

A Cross-Case Study on Integrating Climate Change Health Risks into Urban Public Health Emergency Preparedness from an Adaptive Governance Perspective

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Abstract:

When heat waves claim tens of thousands of lives each year, and floods inundate city hospitals, climate change is no longer just a future environmental challenge, but the most severe public health governance crisis of our time. However, global urban emergency preparedness systems still generally suffer from an “adaptation deficit.” Climate change poses an increasingly serious challenge to the health of urban residents worldwide through extreme weather events, changes in vector spread, increased air pollution, and food safety threats. However, traditional urban public health emergency systems primarily focus on acute emergencies (such as infectious disease outbreaks or chemical spills), and their integration of the long-term, systemic pressure of climate change remains insufficient. This paper aims to explore, from an international perspective, how to systematically incorporate the health risks of climate change into urban public health emergency management systems. This study employs a systematic literature review and multiple case study design. Following the case study design principles of Yin (2018), it selects four representative cities as the analysis subjects: New York (post-hurricane resilient reconstruction), Rotterdam (integrated flood and heat wave management), Beijing (coordinated governance of air pollution and heat waves), and Dhaka (community adaptation to high temperatures and floods). This study constructs a three-dimensional analysis model of “climate-health-emergency” by combining the latest data and policy documents from the World Health Organization (WHO), the Intergovernmental Panel on Climate Change (IPCC), and public health departments of various countries, embedding Adaptive Governance Theory as its theoretical foundation. The study finds that although some high-income cities have established preliminary climate-adaptive health strategies, significant gaps remain in dynamic risk assessment, inter-sectoral coordination mechanisms, the breadth of community participation, and the protection of vulnerable populations. Based on this, this paper proposes the “Dynamic Adaptive Public Health Emergency Framework” (DAPHEF), advocating for the reconstruction of urban public health systems with health equity as the core principle, and providing a replicable policy tool for building climate-resilient health systems in cities worldwide.

Keywords:

Climate Change, Public Health, Health Risk, Emergency Preparedness, Urban Resilience

1. Introduction

1.1. Research Background and Problem Statement

Climate change has been identified by the World Health Organization (WHO, 2021) [2] as the greatest global health threat of the 21st century. According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [3], the global average temperature has risen by approximately 1.1°C above pre-industrial levels, and without urgent action, it could exceed the 1.5°C threshold by 2030 [3].

According to The Lancet's "Health and Climate Change Countdown 2024," [4] global heat-related mortality rates among adults aged 65 and older have increased by 85% over the past two decades compared to the 1990s baseline. Urban areas are particularly hard hit due to the combined effects of the heat island effect and an aging population. In 2023 alone, extreme weather events caused more than \$300 billion in economic losses globally and disrupted healthcare services in more than 50 major cities [5].

Human-induced climate change is leading to a significant increase in the frequency, intensity, and duration of extreme weather events. Cities, as highly concentrated areas of population, economy, and infrastructure, are particularly vulnerable to climate hazards such as heat waves, floods, storms, sea-level rise, and the resulting increased air pollution. These hazards directly or indirectly trigger a range of health risks, including increased morbidity and mortality from heatstroke, altered spread of waterborne and insect-borne infectious diseases, exacerbation of respiratory and cardiovascular diseases, and mental health problems caused by extreme events.

Despite the clear risks, public health emergency preparedness frameworks in many cities worldwide are still primarily built around traditional threats such as influenza pandemics, bio terrorism attacks, or chemical spills, failing to systematically integrate the long-term, complex health risks posed by climate change. This "adaptation deficit" results in delayed emergency response, resource misallocation, and exacerbated health inequalities [6].

Furthermore, from a political ecology perspective, the unequal distribution of power in climate change response often results in low-income communities and marginalized groups bearing a disproportionate share of the risks [7]. The sociology of scientific knowledge also reminds us that the perception and response to climate health risks are influenced by local knowledge, cultural practices, and social trust, and a single model is insufficient for effective intervention.

1.2. Research Questions and Objectives

This study aims to answer the following core questions:

- How do major international cities currently identify and respond to climate change-related health risks in their public health emergency preparedness?
- What are the commonalities and differences among different cities in terms of

institutional design, policy tools, and implementation effectiveness?

- How can a more resilient, equitable, and forward-looking urban public health emergency preparedness framework be constructed to address climate health risks?
- How can cities effectively integrate climate change-related health risks into their existing public health emergency preparedness frameworks to improve residents' health and safety?

Research objectives include:

- Assessing the climate adaptability of existing emergency preparedness systems;
- Identifying best practices and key obstacles;
- Proposing evidence-based policy recommendations.

1.3. Core argument

The core argument of this paper is that incorporating climate change health risks into urban public health emergency preparedness is not simply an "additional" task, but a profound paradigm shift. It requires moving from passive disaster response to proactive, forward-looking risk reduction and adaptation planning. This necessitates embedding climate health risk assessment, monitoring, and response mechanisms into the entire process of urban public health emergency preparedness through cross-sectoral collaboration, data-driven decision-making, and deep and broad community participation. The goal is to build a truly climate-resilient public health system that prioritizes the protection of vulnerable populations, guided by the value of health equity.

To this end, this paper introduces **adaptive governance theory** [8], emphasizing the flexibility, learning capacity, and multi-center collaboration of governance systems. Simultaneously, drawing on the **socio-ecological system resilience framework** (Walker & Salt, 2006) [9], it views the city as a complex adaptive system whose resilience depends on its capacity for resistance, adaptation, and transformation. This theoretical foundation ensures that this study not only describes the phenomena but also explains the mechanisms, guaranteeing academic rigor.

2. Methods

2.1. Research Methods and Framework

This study employed a systematic literature review and multiple case study design, adhering to the case study design principles proposed by Yin (2018) [1] to ensure the reliability and validity of the research.

Data sources included: academic literature (PubMed, Web of Science, Scopus, 2018–2024); government reports (such as the US CDC Climate and Health Program, and the UK UKHSA Climate Strategy); documents from international organizations (WHO, IPCC, UN-Habitat); and publicly available data and emergency response plan texts from urban public health departments.

The study selected four cities with distinctive characteristics and representativeness in addressing the health risks of climate change: New York (high-income country, systematic post-disaster reconstruction), Rotterdam (leading European water management and spatial planning), Beijing (middle-income country, complex pollution control), and Dhaka (low-income country, community-led adaptation).

Selection criteria included: city size, geographical diversity, climate risk type, economic development level, and policy transparency.

2.2. Analysis Model

A three-dimensional analysis framework of “climate-health-emergency” is constructed to systematically evaluate the performance of each city. (See Figure 1)

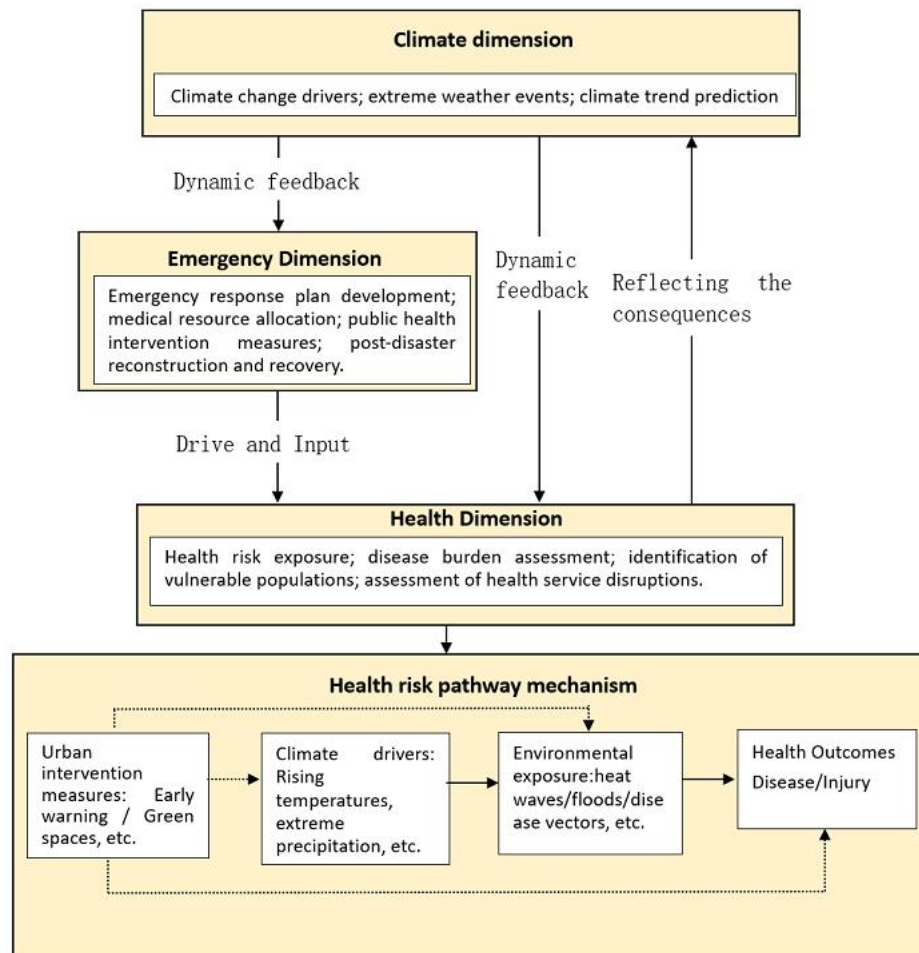


Figure 1. Three-dimensional analysis framework of “climate-health-emergency”.

Note: 1. This model references the WHO's Climate Health Risk Mapping Tool (WHO, 2021) [2] and the CDC's BRACE (Building Resilience Against Climate Effects) framework.

Table 1. Dimensions and Assessment Indicators.

Dimension	Indicators by Dimension
Climate Dimension	Frequency and trends of extreme events, size of exposed population
Health Dimension	Major health impacts (e.g., heat-related deaths, respiratory diseases), identification of vulnerable populations
Emergency Dimension	Risk assessment mechanisms, early warning systems, contingency plan coverage, inter-departmental coordination, resource reserves, community participation

- **Climate Dimension (Drivers and Stressors)** The core is “risk identification and prediction,” which is the starting point of the entire response process. Through climate science and data models, future climate drivers are identified and predicted, providing early warning timelines for public health systems.

- **Emergency Dimension (Response and Action)** The core is the “management

cycle” a dynamic, closed-loop emergency management process that includes a health risk early warning system, actions taken before and after health risk events, assessment of the health impacts of the event, and evaluation of the effectiveness of the emergency response.

- **Health Dimension (Impacts and Consequences)** The core is the “mechanism,” which reveals how climate change affects population health through environmental exposure.

Through targeted content analysis of collected policy texts, reports, and academic literature, using a pre-defined “climate-health-emergency” three-dimensional framework and its indicators, the themes of each case in terms of governance models, core strategies, effectiveness, and challenges are identified.

The framework’s interconnected logic follows a positive flow: climate risk drives health impacts, which in turn triggers an emergency response. Feedback loops transmit the experience and data gained in practice back to the climate dimension (to optimize prediction models) and the health dimension (to deepen the understanding of mechanisms and adjust intervention links), thereby enabling the entire framework to learn and optimize continuously and improve the city’s public health resilience.

3. Results and Discussions

3.1. Case Study: Comparison of Current Status of Urban Emergency Preparedness

The case study will revolve around the following dimensions:

- **Driving Factors:** Key climate events or policies that prompted the city to take action.
- **Integrated Strategies:** Specific policies, plans, and technological measures adopted.
- **Governance Structure:** Government departments, agencies involved, and their collaborative mechanisms.
- **Key Interventions:** Specific practices in monitoring, early warning, infrastructure, and community engagement.
- **Effectiveness and Challenges:** Post-implementation effectiveness evaluation and major obstacles encountered.
- **Theoretical Analysis:** The core theories of this paper (adaptive governance theory, the “climate-health-emergency” three-dimensional analysis model) will be used to interpret the specific case.
- **Implications for this Study:** In what ways does this case support or challenge the core arguments of this study?

3.1.1. Case Study 1: New York City–Systemic Resilience Rebuilding After Hurricane Sandy

- **Driving Factors:** Hurricane Sandy in 2012 devastated New York City, exposing the vulnerability of critical public health infrastructure.
- **Integrated Strategy:** New York City released the “PlaNYC: Getting Sustainability Done” plan, making climate resilience a core pillar. Its “Climate Resilience Design Guidelines” require all new and renovated public facilities, including hospitals and clinics, to meet higher flood and wind resistance standards.

- **Governance and Intervention: Infrastructure Reinforcement – NYC Health + Hospitals** undertook large-scale renovations of several of its hospitals, including moving emergency rooms and electrical equipment to higher floors and equipping them with backup power systems. **Fiscal and Equity Challenges**–The high cost of renovations was underpinned by the “lock-in effect” of historical infrastructure investments and fiscal equity issues. Low-income communities have a lower proportion of access to funding support.

- **Achievements and Challenges:** Significantly improved the operational reliability of critical medical facilities under extreme weather conditions. Challenges lie in the enormous investment required and the technical and spatial constraints of retrofitting in highly developed areas.

- **Theoretical Analysis:** From the perspective of adaptive governance theory, New York’s post-disaster reconstruction embodies a typical “crisis-driven adaptation,” with its governance model exhibiting characteristics of “centralized multi-center governance.” The mayor’s office formed a temporary but powerful collaborative mechanism with departments such as health, emergency response, and urban development, demonstrating the system’s learning ability and flexibility after significant disruptions. Within the “climate-health-emergency” three-dimensional framework, this case excels in “resource reserves” and “infrastructure resilience” in the “emergency dimension,” significantly enhancing the system’s buffering capacity against storm and flood risks in the “climate dimension” through physical modifications.

However, the multi-center nature of its governance is primarily reflected in inter-departmental collaboration within the government, rather than truly incorporating diverse stakeholders such as communities and non-governmental organizations. While inter-departmental coordination strengthened after the crisis, there is a risk of “coordination fatigue.” Once the crisis subsides, departments may revert to an “island” state, weakening the long-term learning and adaptation loop. Furthermore, the insufficient support for low-income communities reflects an imbalance in the allocation of power, resulting in adaptive investments failing to effectively reach the most vulnerable groups and violating the resilience building requirements centered on health and equity.

- **Implications for this study:** The New York case demonstrates that while systemic post-disaster reconstruction can proceed rapidly, the risk of “green gentrification” must be guarded against to ensure that vulnerable groups are not excluded from resilience building.

3.1.2. Case Study 2: Rotterdam, Netherlands–Integrated Hydrothermal Risk Management Led by Spatial Planning

- **Driving Factors:** As a low-lying country, Rotterdam has long faced threats from rising sea levels and river flooding, while Europe’s heatwave events have also highlighted the health risks associated with high temperatures.

- **Integrated Strategies:** Rotterdam has deeply integrated its climate adaptation strategy into its urban master plan and public health agenda. At its core are nature-based solutions such as “water squares” and green roofs [10].

- **Governance and Intervention: Infrastructure Resilience**–Public health departments, water authorities, and urban planning departments work closely together to design

public spaces as facilities that combine recreation and rainwater retention, reducing urban flooding, while increasing green spaces to mitigate the urban heat island effect [11]. Vulnerable Group Protection—A registration and care network has been established for heat-vulnerable groups such as the elderly and those living alone, with volunteers conducting home visits during heatwaves.

- **Achievements and Challenges:** Significantly enhanced the city's capacity to absorb heavy rainfall and reduced excess mortality during heat waves. The main challenges lie in long-term maintenance costs and the ability to cope with extreme scenarios.

- **Theoretical Analysis:** Rotterdam is a model of adaptive governance. Its "Water Plaza" is not only an engineering innovation but also a manifestation of socio-ecological resilience. Through the combination of ecological and engineering measures, it significantly enhances the city's buffering capacity against floods and heat waves. In the "climate-health-emergency" three-dimensional framework, the "climate dimension" and the "emergency dimension" are deeply coupled through spatial planning, internalizing the reduction of risk exposure into the city's daily functions.

Its governance model exhibits a high degree of polycentricity and cross-sectoral collaboration, demonstrating the flexibility of the governance system and its ability to adjust urban design standards according to long-term climate change trends. The care network for vulnerable groups constructs a "feedback loop" from the system to the individual, inputting health monitoring data (health dimension) back into the early warning and response mechanism (emergency dimension), enabling dynamic adjustments.

However, the sustainability of this model depends on stable financial investment and continuous public participation. If higher-level government policies shift or funding is reduced, such grassroots innovations may face the risk of "governance disembedding." Therefore, their learning capacity needs further institutionalization to ensure that adaptive practices are not interrupted by political cycles.

- **Implications for this study:** Rotterdam demonstrates the importance of cross-sectoral collaboration and spatial justice, and its "planning-led" model is worth learning from for high-density cities.

3.1.3. Case Study 3: Beijing, China—Collaborative Governance of Air Pollution and Heat Waves

- **Driving Factors:** Severe smog and the increasingly frequent urban heat island effect have triggered widespread public health concerns and a demand for a high-quality living environment.

- **Integrated Strategy:** Beijing, through top-level design such as the "Beijing 14th Five-Year Plan for Ecological and Environmental Protection" and the "Beijing General Emergency Response Plan for Public Emergencies," has coordinated the prevention and control of air pollution with heat wave response, and incorporated health impact assessments into the decision-making process.

- **Governance and Intervention:** Cross-departmental Monitoring and Early Warning—The ecological environment, meteorological, and health departments jointly constructed and issued an "Air Pollution and High Temperature Heat Wave Health Early Warning Release System" and took corresponding measures. Health Impact

Assessment–Major urban planning projects and industrial projects are required to undergo health impact assessments, focusing on analyzing their adaptability to climate change and the potential impact on residents' respiratory health and heat stress. **Green Infrastructure Construction**–The construction of “sponge cities” and the expansion of forests and green spaces are promoted, and permeable surfaces and vegetation cover are increased to alleviate urban flooding and the urban heat island effect.

- **Achievements and Challenges:** According to official data, Beijing's annual average PM2.5 concentration continued to improve in 2023, and the acute health risks to the public caused by air pollution significantly decreased [13]. The challenges lie in the governance of complex pollution problems such as ozone pollution, and the long-term nature of regional collaborative governance.

- **Theoretical Analysis:** Beijing's governance model is a typical “top-level driven adaptation,” with advantages in strong policy implementation and resource mobilization capabilities. It rapidly established a cross-departmental monitoring and early warning system in the “emergency dimension,” demonstrating the centralized flexibility of the system in responding to complex climate health risks. Within the “climate-health-emergency” framework, its “health impact assessment” mechanism is a key innovation connecting the “health dimension” and the “emergency dimension,” proactively addressing health risks and promoting a shift from “passive response” to “proactive prevention.”

However, from the perspective of adaptive governance theory, its “polycentricity” and “learning capacity” are relatively limited. The decision-making process is mainly led by high-level government, with community and public participation largely limited to information reception, lacking substantive consultation and co-governance. Furthermore, the challenges of regional collaborative governance reflect institutional barriers to cross-administrative and cross-departmental collaboration, which constrain the construction of socio-ecological resilience on a larger scale.

- **Implications for this study:** Beijing's strong policy-driven model is highly efficient, but it needs to strengthen community participation and long-term sustainability to avoid “campaign-style governance.”

3.1.4. Case Study 4: Dhaka, Bangladesh Community-Led Adaptation to Heatwaves and Floods

- **Driving Factors:** Dhaka frequently experiences seasonal floods and increasingly severe heatwaves, with slum dwellers being the most vulnerable and severely affected group.

- **Integrated Strategy:** With limited financial resources, Dhaka adopted a community-based adaptation model with deep involvement from non-governmental organizations (NGOs) [12].

- **Governance and Intervention:** Early Warning System – Utilizing simple weather forecasts and community broadcasts, training community volunteers to organize evacuations and issue protective advice before floods and heatwaves [12]. Low-Tech Solutions–Promoting low-cost measures such as using reflective coatings and increasing ventilation in slum dwellings to reduce indoor temperatures.

- **Outcomes and Challenges:** Effectively reduced casualty rates and enhanced community self-help capabilities. Challenges lie in sustainability, scale, and the absence of government responsibility under neoliberal governance.

- **Theoretical Analysis:** The Dhaka case vividly illustrates “grassroots-driven, multi-center governance” in adaptive governance. Against the backdrop of weak institutional support at the national level, community organizations and NGOs have filled the governance gap, forming an adaptation network centered on the community and demonstrating strong local learning capabilities and flexibility. Within the three-dimensional framework of “climate-health-emergency,” their “community broadcasting” and “volunteer networks” construct an efficient response mechanism for the “emergency dimension,” directly impacting the most vulnerable groups in the “health dimension.”

However, this model, a typical example of “polycentric governance,” also reflects a severe imbalance in power allocation due to the lack of institutional support and resource guarantees from higher-level governments, facing serious sustainability challenges. This indicates that true resilience requires “nested governance,” combining grassroots innovation with institutional and financial support at the national/international level to achieve systemic adaptation.

- **Implications for this study:** The Dhaka model highlights the value of grassroots resilience, but requires a combination of international aid and national responsibility to avoid shifting the burden of adaptation onto the most vulnerable groups.

We construct an analytical diagram using two dimensions: “economic development level (high/low)” and “governance model (top-level driven/grassroots driven),” as shown in Figure 2.

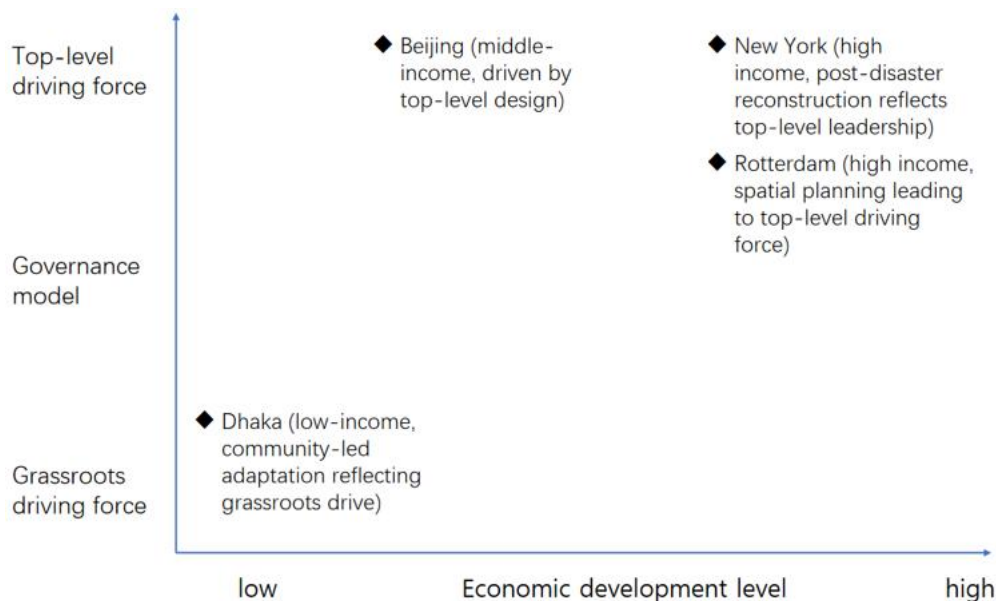


Figure 2. Analysis of Economic Development Level and Governance Model in Typical Cities.

3.2. Comparative analysis of multiple cases

The following cross-case comparison is based on dimensions such as major climate health risks, governance models, core integration strategies, key technologies or measures, outstanding advantages, and major challenges. See Table 2.

Table 2. *Comparison of Integrated Strategies for Climate Change Health Risks in Four Cities.*

Analysis Dimensions	New York (USA)	Rotterdam (Netherlands)	Beijing (China)	Dhaka (Bangladesh)
Main Climate Health Risks	Coastal storms, heavy rains, heat waves	floods, sea-level rise, heat waves	air pollution/heat waves	floods, high temperatures, waterborne diseases
Governance Models	Post-disaster systemic reconstruction	spatial planning-led	top-level design-driven	community-NGO collaboration
Core Integration Strategy	Critical Infrastructure Resilience Standards	Nature-Based Solutions	Multi-Sectoral Collaborative Governance	Community-Based Early Warning
Key Technologies/Measures	Relocation of Key Hospital Departments/Backup Power	Water Plazas, Green Roofs	Health Early Warning Systems, Health Impact Assessments	Low-Cost Cooling Technologies, Community Broadcasting
Key Strengths	Strong Protection of Critical Lifelines	Combination of Engineering and Ecological Measures	Strong Policy Implementation and Rapid Results;	Low Cost and High Community Participation
Main Challenges	High Retrofit Costs, Space Constraints	Long-Term Costs, Extreme Scenario Response	Complex Pollution Control, Regional Coordination	Insufficient Sustainability and Systemic Support

Common problems revealed include:

- Static risk assessment: Most cities rely on historical data and lack dynamic climate scenario simulations (such as IPCC SSP scenarios) embedded in emergency planning.
- Marginalization of vulnerable populations: The elderly, low-income individuals, and those with chronic diseases are often overlooked in emergency resource allocation.
- Weak cross-departmental collaboration mechanisms: Insufficient data sharing and action coordination between health departments and departments such as meteorology, urban construction, and transportation.

3.3. Integrated Framework Recommendation: Dynamic Adaptive Public Health Emergency Response Framework

Based on the successful experiences and common challenges of the above cases, we found that an ideal emergency response framework must possess four key characteristics: dynamism, collaboration, grassroots resilience, and equity. Therefore, this paper proposes the “Dynamic Adaptive Public Health Emergency Framework” (DAPHEF), whose core innovation lies in integrating AI-driven dynamic assessment, a cross-sectoral collaborative platform, community resilience building, and a health equity orientation.

Compared to existing frameworks, DAPHEF emphasizes AI-driven dynamic risk assessment and equity tools such as the “Climate Health Card.” Compared to the WHO's “Climate Resilient Health Systems” framework, which focuses on internal health system development, or the traditional emergency management “preparedness-

response-recovery” cycle, DAPHEF places greater emphasis on real-time integration and driving force of cross-sectoral data, and a continuous “learning and adaptation” closed loop. DAPHEF places AI-driven dynamic assessment at its core, achieving a fundamental shift from “response” to “proactive,” and using “learning and adaptation” as the core engine of closed-loop management, rather than post-event summary and reflection. Specifically, it comprises four pillars:

3.3.1. Dynamic Risk Assessment System

- **Measures:** Integrate climate models (such as CMIP6), real-time health monitoring data, and social vulnerability indices; utilize AI and machine learning technologies to regularly update risk maps.
- **Implementation Path:** First, the city’s meteorological and health departments should take the lead in establishing a data sharing agreement, introducing technology vendors in stages, and training public health analysts.
- **Costs and Resistance:** High initial technology investment and maintenance costs; potential obstacles such as data privacy regulations and inconsistent data standards across different departments.

3.3.2. Multi-Department Collaborative Platform

- **Measures:** Establish a permanent "Climate and Health Emergency Committee" led by the mayor’s office or a higher level of government; develop joint emergency plans and conduct regular cross-departmental drills.
- **Implementation Path:** Grant the committee legal authority through local legislation or administrative orders, clarify the responsibilities of each department, and establish a unified “one-network” emergency information platform.
- **Costs and Resistance:** The main costs lie in coordinating time and platform construction. The biggest resistance comes from departmental bureaucracy, power struggles, and budget competition.

3.3.3. Community Resilience Building

- **Measures:** Train community health volunteers, establish “climate health sentinels,” and incorporate climate health risk assessment and response knowledge into family doctor services.
- **Implementation Path:** Collaborate with community organizations, NGOs, and primary healthcare institutions to develop standardized training toolkits and establish incentive mechanisms.
- **Costs and Resistance:** Human resource training and organizational costs. The challenge lies in ensuring long-term participation and sustainability of community projects and avoiding volunteer fatigue.

3.3.4. Health Equity Orientation

- **Measures:** Adopt the “vulnerability-weighted” principle in emergency resource allocation, design tools such as “climate health cards” to proactively identify high-risk individuals (such as elderly people living alone or patients with chronic diseases), and establish priority response channels for high-risk groups.
- **Implementation Path:** Embed a social equity index into a dynamic risk assessment

system and conduct accurate identification and registration through community networks.

- **Costs and Resistance:** Requires additional social worker input. May trigger political controversy regarding “unequal resource allocation,” requiring strong public communication to explain its necessity. Compared to existing frameworks, DAPHEF places particular emphasis on AI-driven dynamic risk assessment and equity tools such as the “Climate Health Card.” DAPHEF framework implementation recommendations are shown in Table 3.

Table 3. *DAPHEF Framework Implementation Recommendations.*

Pillars	Specific Measures
Dynamic Risk Assessment	Introducing AI predictive models and integrating satellite remote sensing and ground monitoring data.
Multi-departmental Collaboration	Establishing a unified information platform.
Community Resilience	Incorporating climate health into family doctor services.
Health Equity	Designing a "Climate Health Card" to identify high-risk individuals.

4. Conclusions and Perspectives

4.1. Conclusions

Through the analysis of four case cities from different stages of development and regions, this paper confirms the core argument and extracts several key insights for incorporating climate change health risks into the urban public health emergency preparedness framework:

Governance integration is key: Whether it's cross-departmental collaboration in Beijing or planning integration in Rotterdam, successful integration relies on institutional cooperation that breaks down departmental barriers.

Investing in resilient infrastructure is fundamental: From hospital renovations in New York to “sponge cities” in Beijing, protecting critical public health facilities and urban lifeline systems is a material prerequisite for maintaining emergency response capabilities.

Data and early warning are lifelines: Developing integrated monitoring and early warning systems that connect climate prediction with health outcome prediction is a key technological step towards shifting from “response” to “foresight.” Beijing's health early warning system serves as a model.

Communities are the first line of defense: The Dhaka case demonstrates that even with limited resources, empowering communities can significantly enhance grassroots resilience. Rotterdam's care for vulnerable groups reflects social equity.

At the policy level, municipal governments must institutionalize climate health risk assessments within the emergency planning cycle; the Ministry of Health should mandate climate vulnerability screening for all public health infrastructure projects; and international organizations such as the World Health Organization and the World Bank can support resilience investments in low-income cities through technical assistance and hybrid financing mechanisms.

4.2. Perspectives

Future research and practice should focus on the following directions:

- **Data Science and Health Risk Modeling:** Utilizing artificial intelligence and big data to develop more accurate, city-scale climate-health risk prediction models to provide a basis for resource allocation.
- **Innovative Financing Mechanisms:** Exploring tools such as climate bonds and resilience insurance to raise funds for costly adaptive infrastructure, which is particularly important for cities like New York and Rotterdam.
- **Focus on Health Equity:** In-depth research into the unequal health impacts of climate change on different socioeconomic groups and designing targeted interventions to ensure climate justice are important issues in cities like Dhaka and Beijing.
- **Global Knowledge Sharing Platform:** Establishing a network for experience exchange and cooperation among cities to accelerate the dissemination and application of best practices. For example, Beijing's experience in air pollution control can be used as a reference for other emerging economy cities, while Rotterdam's wisdom in water management has global value.

Climate change is not a distant threat, but a current public health emergency. Only by deeply integrating climate science, public health, and emergency management can we build a truly resilient, equitable, and sustainable urban future.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Declaration of Competing Interest

This study employs triangulation of policy texts, third-party academic evaluation reports, and data from international organizations to maximize the objectivity and accuracy of the case analysis. The authors declare that there are no financial interests or personal relationships that could influence this research report.

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