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Preventing Zoonoses is Key to Sustainable Public Health in Developing Urban Cities

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ABSTRACT

The unprecedented growth of urban populations in developing nations has brought significant changes in human-environmental interactions, reshaping the dynamics of disease emergence and transmission. Zoonoses have become increasingly prominent in these rapidly urbanizing landscapes due to environmental degradation, unregulated wildlife markets, poor sanitation, informal livestock rearing, and weak health infrastructure. This review explores the influence of urbanization on zoonotic outbreak occurrence, exploring integrative strategies for its prevention through a One Health lens. Drawing on insights from environmental health, urban planning, veterinary public health, and epidemiology, we highlight key interventions such as improved water, sanitation, and hygiene (WASH) infrastructure, regulation of urban wildlife trade, formalization of backyard livestock systems, and the expansion of community-based surveillance. It argues that operationalizing One Health in resource-limited cities through institutional coordination, risk-based policy reform, and participatory governance offers a feasible pathway toward resilience. Ultimately, preventing zoonoses must become a core pillar of sustainable urban public health, contributing not only to epidemic control but also to broader development goals such as food safety, environmental justice, and the attainment of the global sustainable development goals (SDGs), particularly goals 3, 6 and 11.

Keywords: Urban cities, WASH, Zoonotic outbreak, Human-environmental interactions, One Health.

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1. INTRODUCTION

The accelerating pace of urbanization, particularly in low- and middle-income countries (LMICs), has precipitated profound transformations in human-environment interactions, with significant implications for public health (Zhang *et al.,* 2023; Sinha, 2024; Vazquez-Prokopec *et al.,* 2024). According to United Nations projections, nearly 68% of the global population will reside in urban areas by 2050, with the majority of this demographic shift occurring in Africa, Asia, and Latin America (United Nations, 2018). While urbanization is often associated with economic growth and improved access to services, it also generates a complex web of socio-ecological challenges that can undermine health systems, deepen environmental degradation, and facilitate the emergence of infectious diseases, particularly zoonoses (Blasdell *et al.,* 2022; Ellwanger *et al.,* 2022; Dorsey, 2025). In many developing urban centers, rapid population growth outpaces the development of critical infrastructure such as waste management, clean water supply, housing, and veterinary services, creating fertile conditions for pathogen emergence and transmission at the human-animal-environment interface (Hassell *et al.,* 2023; Singh *et al.,* 2024).

Zoonotic diseases, which are infections transmissible from animals to humans, constitute over 60% of emerging infectious diseases globally (Rahman *et al.,* 2020; Wikel, 2024). In urban settings, the risk of zoonotic transmission is amplified by several converging factors such as increased population density, unregulated wildlife trade, poor sanitation, food insecurity, and the informal integration of animal husbandry into residential spaces (Ahmed *et al.,* 2019; Esposito *et al.,* 2023). These dynamics are particularly evident in the rapidly growing informal settlements and peri-urban fringes of cities such as Lagos, Nairobi, Dhaka, and Jakarta, where limited state oversight and inadequate health infrastructure expose populations to heightened infectious disease risk (Satterthwaite *et al.,* 2019; Hambrecht *et al.,* 2022; Rahaman *et al.,* 2023). The convergence of human, animal, and environmental health challenges in these urban areas call for a rethinking of public health strategies that transcend traditional biomedical paradigms (Destoumieux-Garzón *et al.,* 2018; Kim *et al.,* 2022).

Table 1. Major zoonotic diseases in developing cities and their key characteristics.

Disease	Primary Reservoir	Transmission Route	Urban Risk Context	Key Prevention Strategies
Rabies	Dogs	Bite/Saliva	Stray dog populations	Vaccination and population control of free-roaming dogs
Leptospirosis	Rodents	Water/Soil contamination	Flood-prone slums	Rodent control and sanitation
Lassa fever	*Mastomys* rodents	Aerosols/Droppings	Poor housing	Rodent-proof housing and hygiene

Avian influenza	Poultry	Respiratory droplets	Live bird markets	Biosecurity and market regulation
COVID-19	Bats (indirect)	Respiratory droplets	High-density crowds	Vaccination, masks, distancing

The 2014-2016 Ebola virus epidemic, while originating in rural Guinea, rapidly spread to major West African cities, revealing how urbanization can facilitate the geographical and social spread of previously isolated pathogens (Keil *et al.,* 2023; Bhatia *et al.,* 2024). Similarly, the COVID-19 pandemic, suspected to have originated at the wildlife-human interface, demonstrated how the globalized and interconnected nature of modern urban life can accelerate disease dissemination across borders (Wilcox and Steele, 2020; Marie and Gordon, 2023). These experiences have reignited discussions around the need for integrative, anticipatory public health frameworks that can address the root causes of zoonotic spillovers in cities (Bhatia *et al.,* 2024).

In response to this multifaceted threat, the One Health approach has gained traction as a holistic strategy that recognizes the interdependence of human, animal, and environmental health (Danasekaran, 2024; Rodriguez, 2024). In urban contexts, operationalizing One Health involves coordinating surveillance systems, regulatory reforms, environmental planning, veterinary care, and community-based risk communication to build resilient public health systems (Mumford *et al.,* 2023; Ahmed *et al.,* 2025). Yet, despite increasing recognition of its relevance, the application of One Health in urban settings remains fragmented and underfunded, particularly in low and medium-income countries (Tiwari *et al.,* 2025).

Hence, drawing from empirical evidences and interdisciplinary perspectives in urban epidemiology, spatial planning, veterinary public health, and environmental science, this paper applies a One Health lens to examine the socio-ecological drivers of zoonoses in cities. Furthermore, it highlights practical interventions, policy innovations, and governance models that can enable urban centers to anticipate, mitigate, and respond effectively to zoonotic threats as an essential component of sustainable development.

2. THE URBAN ENVIRONMENT AND RISK OF ZOONOTIC SPILLOVERS

Urbanization and the Changing Ecology of Diseases

The transformation of natural landscapes into densely inhabited urban settlements has profound implications for ecological integrity and public health, particularly through its influence on the transmission dynamics of zoonotic pathogens (Esposito *et al.,* 2023). Urban expansion, especially in low- and middle-income countries, is frequently accompanied by widespread deforestation, degradation of natural ecosystems, and the loss of biodiversity, all of which contribute to the fragmentation of wildlife habitats and the disruption of long-standing ecological relationships (Combs *et al.,* 2022; Rulli *et al.,* 2025). As formerly remote areas are converted into residential or commercial zones, human populations are brought into direct or indirect contact with a diverse range of wildlife species, many of which serve as reservoirs or vectors of zoonotic diseases (Marrana, 2022). Bats, rodents, and non-human primates are increasingly recognized as hosts for emerging zoonotic agents due to their ecological adaptability and proximity to human settlements (White and Razgour, 2020; Latif *et al.,* 2023).

Urban Wildlife Trade

The consumption and trade of wild animals in urban centers represent a persistent and complex zoonotic threat, especially in regions where informal markets operate beyond the reach of sanitary oversight or veterinary regulation (Akpan *et al.,* 2025). In several African and Asian cities, bushmeat is openly sold in wet markets that lack adequate hygiene protocols and cold chain infrastructure, creating ideal conditions for pathogen survival and transmission (Peros *et al.,* 2021; van Vliet *et al.,* 2022). These environments bring humans, wild animals, and domestic species into unnaturally close contact, facilitating viral spillover and recombination events (Bhatia *et al.,* 2024). Research has linked such settings to outbreaks of zoonotic diseases including SARS, Ebola, and potentially COVID-19, all of which originated at the human-animal-environment interface under conditions of poor biosecurity (Lin *et al.,* 2021).

3. ENVIRONMENTAL DETERMINANTS OF ZOONOSES IN DEVELOPING CITIES

Sanitation and Waste Management Deficits

Urban environmental health in developing countries is often compromised by inadequate sanitation, inefficient waste disposal, and open sewage systems (Tariq and Mushtaq, 2023). These conditions degrade water quality and promote infestations by rodents and stray animals, both of which are important reservoirs of zoonotic pathogens (Krystosik *et al.,* 2020). Compounding this problem is the limited capacity of governments to manage growing waste burdens. Improper management of animal waste from abattoirs and urban farms leads to environmental contamination with pathogens such as *Salmonella*, *E. coli*, and *Campylobacter* (Ekpunobi *et al.,* 2024). The loss of urban biodiversity, particularly the displacement of natural predators, has allowed synanthropic species like rats and pigeons to proliferate in human-dominated environments, increasing zoonotic risks (Ramadhan, 2024). Reduced green spaces further contribute to higher rodent densities, which have been correlated with increase in leptospirosis cases (Judson and Rabinowitz, 2021). Overbuilt urban landscapes also lack the ecological resilience needed to buffer against pathogen reservoirs, making them more vulnerable to disease emergence (Lederman *et al.,* 2021).

Climate Change Impacts

Climate change-induced weather variability and poor drainage systems in cities contribute to recurrent urban flooding, which creates breeding grounds for zoonotic disease vectors such as mosquitoes and snails (Sonne, 2022). Diseases like Rift Valley fever, leptospirosis, and schistosomiasis are often increased in post-flood scenarios (Acosta-España *et al.,* 2024). Urban floodwaters, contaminated with faecal matter from animals and humans, serve as a medium for pathogen transmission across human communities (Paruch and Paruch, 2018). Climate-induced urban flooding also reduces ecosystem services by disrupting water purification and natural drainage systems, thereby facilitating the spread of waterborne zoonoses (Umar, 2024). However, urban ecological models emphasise that resilient cities must maintain or restore green and blue infrastructure, such as urban wetlands and vegetated corridors, to mitigate vector proliferation and pathogen dispersion (Bruno *et al.,* 2024).

4. URBAN FOOD SYSTEMS

Food safety remains a critical concern in the urban meat value chain of developing cities, and many consumers rely on informal meat vendors due to affordability and access (Nyokabi *et al.,* 2023). However, these vendors frequently operate without veterinary inspection, refrigeration, or proper hygiene (Siddiky *et al.,* 2022). Contaminated meat and animal products are common sources of zoonotic foodborne illnesses such as salmonellosis, toxoplasmosis, and listeriosis (Ali and Alsayeqh, 2022). In Nigeria, over 80% of meat consumed in urban centers such as Ibadan and Kano is processed through informal abattoirs lacking formal inspection systems (Ibrahim *et al.,* 2021). These facilities often operate with minimal oversight, and studies have reported contamination rates of up to 35% for *Salmonella* in retail meat samples.

WASH Infrastructure

Water, sanitation, and hygiene (WASH) services are fundamental to preventing zoonotic disease transmission in urban environments, particularly in overcrowded informal settlements where infrastructural deficits are most pronounced (Wolking *et al.,* 2020). In such settings, shared water points, communal toilets, and widespread open defecation create high-risk conditions for the spread of zoonotic enteric pathogens such as *Cryptosporidium*, *Giardia*, *Salmonella*, and *Escherichia coli* (Muyyarikkandy *et al.,* 2024). These organisms are commonly transmitted via the fecal-oral route and thrive in environments where human-animal interactions are frequent and unregulated. As cities continue to grow, the intersection between WASH deficiencies and zoonotic disease transmission must be recognized not just as a public health concern but as a systemic urban development challenge demanding coordinated multisectoral solutions.

5. VETERINARY PUBLIC HEALTH AND ZOONOTIC DISEASE CONTROL

Surveillance and Early Warning Systems

A critical gap in the prevention and control of zoonotic diseases in urban environments is the absence of integrated and responsive surveillance systems that link human, animal, and environmental health data (Sharan *et al.,* 2023). In many rapidly urbanizing cities, there is minimal routine monitoring of zoonotic pathogens in livestock, companion animals, peri-domestic wildlife, or vector populations (Gamble *et al.,* 2023). Surveillance efforts tend to be fragmented across sectors, underfunded, and reactive rather than proactive (Lee *et al.,* 2024). As a result, outbreaks of zoonotic diseases such as leptospirosis, brucellosis, or avian influenza are often identified only after widespread human transmission has occurred, limiting the window for timely containment and increasing the likelihood of public health emergencies (Gupta *et al.,* 2024). Emerging technologies can offer significant potential to enhance surveillance capacity in urban settings (Vogiatzaki *et al.,* 2020). Mobile health (mHealth) applications, for instance, can facilitate real-time disease reporting by frontline health workers, livestock owners, and community health volunteers (Takuwa *et al.,* 2023). Geographic Information Systems (GIS) and remote sensing technologies can map zoonotic hotspots, track animal movements, and monitor environmental changes that affect disease ecology (Zhang *et al.,* 2024). Digital dashboards and AI-driven analytics can further support decision-makers in forecasting outbreaks and targeting interventions efficiently. However, technical solutions alone are insufficient: effective surveillance depends on the existence of strong institutional infrastructure, cross-sectoral trust, trained personnel, and sustained political will (Thomas *et al.,* 2021).

Urban Veterinary Services

Urban veterinary services are often unevenly distributed and poorly integrated into city health systems, leaving informal animal keepers in underserved neighborhoods with limited or no access to basic veterinary care (Roberts *et al.,* 2023). In many urban centers, veterinary infrastructure is concentrated in commercial zones or peri-urban agricultural corridors, primarily catering to industrial-scale or formally registered operations (Ng *et al.,* 2022). This structural exclusion disproportionately affects low-income households who rear poultry, goats, pigs, or dogs within densely populated informal settlements. A cross-sectional study in Nairobi found that only 22% of informal animal keepers had accessed veterinary services in the preceding year, citing cost, distance, and lack of awareness as the primary barriers (Mwangi *et al.,* 2020). Such inequities in service delivery not only compromise animal welfare but also undermine early detection of zoonotic pathogens and limit uptake of preventive interventions such as routine vaccination.

6. THE ONE HEALTH APPROACH TO SUSTAINABLE URBAN PUBLIC HEALTH

The complexity of zoonotic transmission in urban environments demands a multisectoral, collaborative framework such as the One Health approach (Ahmed *et al.,* 2025). By recognizing the interdependence of human, animal, and environmental health, One Health enables coordinated planning, data sharing, and joint intervention among health authorities, veterinary services, urban planners, and environmental managers (Erkyihun and Alemayehu, 2022).

A real-world example is seen in Kenya, where a city-level One Health platform was piloted in collaboration with the Kenya Zoonotic Disease Unit (ZDU), the International Livestock Research Institute (ILRI), and the Nairobi County Government (Mwatondo *et al.,* 2017). This initiative coordinated human and animal health surveillance, strengthened reporting mechanisms for rabies and brucellosis, and implemented community-based risk communication campaigns in informal settlements like Kibera. The Nairobi model demonstrated that even in the context of informal economies and fragmented infrastructure, urban One Health frameworks can be operationalized through strategic partnerships, grassroots engagement, and adaptive governance.

Institutionalizing One Health within resource-limited urban governance systems requires adaptive, decentralized, and multisectoral mechanisms that align with existing urban development structures (Gashu, 2024). Regional urban governments can create interdepartmental One Health task forces that include representatives from public health, veterinary services, urban planning, and environmental management (Li *et al.,* 2025). These units should be embedded within city councils or metropolitan health boards, with a mandate to assess zoonotic risks, coordinate surveillance, and implement cross-sector interventions. To address financial constraints, cities can leverage donor funding, public-private partnerships, and integrate zoonotic prevention into broader urban resilience projects funded under climate or health adaptation frameworks (Nguyen-Viet *et al.,* 2025). Building local capacity through training of community health volunteers and animal health workers ensures sustainability and community ownership (Sakeah *et al.,* 2021).

7. POLICY RECOMMENDATIONS AND FUTURE DIRECTIONS

Addressing zoonotic threats in developing urban cities requires a paradigm shift from reactive, siloed approaches to integrated, proactive governance models that reflect the complex interplay between health, infrastructure, livelihoods, and the environment. Urban policymakers must embed zoonotic disease prevention into the core of urban planning processes, ensuring that health risk assessments are conducted prior to housing expansion, waste zoning, wet market establishment, or road development (Murugesan, 2020, Blasdell *et al.,* 2022). This necessitates strong inter-ministerial coordination, especially between the ministries of health, agriculture, environment, and urban development, anchored in decentralized One Health governance platforms. While the institutionalization of One Health may appear ambitious in resource-constrained urban settings, pragmatic and context-specific mechanisms have proven feasible.

Urban health tends to be underfunded, with zoonoses receiving even less attention due to their "cross-cutting" nature, falling between sectors (Ahmed *et al.,* 2019). Additionally, community resistance to regulation, particularly in informal food systems or wildlife trade, is common when interventions are perceived as punitive or insensitive to livelihoods (Gore *et al.,* 2021). Addressing these barriers requires strategic investment in urban health systems and the co-creation of solutions with communities most affected by policy shifts. To ensure long-term effectiveness, monitoring and evaluation (M&E) frameworks tailored to urban zoonosis control should be developed (Singh *et al.,* 2024). These frameworks should incorporate indicators across health, environmental, and governance domains such as zoonotic outbreak frequency, vector presence in flood-prone areas, animal vaccination coverage, and public awareness levels (Wilcox and Steele, 2020). Tools like risk mapping, community scorecards, and One Health impact dashboards can facilitate real-time tracking and accountability (Katapally and Ibrahim, 2023). A participatory risk surveillance model used in slums of Dhaka, Bangladesh, combined geospatial data, informal reporting, and mobile health technologies to map hotspots of zoonotic risk and guide targeted interventions (Rahaman *et al.,* 2023). Replicating such models in urban cities of developing countries could significantly enhance urban preparedness.

Finally, the inclusion of zoonotic prevention within national and subnational development agendas is critical. Urban zoonoses must be explicitly recognized in strategies aligned with the Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), and SDG 11 (Sustainable Cities and Communities) (Vaidya and Chatterji, 2019). As the 21st century unfolds, urban resilience will increasingly be defined by the capacity of cities to anticipate, prevent, and respond to health threats at the human-animal-environment interface. Investing in zoonotic prevention today is a safeguard for sustainable urban futures (Kapucu *et al.,* 2021).

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