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Resilience building in public health rapid response teams in urban multi-hazard scenarios: Pathways and strategies from Shanghai, China

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Abstract: Urban centers face a complex and multifaceted array of public health threats from infectious disease outbreaks and incidents of foodborne pathogens to health crises due to disasters, posing grave risks to people's health and societal stability. As the operational backbone of emergency response systems, public health rapid response teams are mission-critical in performing disease surveillance, outbreak containment, and clinical case management across all phases of emergencies. Nevertheless, persistent structural barriers including workforce deficits and competency mismatches constrain operational effectiveness during large-scale health emergencies. To address these challenges, this study proposes a resilience-building framework for public health rapid response teams that takes into account multi-hazard scenario planning and the evolving nature of events. Key interventions including institutional capacity building, strategic foresight initiatives, cross-sector policy integration, and tiered resource allocation systems have been implemented in order to enhance the core resilience dimensions of withstanding shocks, agile adaptability, and restoration of functioning.

***Keywords*:** public health rapid response teams, resilience building, multi-hazard scenarios

Introduction

Over the past few years, the frequent occurrence of major public health emergencies worldwide (*1-3*) has posed unprecedented challenges to human health, social stability, and economic development (*4*). The COVID-19 pandemic has exposed the fragilities inherent in the global public health system, rigorously testing the emergency management capabilities of nations and regions worldwide. In this context, effective mitigation of the impacts of significant public health risks from the perspective of urban governance has become an urgent issue requiring prompt resolution.

During public health emergencies, professional and efficient public health rapid response teams can promptly mobilize to mitigate and control the spread of public health risks. Public health rapid response teams are defined as trained and equipped teams with the capacity to deploy rapidly, efficiently, and effectively respond to public health emergencies in coordination with other response efforts (*5*). However, when confronting increasingly complex and evolving disaster scenarios, multiple limitations in team building and management, such as insufficient workforce deployment during mass-casualty incidents, lack of cross-disciplinary expertise and coordinated operational capabilities in addressing complex disasters, and occupational burnout arising from prolonged high-intensity responses, have become apparent.

To address diverse disaster risks, Shanghai has issued guidelines to promote the construction of a new urban infrastructure to develop a resilient city (*6*), systematically enhancing the city's capacities to withstand, adapt to, and rapidly recover from disruptive conditions and to develop sustainably. By integrating resilience principles into the creation of public health rapid response teams, the city aims to establish an operational team system with reinforced adaptive capacity, restorative capability, and organizational learning capacity. This system is designed to enable a rapid response, provide sustained mitigation, and conduct scenario-adapting operations when confronting acute public health crises or enduring chronic public health risk pressures in varying contexts (*7*).

Connotations and theoretical foundations of resilient public health rapid response teams

Resilience building in public health systems

Originating from the fields of engineering and ecology (*8,9*), resilience is a ubiquitous concept that has been increasingly applied to the area of public health and development in recent years (*10*). A resilient health system is typically characterized as one that recognizes its inherent strengths and vulnerabilities; safeguards people's health during public health crises; responds effectively to public health crises of all types, learns from them, and turns lessons into better preparedness, and integrates diverse stakeholders and initiatives into coordinated efforts through systemic learning mechanisms (*11,12*). Such a system includes a wide variety of actors and actions in a coordinated effort to yield positive health outcomes.

Resilience building in public health rapid response teams

Public health rapid response teams refer to professionally trained units capable of rapidly deploying during public health emergencies to provide technical support and coordinate response efforts (*13*). Team members routinely provide healthcare during normal times and can be mobilized either full-time or part-time for emergency operations when required. To enhance the resilience of urban public health rapid response teams, strategies should focus on enhancing three core capacities: stress resistance (withstanding acute shocks), adaptability (adjusting to evolving threats), and the capacity for recovery (restoring functions post-crisis). This ensures agile responses to complex and dynamic emergencies while safeguarding public safety.

Strategies for building resilient public health rapid response teams

Resilience building with public health emergency response teams requires a multi-dimensional approach to establish a system that is highly adaptable and able to restore functioning.

Risk profiling and scenario mapping

Urban risks and disaster scenarios need to be systematically identified and catalogued, and demand for public health emergency response capabilities needs to be forecast.

Goal-oriented capacity planning

To achieve the dual objectives of a rapid response to small-scale incidents and sustained resilience in response to prolonged large-scale emergencies, a goal-oriented approach is required to develop and manage public health emergency response teams. This entails ensuring that both front-line teams and reserve forces meet critical criteria including sufficient workforce capacity to rapidly mobilize, adaptive competencies that align with evolving threats, and geographic distribution to ensure the coverage of vulnerable populations.

Establishing multi-sectoral collaboration mechanisms

The development of public health emergency response teams is inherently systemic. Adopting a systems thinking approach ensures integrated and coordinated efforts that integrate governmental agencies, healthcare facilities, community organizations, and civil society stakeholders through societal engagement models.

Enhancing competencies through iterative learning

The technical and professional competencies of public health rapid response teams need to be continuously enhanced, with a priority on enhancing community-based public health emergency teams to accelerate localized responses. Lessons learned from varied incident responses need to be adopted institutionally to iteratively improve operational mechanisms and workforce capabilities, such as implementing structured post-event debriefing protocols to codify operational lessons.

Shanghai's approach to building resilient public health rapid response teams

Delineating urban risks

Shanghai faces public health emergencies that may cause severe threats to people's health, including: major outbreaks of infectious diseases (*e.g.*, epidemics involving novel pathogens); clusters of diseases of unknown origin; serious incidents of foodborne and occupational diseases; health hazards triggered by natural disasters (*e.g.*, typhoons and urban waterlogging) and industrial accidents (*e.g.*, chemical leaks).

Analyzing scenario-specific demands on public health rapid response teams

Public health rapid response teams serve as the core operational force in managing public health emergencies, functioning during every phase — prevention, response, rescue, and recovery — with scenario-specific demands.

i) Routine/normal risk scenarios. During periods of sporadic disease outbreaks or incubation of latent risks, public health rapid response teams must focus on priority capacity-building objectives: enhancing future adaptability through quality system development and enabling early detection, identification, and mitigation of latent public health risks at the community level to prevent risk proliferation or incident escalation.

ii) Small-scale incident scenarios. Community-based public health rapid teams must demonstrate resilience to diverse risks, delivering a timely and coordinated response while ensuring operational stability. If initial

containment measures fail to effectively control the event, resulting in a rapid increase in cases exceeding the community's capacity, additional teams must be mobilized regionally. These teams should rapidly assemble and adeptly conduct case management, epidemiological investigations, close contact tracing, environmental disinfection, *etc*.

iii) Large-scale incident scenarios. During catastrophic events such as pandemics or major natural disasters, public health rapid response teams must demonstrate robust resilience to withstand sustained systemic shocks. During such crises, risks propagate citywide, characterized by exponential surges in cases that trigger cascading societal disruptions and impose an overwhelming strain on the urban healthcare system. To address these challenges, coordinated mobilization of all municipal public health emergency teams is imperative, ensuring optimal resource allocation through centralized command systems. Moreover, social mobilization protocols should be activated when necessary, including the strategic deployment of reserve forces from emergency response personnel pools to augment frontline capacities.

iv) Post-crisis reconstruction scenarios. During the transition from emergency to routine operations, efforts must focus on consolidating containment, preventing a resurgence, and restoring social order. Concurrently, lessons learned from public health emergency responses should be systematically identified through debriefing and evaluation of team performance, with mechanisms tailored to enhance daily preparedness and further response capabilities.

Key measures to enhance resilience building in public health rapid response teams

Integrated policy and planning

Policy support (*e.g.*, through the Shanghai Municipal Regulations on Public Health Emergencies) needs to be enhanced to mandate the establishment of a public health governance framework, a centralized emergency command system to coordinate multi-sectoral responses, and a specialized and multidisciplinary public health workforce with dual-role capabilities that integrate peacetime preparedness and emergency response. Standardized emergency management protocols shall be followed, including the creation of a tiered public health emergency response plan framework specifying operational requirements and task allocation matrices for varied incident scenarios. Municipal and district health authorities need to develop versatile and comprehensive public health teams capable of responding to multiple scenarios on-site. Additionally, all healthcare facilities should create specialized emergency response teams or rapid response units to ensure system-wide preparedness, thereby advancing a well-rounded public health emergency response system.

Establishing a tiered and categorized team system

Based on the characteristics and demands of public health emergency work in multiple scenarios, the rapid response team system should be structured through classification by function and stratification by administrative level. Teams should be classified by specialization or mission into infectious disease control teams, medical rescue teams, laboratory testing teams, sanitation and quarantine teams, and psychological crisis intervention teams, operating synergistically to achieve mission objectives. A three-tiered hierarchical structure is established at the municipal, district, and community level corresponding to administrative levels. Municipal-level teams coordinate responses to large-scale incidents and provide technical guidance, while district and community-level teams take primary responsibility for on-site emergency operations within their jurisdiction, ensuring localized containment and recovery. A scenario-driven mechanism to dispatch public health emergency response teams is needed, enabling rapid deployment of required units based on incident-specific scenarios and achieving optimized allocation of emergency resources in alignment with the city public health emergency response framework.

Enhancing district and community-level teams

District-level public rapid response teams provide guidance to community teams on preparedness and response operations. Each district-level team should maintain a reserve capacity of at least three times the size of the core team to ensure rapid augmentation of personnel in the event of surges.

Community-level teams conduct health education campaigns, risk surveillance, and reporting during routine operations. During localized incidents, these teams perform early detection, provide timely reporting, and implement initial containment measures. During large-scale emergencies, they conduct emergency response operations within designated zones.

Additionally, a standardized equipment configuration for district and community-level teams is needed, ensuring robust support in communication and command systems, field investigations, on-site operations, and logistical support.

Enhancing capacity development

A resilience-oriented mindset and culture of crisis learning should be fostered within healthcare systems by integrating public health emergency response capacity building into the routine development of healthcare frameworks through institutionalized training and scenario-based drills (*14*). General and tailored training programs and curriculum systems should be developed to foster a specialized and multidisciplinary emergency workforce. An online training platform should be constructed and hybrid training models should be adopted to expand training coverage and enhance

operational efficiency.

A city-wide annual operational plan for public health emergency response team exercises and mobilization should be formulated, mandating that all teams conduct at least one full-scale exercise annually in a scenario involving a large-scale incident. These measures ensure a rapid transition between routine and emergency modes while enhancing capabilities in cross-functional coordination, adaptive problem-solving, and scenario-specific responses under abnormal conditions.

Establishing a supportive social environment

Public health rapid response teams should be designated as high-risk occupational groups under legal regulations, mandating comprehensive safeguards for occupational safety and mental health. This includes the provision of biosafety-compliant personal protective equipment (PPE) and field investigation and response facilities. Financial and career incentives such as targeted subsidies and performance-based rewards should be offered during emergency operations. Career advancement opportunities for team members should be provided, such as professional advancement or prioritized promotions for frontline responders. A dedicated merit-based reward fund should be established to recognize individuals and units making exceptional contributions during public health crises. Strategic partnerships with academic and research institutions need to be formed to establish public health workforce pipelines *via* specialized training centers, ensuring sustained capacity development that is responsive to evolving public health threats (*15*).

Establishing a reserve workforce

A baseline assessment of healthcare professionals throughout the municipality must be prioritized through systematic workforce mapping, with targeted capacity-building in public health emergency preparedness and response delivered *via* degree-granting academic programs, credentialed residency training, and lifelong learning initiatives.

Reserve mechanisms and emergency medical reserve teams should be created to ensure capacity in the event of surges. This initiative will establish dual-role workforce reserve pools and multi-tiered emergency public health teams. At the same time, volunteer teams should be systematically created through formalized collaborations with civil society organizations. Volunteers should be strategically deployed in the following roles, with task assignments based on competency assessments and supervision by public health professionals: health education and risk communication, community containment measures, crowd control and logistical coordination, port-of-entry quarantine operations, psychological first aid, and epidemiological field investigations (Figure 1).

Limitations and priority areas for further development

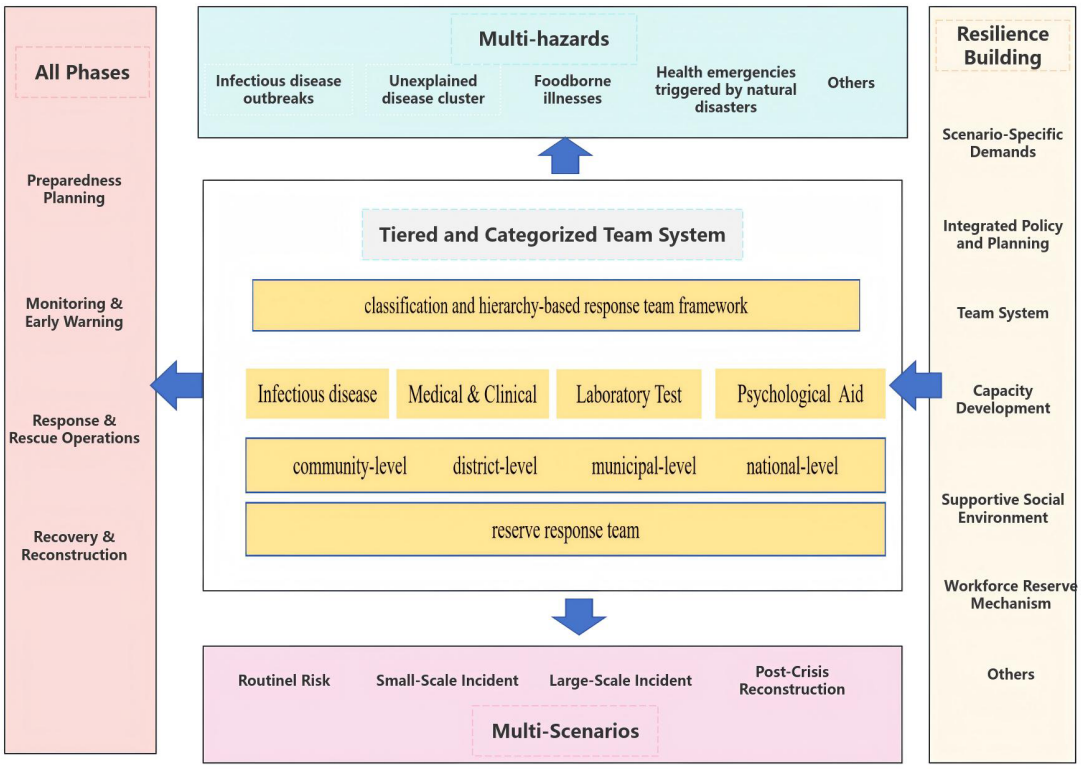

Figure 1. Core elements of resilience building. This figure comprehensively illustrates the key elements of resilience development in public health emergency response teams across multiple hazards, scenarios, and phases.

Health system resilience remains an emerging field with limited dedicated policy frameworks and implementation case studies globally. Future efforts to enhance resilience in public health rapid response teams face critical challenges, particularly in:

i) Balancing routine provision of healthcare with crisis response, especially during large-scale emergencies where evidence-based countermeasures (*e.g*., vaccines and targeted therapies) are not yet unavailable. Implementing tiered emergency response mechanisms (*16*), coupled with structured protocols for team rotation, replenishment, and cross-sector coordination to sustain essential healthcare during prolonged crises.

ii) The ability to scientifically assess evolving trajectories of public health emergencies and conduct intelligent command-dispatch operations is critical to rationally allocating emergency response teams and optimizing emergency management efficiency. The potential for further innovation lies in advances in emerging technologies to build resilience, including AI-optimized emergency decision-making architectures and blockchain-secured emergency supply chains. These technologies can catalyze intelligent operationalization of public health emergency response systems while addressing current gaps in dynamic resource coordination.

iii) Given the significant international divergence in understanding the concept of resilience and its implementation, there is a pressing need for research on quantitative assessment of resilience building in public health rapid response teams. Such research will provide data-driven support and evidence-based decision-making tools to optimize systemic adaptability and resource prioritization. Concurrently, enhanced international collaboration and exchanges of knowledge, adoption of advanced public health emergency management frameworks and technologies, and fostering strategically minded public health emergency personnel will help to enhance the systemic capabilities of rapid response teams and drive holistic improvements in public health resilience.

Conclusion

Building a resilient urban public health rapid response system is a complex, iterative systems engineering process. To ensure a rapid response to and effective mitigation of diverse urban risk scenarios, public health rapid response teams need prioritized investments in proactive preparedness including scenario-specific capacity building, stockpiling of resources for surges, and pre-determined response protocols to enhance systemic resilience. When confronted with sustained shocks and stressors, public health rapid response teams can maintain operational continuity and sustain core functions through tiered team development and integrated support mechanisms. Various strategies and methods can be used to enhance the adaptive capacity of rapid response teams, such as conducting after-action analyses, establishing institutional mechanisms to learn from crises, and implementing data-driven policies.

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