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Urban policies for in-house vaccination of vulnerable people during COVID-19 based on critical systems learning

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ABSTRACT

BACKGROUND AND OBJECTIVES: Urban managers and local authorities tried to provide public health services to vulnerable groups and establish urban justice during the COVID-19 pandemic. This research aims to evaluate the vaccination services of vulnerable groups at their houses in Tehran during the COVID-19 pandemic through critical rethinking. Then it provides policies for developing an in-house healthcare services system for vulnerable groups.

METHODS: This study applies a multi-methodology and multi-paradigm exploratory approach to design a systemic intervention by using qualitative and quantitative methods. For this purpose, the activists involved in the vaccination services of vulnerable groups in Tehran are primarily interviewed based on Critical Systems Heuristics methodology, and then the responses to the boundary questions in four basic areas, including motivation, control, knowledge, and legitimacy, have been analyzed. Afterward, the Strategic Assumptions Surfacing and Testing methodology, a systems approach for learning in complex problem situations, is used, along with the participation of urban decision-makers, to reveal the strategic assumptions for the development of an in-house vaccination services system for vulnerable populations. Finally, after dialectical discussions, system development solutions have been synthesized and integrated, and based on the importance level and certainty of the right assumption, certain planning regions have been detected.

FINDINGS: Generally, healthcare services to vulnerable groups during the pandemic must be redefined based on the boundaries of control, knowledge, and legitimacy. According to the findings, 34 strategic defaults were identified and 17 defaults were proposed in the secure planning area, including: redefining the provision of healthcare services to vulnerable groups during the pandemics; providing services to all vulnerable groups during disasters through Tehran's joint emergency response call center; providing stable financial resources to perform services to vulnerable populations during the pandemics; collecting, updating, and integrating the related databases (such as elderlies, patients, people with disabilities, etc.); training service providers (e.g. call center operators, vaccinators, etc.) in accordance with the specific situations of vulnerable groups; developing guidelines for providing in-house services to vulnerable people; obliging the managers to be accountable for obeying protective laws relating to vulnerable groups in disaster; identifying the potential capacities of the private sectors and nongovernmental organizations; considering a medical support team; consulting with advisors and caregivers of vulnerable groups; using temperature recording devices to ensure the cold chain of vaccines; and setting up local disaster management support bases in order to assure the agility of the provided services to the vulnerable populations in Tehran.

CONCLUSION: The current study deals with the critical rethinking of providing health services to vulnerable populations during a pandemic, by designing a systemic intervention. Besides finding learning fields from the COVID-19 experiences, this research explores the strategies for redesigning and developing a more efficient healthcare service system for vulnerable groups in disasters like the COVID-19 pandemic.

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INTRODUCTION

The coronavirus disease (COVID-19) posed significant challenges to universal public health (Moodley *et al.*, 2021). Despite the impact of this virus on the general population, its related rates of infection and death were higher in socially underserved and vulnerable populations all across the world (McNeely *et al.*, 2020). "Vulnerable people" simply refers to disadvantaged sections of the community that require close attention, special complementary consideration, and enhanced protection (Shivayogi, 2013), which can involve children and seniors; pregnant women; people with impaired intellectual, physical, psychological, or sensory functioning; drug addicts; etc. The COVID-19 pandemic intensified the existing health inequities and revealed that people from lower socio-economic groups of society are more exposed to the virus and more vulnerable to the disease (Dassieu *et al.*, 2021). The COVID-19 pandemic demonstrated that deprived and vulnerable populations of societies are mostly exposed to the detrimental effects of the pandemic (Ashcroft *et al.*, 2021). This recent pandemic provided a historic paradigm to examine and dispute the values of economic, social, environmental, and cultural belief systems (Haley *et al.*, 2021). Cities have two main tasks in dealing with public health crises; one is to deal with the sudden mass of sick people, and the other is to ensure normal living conditions for every resident, especially the most vulnerable ones. Local governments have to ensure higher living standards for their growing populations (Guida & Carpentieri, 2021). Implementing new policies during the pandemic, as the COVID-19 experience has proved, can play a significant role in mitigating its detrimental impacts and protecting lives (Ashcroft *et al.*, 2021). Authorities had to decide during the COVID-19 pandemic about the priority groups for vaccination in a changing socio-epidemiological landscape, where the success of large-scale non-pharmacological interventions needs widespread social acceptance (Jentsch *et al.*, 2021). In this area, extensive studies have been conducted to investigate the inequities caused by the pandemic. Bilal *et al.*, (2022) studied major cities in the United States to investigate the health inequalities, and unfair and systematic differences in health between different groups of people, across urban areas during the COVID-19 pandemic. They concluded a trend of inequalities in the field of health based on demographic characteristics such as race, ethnicity, neighborhood, and city. The results of their study revealed higher age-adjusted mortality in non-Hispanic Black populations, compared with non-Hispanic White persons in all the studied cities. Ngcamu & Mantzaris (2021) determined the socio-economic effects of COVID-19 on vulnerable communities in South Africa. They revealed the frustration of civil society organizations in providing humanitarian aid to the affected groups. They mentioned fragmentation, bureaucracy, mismanagement, and corruption of the South African government's administration as a negative factor affecting the well-being of vulnerable people, who live in informal settlements. Ndumbe-Eyoh *et al.*, (2021) investigated the factors affecting inequalities in the field of health. They showed that equity and justice have not been integrated in the planning and response phases of the COVID-19 pandemic. They stated that fully exploiting political opportunities can be the key to leading to social transformation. In a qualitative study, Kaihlanen *et al.*, (2022) examined the challenges experienced by vulnerable populations in Finland in using digital health services during the COVID-19 pandemic and deduced that along with the increasing digital health services, traditional face-to-face services must be offered to ensure equal access of all society groups to services. Using the examples of two social organizations that provide services to homeless and addicted people, Farkas & Romaniuk (2020) explored the support services for vulnerable populations during the COVID-19 outbreak and presented some insights for future social work. Through systematic review and meta-analysis, Nam *et al.*, (2021) compared the mental health effects of coronavirus disease on non-vulnerable populations and various vulnerable groups, including people with chronic diseases, patients with serious mental illness, elderly people, and pregnant women. The results of this study showed that the mental health of each vulnerable group has been impacted differently by the pandemic. In a qualitative study, Nasiri *et al.*, (2023) explored the leaders' experiences on how local authorities in Tehran prevent the spread of coronavirus infection among socioeconomically vulnerable groups. According to the experts' opinions, developing protection plans for vulnerable populations and providing resources outside of the

bureaucracy will help policymakers to be prepared for responding to disasters. Extensive studies have also investigated government policies and plans on how to ration the coronavirus vaccine, with a concentration on vulnerable groups. Applying a triple-coding method, Strodel *et al.,* (2021) analyzed the United States government programs in prioritizing the COVID-19 vaccine for incarcerated people over other vulnerable communities. They showed that COVID-19 vaccine allocation programs in 50 states and the District of Columbia do not prioritize incarcerated individuals. Moreover, there is little guidance on inmate vaccination protocols, and due to inappropriately prioritizing incarcerated individuals for vaccination, a critical opportunity to mitigate COVID-19 is missed. Jentsch *et al.,* (2021) formulated a mathematical model of SARS-CoV-2 infection, in which social and epidemiological dynamics interact. They identified four COVID-19 vaccine prioritization strategies: prioritizing people older than 60 years, prioritizing people younger than 20 years, vaccinating uniformly according to age, and a new contact-based strategy. They stated that the most effective vaccination strategy to reduce the mortality of COVID-19 is dependent on the time course of the pandemic in the population. Schmidt (2020) examined vaccine rationing and social justice in response to COVID-19 and argued that for ethical, epidemiological, and economic reasons, rationing approaches should prioritize structurally and historically disadvantaged groups, even if this results in shorter overall life expectancies. Although the complexity of cities has long been recognized by urban health scientists and decision-makers, it has not yet been functionally integrated into urban health research, policy, and practice (Gatzweiler *et al.*, 2023), and limited studies have dealt with managing the complexity of urban health systems. Haley *et al.,* (2021) addressed the value of integral critical systems during the COVID-19 outbreak and considered the potential role of systems thinking in managing communities' responses to the pandemic. They used examples from Brazil and the UK to investigate the validity of current disaster management systems. Nguyen *et al.,* (2023) examined the application of an integrated management approach to coping with the uncertainty of COVID-19 using a comprehensive systems intervention. To clarify the strengths and weaknesses of different management approaches, three different countries from Europe, Oceania, and Asia have been chosen as typical case studies. The results showed that decision-makers can take advantage of an integrated management approach in dealing with crises and definitively revealed this approach's superiority, regardless of the cultural environment. Actually, in the recovery phase of disaster management in the coronavirus disease, the attention of city managers was paid more than ever to keeping a rethinking and critical position of urban management experiences (Nasiri *et al.*, 2022). Using a critical systems heuristics perspective, Godage *et al.* (2023) evaluated the sustainability of a hospital digital health system in Sri Lanka through key stakeholders' engagement. A holistic approach is required to assess the sustainability of digital health systems, including obtaining multiple stakeholders'/beneficiaries' perspectives, based on Ulrich's concept (boundary judgment which is the initial judgment and overview of the system). They concluded that the theoretical concept of Critical Systems Heuristics (CSH) can be applied in the sustainability assessment of digital health systems by various stakeholders. Implementing ethics in medical Artificial Intelligence (AI) is a complex issue that requires a systems approach (Goirand *et al.*, 2023). Although CSH has been effective in developing critical systems thinking, it has not been fully exploited compared to soft system approaches, like Soft Systems Methodology (SSM) and cognitive mapping. This may be partially because of the complexity of the underlying idea of CSH (Hutcheson *et al.*, 2024). The system approach emphasizes considering the values of all stakeholders in the design and decision-making (Kunc (2024), Driscoll *et al.,* (2022), Samadi-Foroushani *et al.,* (2024), and Edson (2017)). A critical understanding of the system places the concept of borders at the center of systemic thinking and shows how different borders of a problem can lead to different perceptions and solutions (Midgley & Rajagopalan (2021), Ulrich & Reynolds (2020) and Ulrich & Reynolds (2010)). It requires paying special attention to deprived stakeholders, especially those who are affected by the plans but are not included in the design process. Applications of CSH are presented in (Midgley & Rajagopalan (2021), Algraini & McIntyre-Mills (2018), Dehghan Nayeri et al. (2020), Hutcheson et al. (2023)). Moreover, Strategic Assumptions Surfacing and Testing (SAST) is a systems approach for learning

in complicated problem situations (Barabba & Mitroff (2014) and Mitroff (2016). Using dialectical dialogue helps managers to encourage a collaborative approach to problem management. The involvement of a large number of decision-makers provides the possibility of different views and facilitates the implementation of new solutions. In recent studies (Novita Wahyu Setyawati *et al.* (2022), Bachri *et al.* (2021), Kholil *et al.,* (2021), Salahudin *et al.* (2019), Keyhanpour & Khalifehei (2023), Nasiri *et al.,* (2024), Zlatanović (2016) and Susanto *et al.,* (2019)), the application of SAST in providing strategic solutions for complex problems have been presented. With the spread of the COVID-19 pandemic, urban managers and local authorities in Tehran decided to provide public health services to vulnerable communities to establish urban social justice. For this purpose, before the introduction of the vaccine, measures such as testing for COVID-19 in sanatoriums; providing health, medical, and educational services and distributing health packages to working and street children and garbage collectors; and sending medical teams to garbage separation garages had been implemented. After the introduction of the vaccine, various plans were put on the agenda to increase urban justice for vulnerable groups, one of which was setting up a call center and providing in-house vaccination services to vulnerable groups in Tehran. According to Tehran's coronavirus disaster management headquarters, a total of 11556 doses of coronavirus vaccine were injected into the vulnerable groups at their houses (Tehran's Corona disaster management headquarters, 2023). Considering critical rethinking, the present study investigates the in-house vaccination service system of vulnerable populations using the hybrid approach of critical systems heuristics and strategic assumptions surfacing and testing. To this end, urban planners and decision-makers have been interviewed to evaluate the in-house vaccination system of vulnerable groups in four basic categories, including motivation, control, knowledge, and legitimacy, and discovered the boundary judgments of the beneficiaries. Besides clarifying learning areas of the COVID-19 pandemic experience, this research reveals the strategic assumptions of the development of the health service system in pandemics for vulnerable people, based on the SAST approach. Finally, by considering dialectical discussions and integrating system development solutions, a certain planning region is proposed. This research is conducted based on the collecting data in Tehran, Iran from 2020 to 2023.

MATERIALS AND METHODS

The current study is action research that analyzes the situation of the problem by focusing on the paradigm of critical systems and multiple methodologies (multi-method and multi-paradigm). In terms of approach, it is exploratory and mixed and uses a combination of qualitative and quantitative methods. The qualitative part of the method deals with the answers of the interviewees to the 12 questions and the integration of the solutions based on qualitative content analysis, And the quantitative part is the prioritization of the solutions based on the group score of experts. This study combines two systematic methodologies, CSH and SAST, to identify developing strategies for in-house vaccination service systems for vulnerable populations. In CSH, the components of the system and its environment will be organized into four basic categories, which include motivation, control, knowledge, and legitimacy (as shown in Table 1), to identify and examine the consequences of boundary decisions.

Strategic Assumptions Surfacing and Testing is a systems approach for learning in complex problem situations. Systems thinking and soft operations research have been successful in contributing to the management of complexity (Masys, 2015). SAST reveals the conflicts and aligns them all as the only way to achieve a constructive synthesis of various worldviews (Jackson, 2019) and (Jackson, 2016). The used methods in SAST are stakeholder analysis, defining assumptions, and ranking assumptions, all of which support the phase of assumptions surfacing in the methodology. The ranking of the assumptions will be done based on the following criteria:

- *What is the importance of these assumptions in terms of their influence on the success or failure of the strategy?*
- *How confident are we about the probability of occurrence or the truth of the statements in the assumptions?*

Finally, the most important assumptions, on which the proposed strategy of the participants depends, will be determined. In this research, the required information has been collected through library research, including documents, reports, related

Table 1: Twelve boundary questions of CSH (Ulrich & Reynolds, 2020)

	Social Roles	***Specific concerns***	***Key problems***
Motivation	*1. Beneficiary* Who is/ ought to be the intended beneficiary of the system?	*2. Purpose* What is/ ought to be the purpose of the system?	*3. Measure of improvement* What is/ ought to be the system's measure of success
Control	*4. Decision-maker* Who is/ ought to be in control of the conditions and resources for the success of the system?	*5. Resources* What conditions or resources are/ ought to be under the control of the system to succeed?	*6. Decision environment* What conditions of success are/ ought to be outside the control of the decision-maker?
Knowledge	*7. Expert* Who is/ ought to be providing the required knowledge and skills for the system?	*8. Expertise* What are/ ought to be the required knowledge and skills for the system?	*9. Guarantor* What are/ ought to be regarded as assurances of successful implementation?
Legitimacy	*10. Witness* Who is/ ought to be representative of those who are negatively affected by but not involved in the system?	*11. Emancipation* What are/ ought to be the opportunities of those negatively affected but cannot argue their interests?	*12. Worldview* What space is/ ought to be available for dealing with different worldviews among those involved in and affected by the system?

Table 2: Information of the interviewees

No.	Education	Expertise	Experience (years)	Responsibility
1	Master of Science	Strategic management	>20	Head of Tehran's Disaster Management Headquarters
2	Doctor of Philosophy	Sociology	<15	Social consultant and geriatrician
3	Master of Science	Urban management	>20	Operations manager and service system planner
4	Doctor of Philosophy	Health in disasters and emergencies	>15	service system planner
5	Doctor of Philosophy	Health in disasters and emergencies	>20	Consultant of medical emergency and health in disasters
6	Doctor of Philosophy	Industrial engineering	<10	service system analyst
7	Doctor of Philosophy	Operations research management	<10	service system analyst
8	Doctor	Medical science	>20	Human resource planner
9	Master of Science	Management	>20	call center operator
10	Master of Science	Social work	<15	Social consultant and specialist of disabled people
11	Master of Science	ICT	>20	call center operator
12	Bachelor of Art	Nursing	<10	Consultant of health and treatment services in medical emergencies
13	Bachelor of Science	HSE	<15	Registrant and vaccinator
14	Bachelor of Art	Management	>20	Planner and coordinator of the vaccination teams
15	Doctor of Philosophy	Psychology	>10	Counselor of psychological services in emergency and medical emergency

laws and regulations, previous studies, a system of in-house vaccination services for vulnerable groups, the call center of Tehran Municipality, and the semi-structured interviews of a combination of key actors involved in the vaccination services of vulnerable groups and urban decision makers of Tehran Disaster Mitigation and Management Organization (TDMMO). The interviewees have been identified by analyzing the beneficiaries of the studied vaccination system. The participants include service providers, such as call center operator, vaccinator, registrant, team coordinator, operation manager; and various specialists, such as social consultant and geriatrician, consultant of medical emergency and health in disasters, and counselor of psychological services in emergency. The details of these people are represented in Table 2. To identify solutions for the development of an in-house vaccination service system for vulnerable groups, the decision makers of TDMMO have participated in group interviews.

RESULTS AND DISCUSSION

Analyzing the extracted data of the vaccination service system of vulnerable groups from Tehran's Corona disaster management headquarters, revealed that in general, 8616 addresses had been registered from September 2021 to March 2023, and 11556 doses of vaccine were injected to vulnerable groups in 22 districts of Tehran; 35% of the vulnerable people who received this service were women and 65% were men. About 50% of this population requested in-house vaccination due to old age and 54% because of physical disability. Fig. 1 demonstrates the distribution of the provided services to vulnerable people during the aforementioned period. As this figure shows, the greatest demand for vaccinations is from November 2021 to January 2022 and the injected vaccine doses were also greater in this period compared to other months. According to Fig. 2, which presents the distribution of vaccination doses based on the districts of Tehran, districts 2, 4, and 5 have received more doses, and districts 19, 21, and 22 had the lowest demands. Fig. 3(a) depicts the medical diseases of

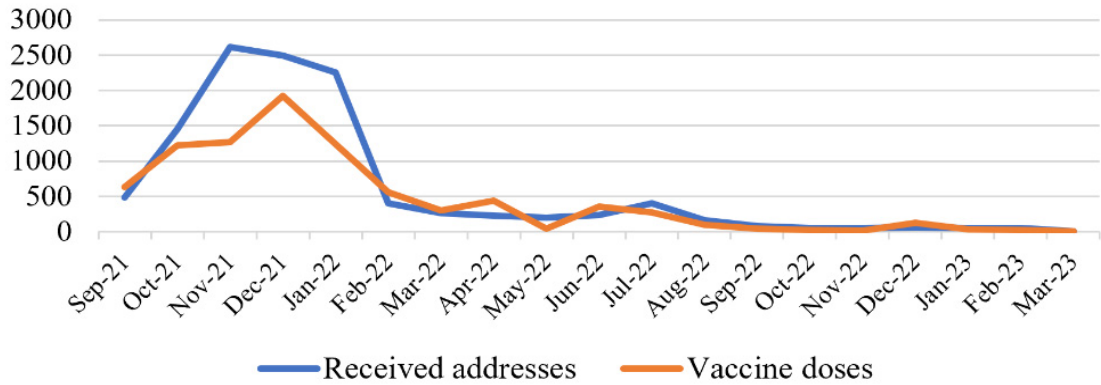

Fig. 1: Distribution of in-house vaccination services provided to vulnerable populations from September 2021 to March 2023 (Tehran's COVID-19 disaster management headquarters)

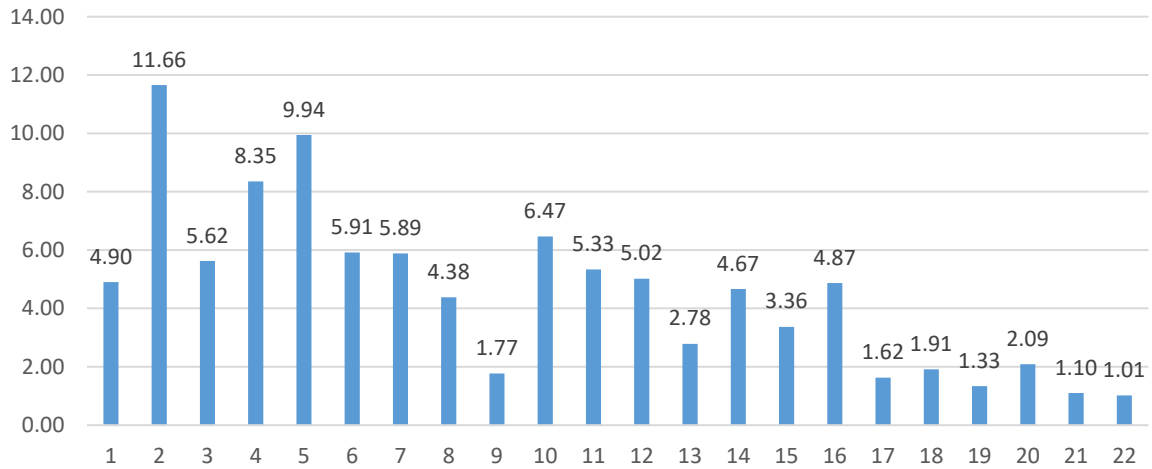

Fig. 2. Distribution of in-house vaccination services provided to vulnerable populations in different districts of Tehran (Tehran's COVID-19 disaster management headquarters)

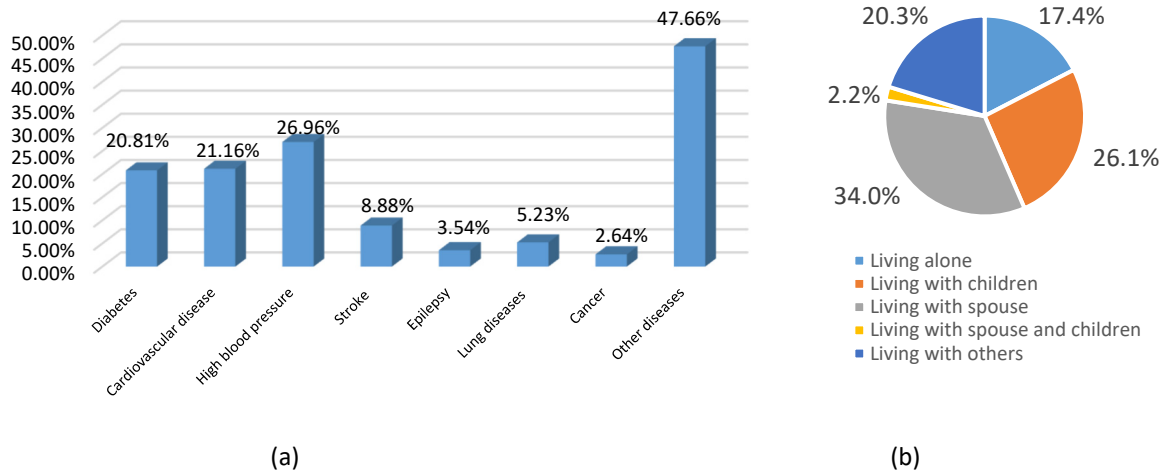

Fig. 3. a) medical records (percentage) and b) life companions (percentage) of vulnerable populations who received in-house vaccination (Tehran's COVID-19 disaster management headquarters)

the vulnerable groups. Examining the disease records reveals that among people who received in-house vaccination services, about 27% had high blood pressure, 21% had cardiovascular problems, and 21% reported diabetes. Some people had also stroke (9%), lung diseases (5%), cancer (2%), or other diseases (47%) in their records. Since every person may have stated more than one issue, the sum of these values is greater than 100%. Moreover, Fig. 3(b) shows the life companions of the vulnerable populations who received in-house vaccination; 17% of applicants lived alone, 26% lived with their children, 34% lived with their spouse, 2% lived with their spouse and children, and 20% lived with others. After analyzing the data of the in-house vaccination services system for vulnerable people, Ulrich's twelve questions have been posed in two cases, the current and desired ones ('was' versus 'ought to be'). The questions and the answers are represented in Table 3.

Considering the SAST methodology, the proposed solutions have been examined during the meetings with the decision makers of the TDMMO, and besides revealing the strategic assumptions of service system development, after dialectical discussions, system development solutions have been integrated. The participants were asked then to rate the proposed strategic assumptions based on two criteria, certainty, and importance, the average of which is represented in Table 4. The participants were also asked to state their opinions about other solutions and measures for solving the key issues. Finally, according to Fig. 4, a certain planning region has been found.

Considering the importance and certainty of the assumptions in Table 4, the certain planning region has been demonstrated in Fig. 4. The strategic assumptions in the first quadrant of the coordinate system represent the certain planning region, which includes the assumptions with higher importance and higher certainty. This includes S01, S02, S03, S04, S06, S07, S08, S09, S11, S12, S14, S18, S19, S20, S23, S28, and S33.

CONCLUSION

Recently, with the emergence of the COVID-19 pandemic, the world faced an enormous challenge in public health. Even though urban health scientists and decision-makers have long acknowledged cities as complex systems, very limited studies have analyzed urban health system issues using complex systems methodologies. Since the critical analysis of crisis management experiences in providing services to vulnerable people during the COVID-19 pandemic in Tehran has not been considered so far, the present study proposes a systemic intervention based on multimethodology-multiparadigm with an innovative combination of two methodologies (CSH and SAST), to critically rethink this issue, create areas for learning from the COVID-19 experience, and provide solutions

Table 3: Summarizing respondents' answers to Ulrich's twelve questions in the current and desired cases ('is' and 'ought to')

	Boundary judgement	The answer to 'was'	The answer to 'ought to be'
Motivation	Q1: Who were/ ought to be the clients of the in-house vaccination service system?	– The Elderly – Physically and mentally disabled people – Patients with special conditions – Managers of senior centers – Elderly family members	– The Elderly – Children – Pregnant women with young children – Physically and mentally disabled people – Patients with special conditions; Drug addicts and people without identity cards
	Q2: What was/ ought to be the purpose of the in-house vaccination service?	– Serving the vulnerable citizens of Tehran – Providing equal opportunity – Preventing the spread of pandemic	– Serving the vulnerable citizens of Tehran – Providing equal opportunity of vaccination to all citizens (social equity) – Preventing/mitigating the spread of pandemic
	Q3: What were/ ought to be the success criteria of in-house vaccination service?	- System startup - Positive feedback from citizens, including vulnerable people who were served and their families - Positive feedback from the Ministry of Health and Medical Education	– The ratio of the citizens who received in-house vaccination to the total vulnerable populations of Tehran – The ratio of the registered requests to the provided services – The waiting time of the vulnerable groups to receive the service – Complying with the expected schedule of vaccination – The quality of providing vaccination services – The level of satisfaction of vulnerable groups from service providers
	Q4: Who was/ ought to be the decision-maker of the in-house vaccination service system?	- The head of TDMMO, on behalf of Tehran's mayor	– Ministry of Health for determining the legal positions, roles, and relationships of the actors – State Welfare Organization of Iran for providing information of disabled populations – National Elderly Council of the Ministry of Labor and Social Affairs for considering the seniors – Tehran Municipality for its access to sanatoriums
Control	Q5: What conditions or resources were/ ought to be available under the control of the decision-makers for the success of the system?	– Volunteers – TDMMO human resources – Medical staff of Shahr Salem Company – Tehran municipality call center and system (137-6) – Municipal cars and taxis – Universities of medical sciences – Vaccinators and registrants – Ensuring the cold chain of the vaccines – Infectious waste management system – Legal gaps related to in-house vaccination services	– Trained volunteers – Financial resources – Databases of vulnerable groups – Efficient call center – Integrated information systems – Available vehicles (taxis, buses, etc.) – Efficiently informing citizens and vulnerable groups – Efficiently managing the volunteers – Legal provisions of in-house vaccination – Announcing capacities of Radio and Television, portals and billboards – GPS for tracking service provider cars – Using intelligent temperature stability in cool boxes to ensure cold chain supply
	Q6: What conditions or resources were/ ought to be as environmental factors?	– Maintaining the cold chain before receiving the vaccines – Receiving various types of vaccines – Coordinating the service delivery time – Receiving complete information – Receiving the same applicant's information from different calls	– Possibility of tracking the service status in an intelligent system by the applicants – Linking the information of vulnerable people to their contact numbers and addresses – The possibility of directing every call to a specific operator – Accessibility to medical information of vulnerable groups – Accessibility to different types of vaccines – Accessibility to emergency medical services in Tehran – The possibility of cultural compatibility between the vaccinator and the service applicant
Expertise	Q7: What kind of expertise and knowledge was/ ought to be necessary to provide in-house vaccination services?	– Registrant and Call center operator – Vaccinator – Driver – Protection unit – HSE inspector	– Vaccination service coordinator; - Registrant; - Vaccinator; - Call center operator; -Driver – HSE inspector – Emergency (doctor, nurse, etc.) – Psychologist and psychiatrist – Social worker and Backup team

Table 3: Summarizing respondents' answers to Ulrich's twelve questions in the current and desired cases ('is' and 'ought to')

	Boundary judgement	The answer to 'was'	The answer to 'ought to be'
Legitimacy	Q8: Which organization or what specialists were/ ought to be involved in designing in-house vaccination services?	– Tehran Disaster Management and Mitigation Organization (TDMMO) – Information and Communication Technology of Tehran Municipality – Shahr Salem Company – Health, treatment and medical education	– Specialist of health, treatment and medical education (doctors, psychiatrists, nurses, etc.) – Specialist of information and communication technology and System analyst and decision maker – Specialist of legal affairs and security unit – Counselors and caregivers of vulnerable groups – Non-profit organizations and Volunteers – Operating staff and Specialists of Safety, Health and Environment (HSE)
	Q9: Who was/ ought to be guaranteeing the success of the system?	– Self-declared reports of in-house vaccine providers	– Government: The Ministry of Health and Medical Education – Corona disaster management headquarters of the country – Tehran's corona disaster management headquarters
	Q10: Who were/ ought to be representing the interests of people who were affected during in-house vaccination?	– Managers of Tehran municipality – Managers of Tehran Disaster Mitigation and Management Organization – Managers of the Ministry of Health and Medical Education	– Tehran Provincial Government – Ministry of Health and Medical Education – Tehran Welfare Organization – Tehran Municipality – Tehran Disaster Mitigation and Management Organization
	Q11: Who or what were/ ought to be there for challenging the fulfillment of the officials' promises to the vulnerable groups?	– Mental perception of the service recipients – Mental perception of citizens – Social networks	– Legislation to support vulnerable people during crisis – Transparency and accountability in implementing laws – Providing transparent reports of the performance of the service providers – Governments' reputation – Media literacy of citizens and vulnerable groups
	Q12: What are/ ought to be the prospects of success?	– Equitable access to vaccination services in Tehran	– Efficient legislation in designing Tehran's disaster management command system – Determining the structure and responsibilities for managing pandemics in Tehran – Determining the position and role of municipality in providing services to vulnerable groups – Trusting the command system and effective cooperation with others – Having access to the information bank of vulnerable groups – Planning services to vulnerable groups to provide social justice – Publishing transparent performance reports

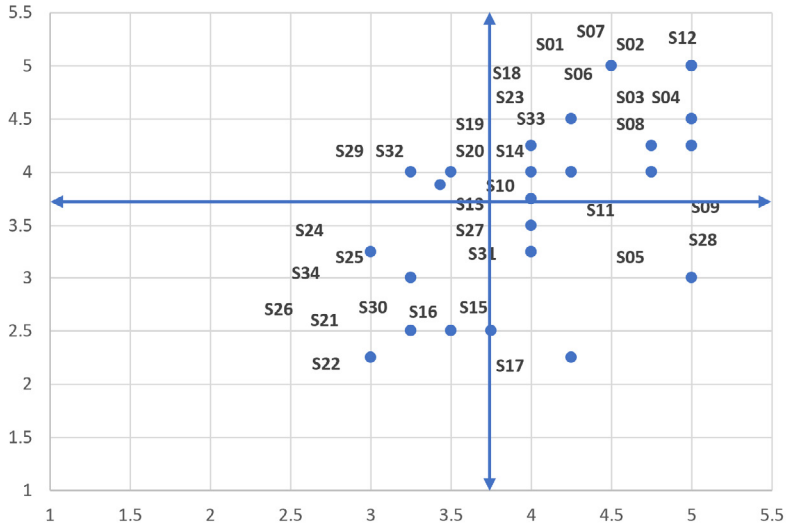

Fig. 4: Demonstration of the strategies by their certainty and importance to find the certain planning regio (The cut off point is determined based on the average of 3.7)

for redesigning and developing the health service system for vulnerable groups during the future pandemics. For this purpose, the extracted data of the vaccination service system of vulnerable groups from Tehran's Corona disaster management headquarters was first analyzed demographically. Then Ulrich's twelve questions have been considered under two scenarios ('was' versus 'ought') and the certain planning region is found by applying the Strategic Assumptions Surfacing and Testing methodology. The contribution of the study is considerable on two levels: firstly, in using an innovative combination of methodologies consistent with the complex dimensions of the problem's situation, and secondly in the application of this combination in providing services to vulnerable groups. Accordingly, the key strategies for system development are identified, which include: designing the pandemic command system; redefining the provision of healthcare services to vulnerable groups during the pandemics; providing services to all vulnerable groups during disasters through Tehran's joint emergency response call center (SOS); providing stable financial resources to perform services to vulnerable populations during the pandemics; collecting, updating, and integrating the related databases (such as elderlies, patients, people with disabilities, etc.); training service providers (e.g. call center operators, vaccinators, etc.) in accordance with the specific situations of vulnerable groups; developing guidelines for providing in-house services to vulnerable people; obliging the managers to be accountable for obeying protective laws relating to vulnerable groups in crisis; identifying the potential capacities of the private sectors and nongovernmental organizations; considering a medical support team; consulting with advisors and caregivers of vulnerable groups; using temperature recording devices to ensure the cold chain of vaccines; and setting up local disaster management support bases in order to assure the agility of the provided services to the vulnerable populations in Tehran. Generally, the research findings based on the Critical Systems Heuristics methodology identify the necessity of redefining the healthcare services system for vulnerable groups in the boundaries of control, knowledge, and legitimacy. This study revealed the values of all involved people and provided a context for critically rethinking the problem according to the concept of "boundary". After summarizing the problem by referring to the urban decision-makers and discussing the situation, it was possible to consider the values of all beneficiaries and consider them in designing the in-house services to vulnerable people. Moreover, the debates on testing the strategic assumptions among managers and urban decision-makers provided opportunities for organizational learning, enhancement of critical rethinking,

Table 4: Strategic assumptions of the development of an in-house health service system for vulnerable groups

Code	Strategic assumption of the development of an in-house health service system	Certainty	Importance
S01	The foundation of a committee for vulnerable groups by the National Disaster Management Organization (NDMO) in cooperation with other organizations that provide services for vulnerable groups, such as the welfare organization, the Ministry of Health and Medical Education, the Relief Foundation, etc., according to the upstream tasks of the documents	4.5	5
S02	Designing Tehran's pandemic crisis command system to clarify the legal positions, roles, and relationships of all parties in providing services to vulnerable groups during the pandemic	5	5
S03	Redefining the provision of health services to vulnerable groups during the pandemics in Tehran	5	4.5
S04	Providing stable financial resources to offer services to vulnerable groups during the pandemic	5	4.5
S05	Designing the vulnerable groups' service system in the Emergency Operations Center (EOC) and its approval in Tehran's disaster management headquarters	5	3
S06	Collecting and updating the database of vulnerable groups, including the elderly, patients, people with disabilities, etc.	5	5
S07	Integrating information databases of vulnerable groups, including the databases in Welfare Organization, Tehran Municipality, Ministry of Health and Medical Education, etc.)	5	5
S08	Planning to provide services to all vulnerable groups during disasters through Tehran's joint emergency response call center	5	4.25
S09	Redesigning the call center (137 system), for providing services to vulnerable groups in the EOC with the possibility of tracking and recording requests and comments/complaints	5	4.25
S10	Communicating with vulnerable citizens through mass media and social networks	4	3.75
S11	Evaluating the system's performance in providing services to vulnerable groups and identifying potential areas for development	4.75	4
S12	Providing legal documents for in-house services to vulnerable groups	5	5
S13	Defining legal requirements for entry of security guards to the houses of vulnerable groups	4	3.5
S14	Obliging the city managers and officials to be accountable and conduct transparent performance in enforcing protective laws for vulnerable groups in disasters	4.25	4
S15	Training volunteer forces to have an effective presentation in the service chain of vulnerable groups	3.75	2.5
S16	Scheduling and routing in-house services to vulnerable groups to reduce the waiting time	3.5	2.5
S17	Including a social worker and a psychiatric mental health nurse in the vaccination team	4.25	2.25
S18	Including a medical support team for advising vaccinators in specific situations	4.75	4.25
S19	Consulting with counselors and caregivers of vulnerable groups to adapt to the expectations and needs of different vulnerable populations (elderly, women, special patients, disabled, etc.)	4	4.25
S20	Tailored training of service providers (call center operators, vaccinators, etc.) based on the specific situations of each vulnerable group	4	4
S21	Holding specialized meetings at the national and local levels, with the participation of all involved actors in providing services to vulnerable groups	3.25	2.5
S22	Holding specialized maneuvers on providing services to vulnerable groups in disasters	3	2.25
S23	Identifying the potential capacities of private sectors and non-governmental organizations in providing services to vulnerable groups during disasters	4.25	4.5
S24	Training to prepare vulnerable people's caregivers/ nurses on how to take care of them during the pandemic	3	3.25
S25	Identifying and networking experts to form specialized teams for vulnerable groups and keep communication	3.25	3
S26	Flexibility in providing services to companions and caregivers of vulnerable groups during disasters	3.25	2.5
S27	Using a vehicle tracking system to ensure the security of the in-house vaccination supply chain	4	3.25
S28	Using temperature recording and warning equipment to ensure the cold chain of vaccines of in-house vaccination services to vulnerable groups	4.75	4
S29	Improving HSE supervision and inspection on infectious waste management of in-house vaccination services for vulnerable groups	3.25	4
S30	investigating the experiences of other countries in providing in-house vaccination services to vulnerable people	3.5	2.5
S31	Considering incentive policies and service compensation for volunteer forces	4	3.25
S32	Networking and strengthening communication to apply the capacity of non-governmental organizations in providing services to vulnerable groups during disasters	3.5	4
S33	Activating more local disaster management bases to improve agility in providing services to vulnerable groups in Tehran	4.25	4
S34	Expanding the provided services to vulnerable groups from the city to the provincial region, according to the received requests	3.25	3

integration, and consensus on the proposed solutions in certain planning. However, the limitations of the present study in terms of methodology and research implementation have revealed areas for future studies. Therefore, future research can apply other critical systems approaches in analyzing in-house services to vulnerable populations during the crisis and compare the results with this study. Moreover, the obstacles to implementing the proposed solutions may be analyzed and the functional model for developing the service system for vulnerable groups can be designed using soft systems methodology, while the participation of all involved stakeholders is considered. Designing a dynamic model of the health service system is another suggestion and the behavior of each proposed solution can be analyzed and compared over time. Besides, the current research has focused on urban management, while future research can consider the problem at local and national levels to identify the areas that can be developed at these levels. Other studies can focus on the needs of vulnerable groups (the elderly, people with disabilities, women, children, and patients with special conditions) during the crisis. A systematic review of other countries and cities' experiences in the field of providing services to vulnerable groups during the COVID-19 pandemic and finding their challenges, successes, and failures is another helpful area that needs further study to enhance the service systems to vulnerable people.

AUTHOR CONTRIBUTION

M. Samadi-Foroushani performed the literature review, and experimental design, analyzed and interpreted the data, and prepared the manuscript text, and manuscript edition. S.S. Miresmaeeli and Z. Molamohamadi performed the experiments and literature review, compiled the data, and manuscript preparation. A. Nasiri reviewed the results and revised the manuscript. All authors reviewed the manuscript.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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ABBREVIATIONS (NOMENCLATURE)

Abbreviation	Complete Word
CSH	Critical Systems Heuristics
EOC	Emergency Operation Center
ICT	Information and communications technology
NDMO	National Disaster Management Organization
SAST	Strategic Assumptions Surfacing and Testing
SSM	Soft Systems Methodology
TDMMO	Tehran Disaster Mitigation and Management Organization

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