multidisciplinary connections (28; 5.4%), data security and privacy concerns (15; 2.9%), regulatory and compliance issues (15; 2.9%) and interoperability of systems (11; 2.1%).

Most participants (76.4%), however, indicated that smart city applications would face all of these obstacles (Table 5). When asking participants about the obstacles of smart cities, most participants (400; 76.5%) selected (all of the above), Table 6.

Among the 123 participants who selected a single obstacle, the cost of implementation and maintenance was the most common (54; 43.9%), followed by multidisciplinary connections (28; 22.8%), data security and privacy concerns (15; 12.2%), regulatory and com-

pliance issues (15; 12.2%), and interoperability of systems (11; 8.9%) (Table 6). Chi-square analysis showed that participants' perceptions were largely independent of age, educational level, and years of experience (Table 7). The only significant association was with gender: 299 of 356 female participants (84.0%) agreed that such smart services are easy to learn to use, compared with 126 of 167 male participants (75.4%) ($X2 = 5.44$, $p = 0.02$). Given the 48 tests performed, this association would not remain significant after Bonferroni correction (adjusted $\alpha = 0.001$) and should be regarded as exploratory. However, perceptions were otherwise uniform across demographic subgroups.

Table 5. Participants' Perception Towards Smart City.

Question	N (%)
Smart city technology will result in better health for citizens	
Yes	492 (94.1)
No	31 (5.9)
Smart city technologies can create new job opportunities	
Yes	450 (86.0)
No	73 (14.0)
Smart city technologies can reduce the cost of living	
Yes	415 (79.3)
No	108 (20.7)
It is easy to use such smart services	
Yes	425 (81.3)
No	98 (18.7)
I think smart cities are applicable in Jordan	
Yes	394 (75.3)
No	129 (24.7)
How many years do you think Jordan needs to become a smart city?	
< 10	151 (28.9)
10-20	272 (52.0)
21-30	25 (4.8)
>30	51 (9.8)
Never	13 (2.5)
I don't know	11 (2.1)

Table 6. Perceived obstacles to implementing smart city applications.

Obstacle	N (%)
Cost of implementation and maintenance	54 (10.3)
Multidisciplinary connections	28 (5.4)
Data security and privacy concerns	15 (2.9)
Regulatory and compliance issues	15 (2.9)
Interoperability of systems	11 (2.1)

Table 7. Association between participants' perceptions and demographic characteristics.

Question	Gender	Age	Education level	Years of experience
A smart city can improve the efficiency of the pharmacist's role	0.267 (0.60) *	3.22 (0.07) *	(0.15) **	0.034 (0.85)*
Smart cities will influence the number of staff pharmacists	2.399 (0.12) *	0.35 (0.55) *	(0.56) **	0.041 (0.84) *
Smart cities will provide better access to real-time health data for pharmacies	0.953 (0.33) *	1.185 (0.28) *	(0.72) **	0.118 (0.73)*
Smart cities will offer better infrastructure for digital prescriptions and electronic pharmacy services	0.939 (0.33) *	(0.77) **	(1.0) **	0.307 (0.57) *
Using such smart services in pharmacies can allow for better management of patients' healthcare needs	1.202 (0.27) *	(0.16) **	(1.0) **	0.782 (0.37) *
Using such smart services in pharmacies can shift decision-making from physician-based to patient-centered care	0.414 (0.52) *	0.062 (0.80) *	(1.0) **	0.346 (0.56) *
Using smart services in pharmacies allows for better management of pharmacist time	0.736 (0.39) *	0.955 (0.33) *	(1.0) **	0.168 (0.68)*
Smart city technology will result in better health for citizens	0.002 (0.97) *	0.069 (0.79) *	(0.90) **	0.387 (0.53) *
Smart city technologies can create new job opportunities	1.611 (0.20) *	0.598 (0.44) *	1.254(0.26) *	0.128 (0.72) *
Smart city technologies can reduce the cost of living	0.663 (0.42) *	0.661 (0.42) *	0.803(0.37) *	0.306 (0.58) *
Smart cities can facilitate better collaboration between pharmacies and other healthcare providers	1.326 (0.25)*	0.414 (0.51)*	(0.48)**	0.414 (0.51)*
It is easy to use such smart services	5.44 (0.02) *	0.003 (0.96) *	0.003 (0.96) *	0.016 (0.90) *
I think smart cities are applicable in Jordan	1.597 (0.21) *	0.807 (0.37) *	1.054 (0.31) *	0.011 (0.92) *

*Values are Pearson χ^2 (p-value). ** Fisher's exact test p-value used where any expected cell count was below 5. Bold indicates statistical significance at $p < 0.05$.

Discussion

This study used a cross-sectional design to evaluate Jordanian community pharmacists' and pharmacy students' perceptions and attitudes toward smart city healthcare technologies. Participants became aware of smart city healthcare technologies through social media and general education rather than professional or continuing-education sources. This finding highlights the significant influence of social platforms on the Jordanian population, where extensive use of these platforms obviously affects perceptions and may reflect excitement for using technology more than grounded, direct professional experience. Also, it enables fast sharing of information, making them a chief source for learning about innovations such as smart city healthcare technologies (18).

Overall, participants expressed favorable attitudes on most items related to pharmacists' roles and patient care. This reflects a broad acknowledgement of the possible benefits that such technologies can create for pharmacy practice. The magnitude of agreement in our study, however, is higher than that typically reported among physicians and nurses in comparable studies (19).

In Jordan, pharmacists traditionally perform essential tasks such as dispensing medications, a key function within the healthcare system (20). However, from a smart city perspective, these traditional roles can be developed and optimized enabling pharmacists to offer a broader range of health services. For instance, pharmacies can use smart systems to collect and analyze patients' clinical data, facilitating more personalized and efficient care (10, 21). Furthermore, they improve patient safety by notifying staff of medication precautions and contraindications, reducing the risk of medication-related problems. Moreover, smart city healthcare technologies enable active and efficient patient follow-up and timely reminders for routine exams, boosting overall patient care (8, 10).

Participants were similarly optimistic about the influence of smart city health care technologies to improve health and adherence, a perspective that aligns well with real-world examples of smart city implementations during the COVID-19 pandemic (22). For instance, cities like Hong Kong and Rio de Janeiro utilized smart technologies to manage the crisis efficiently, from improving patient adherence to ensuring timely access to healthcare services (22). This mirrors participants' views that smart city technology can shift decision-making toward patient-centered care and promote collaboration among healthcare providers (23).

In addition, participants' high expectations for telepharmacy and adherence are broadly consistent with earlier Jordanian studies. In a survey of pharmacy students, pharmacists and physicians in Jordan, 93.0% supported a website providing pharmaceutical care, and 89.8% agreed that a comprehensive patient database would help reduce medical errors (24).Community pharmacists in Jordan have likewise shown positive attitudes and willingness towards implementing AI in pharmacies(17).

By contrast, hospital pharmacists in Saudi Arabia were uncertain about telepharmacy, with only 29.3% agreeing that it improves medication adherence(25). This difference may reflect our broader, more student-heavy sample and the general wording of our items and suggests that expectations may become more cautious as pharmacists gain direct experience with specific services.

Most participants (94.1%) expected smart cities to improve citizens' health. This expectation is consistent with reports that smart city initiatives can support urban planning, improve housing and access to essential services, and contribute to healthier living conditions(26). Smart city initiatives have also been associated with reduced pollution and congestion, greater social engagement, and

more efficient resource use, which may support both physical and mental well-being (26, 27).

Most participants (86.0%) also expected smart cities to create new job opportunities. This expectation aligns with reports from other countries where smart city development has been linked to economic growth and job creation. In Barcelona, for example, smart city projects have been reported to support the regeneration of older districts, attract companies and generate employment(28, 29). Whether similar benefits would be achieved in Jordan will depend on local economic, infrastructural and policy conditions, and cannot be inferred from participants' expectations alone (28).

While participants recognized the benefits of smart cities, they also expected substantial obstacles. Implementation and maintenance costs were the most common issue (43.9%). This finding aligns with previous studies on smart cities in Jordan, which identified several hindrances such as a vague vision of a smart city implementation, lack of collaboration, and weak public-private contribution (30).

Other significant challenges highlighted by the participants were data security and privacy issues, system interoperability, and regulatory and compliance concerns. These concerns underline various barriers Jordan may face in implementing smart cities. Tackling these obstacles should involve thorough planning, large investment, and collaboration and partnership across multiple sectors (31).

Limitations of the Study

This study has some limitations that should be considered when explaining the findings. First, the cross-sectional design can't establish a causal relationship because it reflects participants' perceptions at a single point in time. Second, convenience and snowball sampling methods using social media platforms may cause selection bias and limit representativeness. In addition, more than one-third of the sample were students, and the questionnaire did not record the practice setting (e.g., community, hospital, or industry). This may restrict generalizability to the pharmacist population in Jordan. Third, response bias is possible because the questionnaire was self-administered. Fourth, the lack of multivariate analysis reduces the potential to detect independent predictors while controlling for suspected confounders. Fifth, the survey wording and items may shape participants' responses, which could contribute to the high levels of agreement observed. Finally, several association tests were conducted without adjusting for multiple comparisons, so that some significant results may have resulted by chance.

Conclusion

Pharmacists and pharmacy students in Jordan believe that smart city healthcare technologies will be valuable and advantageous to pharmacy practice. However, effective implementation will require addressing key challenges, including implementation and maintenance costs, data security, and interoperability.

Ethical Approval and Consent to Participate

The Institutional Review Board (IRB) at ……. approved the study (approval reference 2024-PHA-29). It was conducted in accordance with the principles of the Declaration of Helsinki. The first page of the online survey explained the study's aims, the expected completion time, and that participation was anonymous and voluntary. All participants confirmed their agreement through electronic informed consent. They could stop at any time without giving a reason. No identifying information was collected.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Data availability

The anonymized data analyzed in this study are available from the corresponding author upon request.

Funding

This research received no specific grant.

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