frontiers | Frontiers in Sustainable Cities

TYPE Perspective
PUBLISHED 17 March 2025
DOI 10.3389/frsc.2025.1493828

OPEN ACCESS

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RECEIVED 09 September 2024
ACCEPTED 28 February 2025
PUBLISHED 17 March 2025

CITATION
Boyce MR, Gordon M, Bowsher G, Brandes U, Lai I, McClelland A, Wenham C, Zendejas D and Katz R (2025) A research agenda for urban health security. *Front. Sustain. Cities* 7:1493828. doi: 10.3389/frsc.2025.1493828

A research agenda for urban health security

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The relationship between urban environments and infectious diseases has been well documented and cities represent a context in which it is critically important to understand the practice of health security—especially as it relates to epidemics, pandemics, and other acute public health emergencies. Recent trends have emphasized the growth of state-centric models but, because of their unique attributes, cities are deserving of their own concerted health security efforts. This perspective piece provides an overview of ten research themes necessary for advancing health security in urban environments—community partnerships, place management organizations, and grassroots engagement; capacity assessments, simulation exercises, and after-action reviews; governance and financing structures; health threat surveillance systems; policymaker perceptions; private sector engagement; resilient urban infrastructure; risk communication; data-enabled urban systems and technological solutions; and urban networks and organizations. These themes should be pursued with intentionality as a means of ensuring that cities are designed and well-prepared to prevent, detect, respond to, and recover from diverse health threats. Realizing this agenda holds the potential to bolster public health, resilience, and sustainability in our cities and around the world.

KEYWORDS

epidemic, global health, health security, pandemic, public health, resilience, sustainability, urban health

1 Introduction

Health security is a concept representing the nexus of public health and security and an acknowledgment that infectious diseases and other acute public health events can pose threats to security at the local, national, regional, and international levels (Stoeva, 2020; Malik et al., 2021; Kamradt-Scott et al., 2022; McCoy et al., 2023). Historically, it has been primarily concerned with both the proactive and reactive actions necessary for preventing, detecting, responding to, and recovering from infectious disease threats—irrespective of their natural or anthropologic origins—to limit the health, societal, and economic impacts associated with the international spread of disease.

The past two decades have witnessed the growth of state-centric health security models and analyses (Fidler and Gostin, 2006; Fidler and Drager, 2006; Keil and Ali, 2007; Stoeva, 2020; Taylor, 2021). These conceptualizations of health security often construct the world as a "community of common fate" and accentuate the interconnectedness of

nation-states—leading to an emphasis on the concept of global health security (Davies et al., 2015). Still, while preparing for and responding to the international spread of disease requires global governance and cooperation, this conceptualization places relatively greater importance on the security aspects of the concept of health security—which are generally handled by national governments—rather than the health aspects—which are generally handled by subnational units of government (i.e., provincial, state, and/or local levels) (Stoeva, 2020; Malik et al., 2021).

Cities and metropolitan regions represent one subnational context in which it is critically important to understand health security, and urban environments have long been defined by their relationships with infectious disease outbreaks (Ali et al., 2023). The United Nations estimates a majority of the world's population has lived in urban environments since 2007, and that 68 percent of the world's population will reside in cities by 2050 (United Nations Department of Economic and Social Affairs, 2018). Urbanization has been a transformational force of global human development, held benefits and consequences for human health, and contributed to health inequalities, both within countries and cities (i.e., urban–rural and rich-poor divides). Indeed, for much of human history, cities were particularly vulnerable to contagion as a result of socio-spatial factors including those related to urban populations, environmental factors, infrastructure systems, persistent inequalities, and their prominence in international trade (Alirol et al., 2011; Ezzati et al., 2018; Bollyky, 2018; Lee et al., 2020). With the protections offered by scientific advancements (e.g., antimicrobials and vaccinations) and urban development and administration (e.g., sanitation and sewerage systems, building codes, access to healthcare) in the twentieth century, many urban environments developed to be relatively healthier than their more rural counterparts. Still in today's globalized world, the relationship between urban environments and health can be more nuanced. Today, cities play a crucial and strategic role in the detection and spread of, response to, and recovery from health security threats (Lee et al., 2020; Katz and Boyce, 2023). Indeed, because of their large, dense populations and social connectivity, cities can act as the rate-enhancing or -limiting factor in the local, domestic, and international spread of infectious diseases (Ezzati et al., 2018).

The significant risks and unique challenges faced by cities means that these contexts are deserving of dedicated research focused on improving the practice of health security. Here, we argue that understanding health security in cities is essential for ensuring both sustainable urban development and global health. We propose key thematic areas required for ensuring that cities are designed and well-prepared to prevent, detect, respond to, and recover from public health threats and events. These thematic areas include the analysis of: community partnerships, place management organizations, and grassroots engagement; capacity assessments, simulation exercises, and after-action reviews; governance and financing structures; health threat surveillance systems; policymaker perceptions; private sector engagement; resilient urban infrastructure; risk communication; data-enabled urban systems and technological solutions; and urban networks and organizations. Taken together, these thematic areas form the outlines of a robust research and action agenda for urban health security.

2 Key thematic research areas for urban health security

2.1 Community partnerships, place management organizations, and grassroots engagement

Health security in cities transcends governmental policy and often hinges on successfully partnering with and engaging community-based and place management organizations. These organizations are frequently endowed with unique organizational capacities, access to highly localized, marginalized, and/or vulnerable communities, and can wield influence in contexts where government actions and representatives do not wield high levels of trust. As a result, they promote cultural awareness and sensitivity, which are necessary for effectively addressing health security threats. For instance, when communities are not included in the design and implementation of health security initiatives, the detection of threats may be delayed. As such, effectively engaging communities and community-based organizations can bolster the implementation and sustainability of health interventions, promote advocacy and health equity, improve the quality and satisfaction of healthcare services, and contribute to health systems responsiveness and strengthening (Gilmore et al., 2020). Future research should delve deeper into this topic by investigating, for example, the role of communities in decision making before, during, and after public health emergencies (e.g., comparing community engagement during "peace time" and times of crises, how to mobilize and scale-up community action etc.); how community partnerships and engagement have impacted specific aspects of urban health security (e.g., influenced behavior change, promoted health equity, etc.); how task delegation to community partners may improve the effectiveness, efficiency, and timeliness of health security prevention, detection, and response mechanisms; and the nature, scope, and sustainability of these partnerships and arrangements.

2.2 Capacity assessments, simulation exercises, and after-action reviews

As outlined in the International Health Regulations (IHR, 2005), State Parties are required to develop, strengthen, and maintain capacities required to detect, assess, and report public health emergencies. These obligations are supported by a formal Monitoring and Evaluation Framework that includes external and self-assessments of health security capacities, simulation exercises, and after-action reviews (World Health Organization, 2024). These exercises can help to map gaps and vulnerabilities, validate plans and procedures, and enhance the competence of various personnel involved in the detection of, response to, and recovery from public health emergencies. Cities have engaged with higher levels of governance to localize other high-level agendas, such as the Sustainable Development Goals, by using the agenda as a planning framework and for engaging in voluntary sub-national reviews of implementation efforts. Historically, cities have demonstrated some level of engagement in the activities outlined in the IHR Monitoring and Evaluation Framework (Boyce et al., 2022) — and the most recent version of the external evaluation tool has incorporated the subnational level to a certain extent (World Health Organization, 2022) — but additional research efforts may

wish to investigate the benefits of more formally localizing the IHR Monitoring and Evaluation Framework. While these efforts would not maintain any official status—at least using the current iterations of the Framework—they could supplement national-level IHR implementation efforts, reinforce coherence between various levels of government, document understandings of localized risk, vulnerability, and capacities, and be instrumental for aligning and tracking local progress toward high-level policy goals and agendas.

2.3 Governance and financing structures

Effective governance and sustained financing enable governments to achieve health security activities and objectives. While international organizations once represented the core of the global health architecture, recent trends have witnessed the rise of a more expansive ecosystem inclusive of hundreds of state and non-state actors at the subnational, national, regional, and international scales—adding a layer of complexity to governance and financing efforts (Moon, 2019; Gostin et al., 2020). Accordingly, these areas are primed for research that could bolster the efficiency of health security activities, improve the stewardship of limited resources, and maximize the cost-effectiveness of health security expenditures. More specifically, as it relates to urban health security, strong subnational and local governance can complement the efforts of higher levels of governance or serve as a counterweight and supplant them in the case of delays or inaction (Haffajee and Mello, 2020; Rozell and Wilcox, 2020; Peters et al., 2021). Specific areas of research could include sustainable and innovative financing models for health security in urban environments; how various governance modalities (i.e., federal versus unitary systems) impact the implementation and effectiveness of health security activities in cities; how different urban areas provide various social protections and the impact that these have on the response to and recovery from public health emergencies; and investigating the advantages and disadvantages of streamlining the governance of preparedness, response, and recovery efforts across larger metropolitan areas and geographic scales.

2.4 Health threat surveillance systems

Health security is buttressed by surveillance and intelligence, with infectious disease surveillance systems providing early warnings about potential health crises, including infectious diseases, contamination of foods or medications, environmental exposure to harmful agents. Robust surveillance allows for linking data to response-oriented decision-making processes, and informing larger health policy agendas. Still, there remains a need for additional research to support cross-sectoral collaboration as a means of developing modern, accessible, and effective health risk surveillance and reporting systems. Future research should continue to explore opportunities for improving surveillance and reporting efforts in urban environments, including investigating the implementation of novel strategies (e.g., the 7-1-7 framework for outbreak detection and control, citizen science surveillance networks, household monitoring systems, open surveillance data, etc.) and technologies to detect health security threats (e.g., wastewater surveillance for priority pathogens); how surveillance systems may be leveraged to better understand specific risks in urban environments (e.g., changing disease patterns, epidemiological trends in vulnerable populations, etc.); how to more efficiently link surveillance data to decision-making processes at the local, subnational, and national levels; and how to ensure that data are transparent, standardized, and reported in a fashion that maximizes their utility for multiple objectives (e.g., decision-making, research, etc.).

2.5 Policymaker perceptions

The implementation of urban health security policies is inextricably linked to the political, institutional, and economic context in which policymakers operate. Importantly, recent trends in governance have resulted in the increasing decentralization of many governmental functions, including several that are critical for preparing for, responding to, and recovering from health security threats (Katz et al., 2012; Ezzati et al., 2018; Stoeva, 2020). Accordingly, the evidence base supporting urban health security requires more robust research that encourages a shift from the current norm of higher-level policymaking and local-level implementation, to one that includes urban policymakers as key stakeholders in health security efforts. More specifically, there is a need for additional interdisciplinary and cross-sector data to understand how policymakers at various governance levels perceive and prioritize the issue of urban health security, especially as it relates to other urban challenges beyond the traditional bounds of public health practice; how to develop a robust and practical understanding of the health security architecture and key processes amongst policymakers; and how to engage policymakers for more sustained commitments to health security priorities and targets as a means of ending the cycle of "panic and neglect" that has infamously plagued health security.

2.6 Private sector engagement

Private enterprises provide critical capacities and skills that can complement, supplement, and enhance, and in some areas lead public efforts. Because of this, there is a growing demand to effectively engage these stakeholders in public health systems and health threat risk mitigation efforts. Furthermore, private enterprises are compelled to manage the risks posed by health threats and often have business continuity plans—that can be aligned with public health plans and actions—as business and sustainability can be profoundly impacted by health security threats. And, while infectious disease outbreaks are inevitable, their economic consequences can be mitigated and avoided (World Economic Forum, 2019). Leveraging interest in local resilience and health security can, therefore, be mutually beneficial for private companies in their local operations and supply chains. Areas primed for future research include exploring baseline requirements for urban health security and modeling how identified gaps may be filled with private sector engagement; how private enterprises can bolster areas of deficiency, including those related to the provision, quality, and distribution of essential and nonessential health and municipal services during public health emergencies; how to ensure the alignment and integration of public and private systems and data; and examining the incentives that motivate various public- and private-sector actors to pursue partnerships for urban health security, especially when the return on investments are often delayed and difficult to measure.

2.7 Resilient urban infrastructure

The urban responses to various health security threats—including the COVID-19 pandemic and West African Ebola virus disease epidemic—have been supported by the *ad hoc* repurposing of existing infrastructure, resources, and capacities. These efforts have involved physical infrastructure (e.g., parks, stadiums, public buildings, etc.), digital infrastructure (e.g., communications and management systems), health system capacities (e.g., measles and polio contact tracing systems), and human resources—ultimately supporting both absorptive and adaptive resilience (Vaz et al., 2016). Some existing work has been conducted investigating several of these aspects, but future research may wish to further investigate and document how existing urban infrastructure and capacities have been used and repurposed to support the response to public health emergencies; how existing urban infrastructure and capacities and can be retrofitted to better support essential health security functions (e.g., vaccine distribution, hospital surge capacity, etc.); and how future urban development and related policy developments (e.g., municipal building codes) can promote urban resilience and public health preparedness by proactively planning for health security threats in cities. Notably, this challenge grows in administrative complexity as these infrastructure systems and public resources become more deeply integrated in digital management frameworks, which may represent another compelling research avenue.

2.8 Risk communication

Cities are home to large, diverse populations, which can render risk communication during public health emergencies challenging. Finding the effective "trusted source" of information for local community audiences is an ongoing administrative challenge in many urban contexts. Further compounding this challenge is the pervasive dissemination of mis-, dis-, and malinformation, which has become especially prevalent in the age of social media. Indeed, much has been written about the infodemic that accompanied the COVID-19 pandemic and complicated response efforts by making it difficult for the public to find clear, factual information. Accordingly, additional research efforts need to be allocated toward determining what, when, and how urban populations and subpopulations prefer to receive information during public health emergencies; investigating how to better promote trust in public health messaging, particularly amongst diverse urban populations; and identifying effective, implementable, and transferable strategies for distributing messaging and combating infodemics in urban environments.

2.9 Data enabled urban systems and technological solutions

Many urban research efforts are increasingly focused on the potential of digitization and data-enabled urban systems, such as urban management strategies that adopt an open posture to the potential of short feed-back loops offered by the advent of remote sensing, the Internet of Things, and other digital technologies. During the COVID-19 pandemic, numerous cities embraced technological solutions for health security to aid in the emergency response. However, there remains an untapped opportunity to delve deeper into which of these technologies are most efficient and effective for strengthening urban resilience. Moreover, beyond recent efforts to collect broader frameworks of localized data in a low-latency manner, the emerging development and increasingly ubiquitous power of artificial intelligence technologies present additional opportunities for technological solutions to support health security. Accordingly, there is a compelling need to investigate opportunities for developing and implementing new technologies, particularly as they relate to the ethical and secure management of various electronic systems and databases; how technology can be used to fully or partially automate select health security processes as a means of promoting efficiency and reducing stress on limited human resource capacities; and how technology can be used to strengthen supply chains in urban environments, particularly in times of crisis and emergency. These advances are coupled with an increasing dependence on technology and digital systems. Understanding potential points of failure and modeling the consequences is necessary to inform the need to maintain a degree of human skills and manual systems.

2.10 Urban networks and organizations

Recent years have witnessed cities establishing themselves as major players in addressing global issues, such as climate change, noncommunicable diseases, and socioeconomic inequalities, often through organized urban networks (Acuto, 2013; Fernández de Losada and Abdullah, 2019). By establishing patterns of communication and policy exchange, these networks can facilitate the transfer of knowledge and promote advocacy. Although relatively few of these networks explicitly prioritize health security, many that maintain other focus areas temporarily pivoted to include health security during the COVID-19 pandemic response (Boyce and Katz, 2021). Further, officials from the World Health Organization have discussed the possibility of creating an urban network for health security—working intentionally with subnational actors beyond their mandate to engage with Member States. Accordingly, future research may wish to investigate the value added by these urban networks to health security. For instance, compelling research topics could include conducting in-depth case studies of how existing urban networks pivoted to support the COVID-19 pandemic response, as well as other public health emergencies; how knowledge management frameworks and professional best practices are shared amongst and advanced in cities around the world; critically examining how the potential creation of a new urban network focused on health security could galvanize local action for global results; and investigating whether the advocacy efforts of these networks influence larger health security agendas, such as those created by the World Health Organization or nation-states.

3 Discussion

Of importance, these thematic areas should not be considered in isolation, as there is considerable overlap between them. For one example, artificial intelligence presents a significant opportunity to bolster urban risk communication efforts, as these technologies could be used to help officials develop tailored communication content for different literacy levels, languages and cultural contexts. Another

example could include policy maker perceptions and governance, as certain governance aspects are likely to be influenced by how policy makers perceive and prioritize health security. Much like health security itself, the agenda proposed here is inherently multidisciplinary, will require breaking down silos, and will require inputs from a diverse collection of academics, policymakers, and practitioners from cities and metropolitan regions around the world.

As the emergence and re-emergence of infectious diseases continue to accelerate, climate change and environmental degradation continue to intensify, and socioeconomic inequalities continue to widen, there is little doubt of the decentralized, community-based nature of this challenge and the fact that there is no time to squander. The thematic areas in this ambitious agenda must be pursued with haste and intentionality if we wish to prevent and mitigate the impacts of future epidemics and pandemics, ensure equity and solidarity in the response to public health emergencies, minimize economic consequences on communities and supply chains, promote urban sustainability and resilience, and secure health in our cities, countries, and world.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MB: Conceptualization, Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing. MG: Conceptualization, Writing – original draft, Writing – review & editing. GB: Writing – original draft, Writing – review & editing. UB: Funding acquisition, Writing – original draft, Writing – review & editing. IL: Writing – original draft, Writing – review & editing. AM: Writing – original draft, Writing – review & editing. CW: Writing – original draft, Writing – review & editing. DZ: Writing – original draft, Writing – review & editing. RK: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. RK and UB received support from an International Collaborative Grant from Georgetown University.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Acuto, M. (2013). City leadership in global governance. *Glob. Gov.* 19, 481–498. doi: 10.1163/19426720-01903008

Ali, S. H., Connolly, C., and Keil, R. (2023). Pandemic urbanism. Cambridge: Polity Press.

Alirol, E., Getaz, L., Stoll, B., Chappuis, F., and Loutan, L. (2011). Urbanisation and infectious diseases in a globalised world. *Lancet Infect. Dis.* 11, 131–141. doi: 10.1016/S1473-3099(10)70223-1

Bollyky, T. J. (2018). Plagues and the paradox of progress: why the world is getting healthier in worrisome ways. Cambridge: MIT Press.

Boyce, M. R., Asprilla, M. C., van Loenen, B., McClelland, A., and Rojhani, A. (2022). How do local-level authorities engage in epidemic and pandemic preparedness activities and coordinate with higher levels of government? Survey results from 33 cities. *PLOS Glob. Public Health* 2:e0000650. doi: 10.1371/journal.pgph.0000650

Boyce, M. R., and Katz, R. (2021). COVID-19 and the proliferation of urban networks for health security. *Health Policy Plan.* 36, 357–359. doi: 10.1093/heapol/czaa194

Davies, S. E., Kamradt-Scott, A., and Rushton, S. (2015). Disease diplomacy: international norms and global health security. Baltimore: Johns Hopkins University Press.

Ezzati, M., Webster, C. J., Doyle, Y. G., Rashid, S., Owusu, G., and Leung, G. M. (2018). Cities for global health. *Br. Med. J.* 363:k3794. doi: 10.1136/bmj.k3794

Fernández de Losada, A., and Abdullah, H. (2019). Rethinking the ecosystem of international city networks: challenges and opportunities. Barcelona: Barcelona Centre for International Affairs.

Fidler, D., and Drager, N. (2006). Health and foreign policy. *Bull. World Health Organ.* 84:687. doi: 10.2471/blt.06-035469

Fidler, D., and Gostin, L. O. (2006). The new international health regulations: a historic development for international law and public health. *J. Law Med. Ethics* 34, 85–94. doi: 10.1111/j.1748-720X.2006.00011.x

Gilmore, B., Ndejjo, R., Tchetchia, A., de Claro, V., Mago, E., Diallo, A. A., et al. (2020). Community engagement for COVID-19 prevention and control: a rapid evidence synthesis. *BMJ Glob. Health* 5:e003188. doi: 10.1136/bmjgh-2020-003188

Gostin, L. O., Moon, S., and Meier, B. M. (2020). Reimagining global health governance in the age of COVID-19. *Am. J. Public Health* 110, 1615–1619. doi: 10.2105/AJPH.2020.305933

Haffajee, R. L., and Mello, M. M. (2020). Thinking globally, acting locally – the U.S. response to Covid-19. *N. Engl. J. Med.* 382:e75. doi: 10.1056/NEJMp2006740

Kamradt-Scott, A., Teo, Y. Y., and Katz, R. (2022). Singapore statement on global health security. *BMJ Glob. Health* 7:e009949. doi: 10.1136/bmjgh-2022-009949

Katz, R., and Boyce, M. R. (2023). Inoculating cities, volume II: case studies of the urban response to the COVID-19 pandemic. Cambridge: Elsevier Academic Press.

Katz, R., Mookherji, S., Kaminski, M., Haté, V., and Fischer, J. E. (2012). Urban governance of disease. *Adm. Sci.* 2, 135–147. doi: 10.3390/admsci2020135

Keil, R., and Ali, H. (2007). Governing the sick city: urban governance in the age of emerging infectious disease. *Antipode* 39, 846–873. doi: 10.1111/j.1467-8330.2007.00555.x

Lee, V. J., Ho, M., Kai, C. W., Aguilera, X., Heymann, D., and Wilder-Smith, A. (2020). Epidemic preparedness in urban settings: new challenges and opportunities. *Lancet Infect. Dis.* 20, 527–529. doi: 10.1016/S1473-3099(20)30249-8

Malik, S. M., Barlow, A., and Johnson, B. (2021). Reconceptualising health security in post-COVID-19 world. *BMJ Glob. Health* 6:e006520. doi: 10.1136/bmjgh-2021-006520

McCoy, D., Roberts, S., Daoudi, S., and Kennedy, J. (2023). Global health security and the health-security nexus: principles, politics and praxis. *BMJ Glob. Health* 8:e013067. doi: 10.1136/bmjgh-2023-013067

Moon, S. (2019). Power in global governance: an expanded typology from global health. *Glob. Health* 15:74. doi: 10.1186/s12992-019-0515-5

Peters, B. G., Grin, E., and Abrucio, F. L. (Eds.) (2021). American federal systems and COVID-19: responses to a complex intergovernmental problem. Emerald Publishing: Bingley.

Rozell, M. J., and Wilcox, C. (2020). Federalism in a time of plague: how federal systems cope with pandemic. *Am. Rev. Public Adm.* 50, 519–525. doi: 10.1177/0275074020941695

Stoeva, P. (2020). Dimensions of health security—a conceptual analysis. *Global Chall.* 4:1700003. doi: 10.1002/gch2.201700003

Taylor, R. C. R. (2021). The global governance of pandemics. *Sociol. Health Illn.* 43, 1540–1553. doi: 10.1111/1467-9566.13293

United Nations Department of Economic and Social Affairs (2018). World urbanization prospects: the 2018 revision. New York: United Nations.

Vaz, R. G., Mkanda, P., Banda, R., Komkech, W., Ekundare-Famiyesin, O. O., Onyibe, R., et al. (2016). The role of the polio program infrastructure in response to Ebola virus disease outbreak in Nigeria 2014. *J. Infect. Dis.* 213, S140–S146. doi: 10.1093/infdis/jiv581

World Economic Forum (2019). Outbreak readiness and business impact protecting lives and livelihoods across the global economy. Geneva: World Economic Forum.

World Health Organization (2022). Joint external evaluation tool: International health regulations (2005). *3rd* Edn. Geneva: World Health Organization.

World Health Organization. International health regulations (2005) monitoring and evaluation framework. (2024). Available online at: https://extranet.who.int/sph/ihr-monitoring-evaluation (Accessed July 29, 2024).