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Perspective

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Imported Ebola as a stress test of hospital resilience in an era of global connectivity

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SUMMARY: In May 2026, an outbreak of Ebola virus disease caused by Bundibugyo ebolavirus emerged in the Democratic Republic of the Congo and spread to Uganda, prompting a WHO Public Health Emergency of International Concern. With no approved vaccine or specific antiviral treatment, Bundibugyo virus poses an acute importation risk in an era of dense global air travel. This perspective frames imported Ebola as a hospital resilience stress test and proposes the Hospital Resilience 4P Framework, organizing preparedness around Prediction, Preparedness, Protection, and Partnership. We critically analyze the drivers of nosocomial amplification, including diagnostic delay, healthcare worker undertraining, and insufficient infection prevention and control. For China, whose aviation hubs in Guangzhou and Shenzhen sustain dense air links with Africa under the Belt and Road Initiative, this risk is particularly urgent. We further examine the vulnerabilities of East Asian healthcare systems - aging workforces, emergency department overcrowding, and skewed PPE stockpiles - and evaluate emerging technologies (deep-ultraviolet laser disinfection, AI-driven surveillance, differential serology) with explicit evidence grading. A full-chain, multi-layered system from the aircraft cabin to isolation ward, guided by the 4P Framework, can ensure imported cases remain contained clinical events rather than triggers of hospital-based outbreaks.

Keywords: Ebola virus disease, importation risk, infection prevention and control, multi-sectoral coordination, future technologies

1. Introduction

1.1. A vaccine-free outbreak with broader implications

In May 2026, an outbreak of Ebola virus disease (EVD) caused by the Bundibugyo ebolavirus emerged in the Democratic Republic of the Congo (DRC) and rapidly spread to Uganda, leading the World Health Organization (WHO) to declare a Public Health Emergency of International Concern (PHEIC) (*1*). This represents the 17th Ebola outbreak in the DRC, and it is distinguished by a critical gap: unlike Zaire ebolavirus, Bundibugyo virus has no approved vaccine or specific antiviral treatment, and the case fatality rates in the previous two Bundibugyo outbreaks ranged from approximately 30 to 50% (*2,3*). The 2026 event was characterized by nosocomial amplification and a four-week delay between the onset of symptoms in the index case and laboratory confirmation, highlighting persistent flaws in infection prevention and control (IPC) even in endemic settings. Although the 2026 Bundibugyo outbreak provides the immediate context for this analysis, the framework and preparedness principles discussed here are applicable to other high-consequence pathogens, including Marburg virus, Lassa fever virus, and future emerging infections with pandemic potential.

1.2. Hospital-centered defense in an era of global mobility

Global air connectivity has shifted the primary barrier against imported filovirus disease from border screening to the hospital. The incubation period of up to 21 days permits an asymptomatic traveler to cross international borders, present to an emergency department far from the point of entry, and initiate nosocomial transmission before the infection is recognized (*4,5*). In the absence of approved vaccines or specific antiviral treatments for Bundibugyo virus, and with limited cross-protection from existing vaccines based only on non-human primate data, containment depends entirely on non-pharmaceutical interventions (*6,7*). For China, the high density of direct flights from Africa to aviation hubs such as Guangzhou and Shenzhen, combined with extensive population mobility under the Belt and Road Initiative, makes importation a predictable long-term risk and reinforces the urgency of hospital-based preparedness (*8,9*).

1.3. A structured framework for hospital resilience

To guide this hospital-centered preparedness, we propose the Hospital Resilience 4P Framework, which organizes the required measures into four interdependent pillars: Prediction (early warning through tiered screening and a graded response activation), Preparedness (institutionalized, simulation-based healthcare worker training), Protection (comprehensive IPC, including environmental decontamination and personal protective equipment (PPE) systems), and Partnership (multisectoral integration linking port health, public health agencies, hospitals, and communities through a shared digital platform) (Figure 1). This article synthesizes the importation risk of EVD from the perspective of hospital system resilience. We critically examine the epidemiological drivers of healthcare-based amplification, detail each pillar of the 4P Framework with supporting evidence, highlight the neglected preparedness challenges facing East Asian healthcare systems, and evaluate emerging technologies with explicit evidence grading. Establishing an integrated, multi-layered system that extends from the aircraft cabin to the isolation ward is essential to ensuring that an imported case remains a contained clinical event rather than triggering a hospital-based outbreak.

2. Importation risk and healthcare facilities as amplifiers

2.1. Nosocomial transmission as a persistent pattern

Healthcare facilities are repeatedly identified as principal sites of Ebola amplification. Among 31 documented EVD outbreaks with human-to-human spread, 80.6% involved nosocomial transmission (*10*). During the 2018-2020 DRC epidemic, healthcare-associated infections accounted for 579 of 3,481 confirmed cases (16.6%), and the case fatality rate among infected healthcare workers reached 41.3% (*11*). The 2026 Bundibugyo virus outbreak reproduced this pattern and further demonstrated how local conditions facilitate international spread. A four-week detection gap elapsed between symptom onset in the presumed index case and

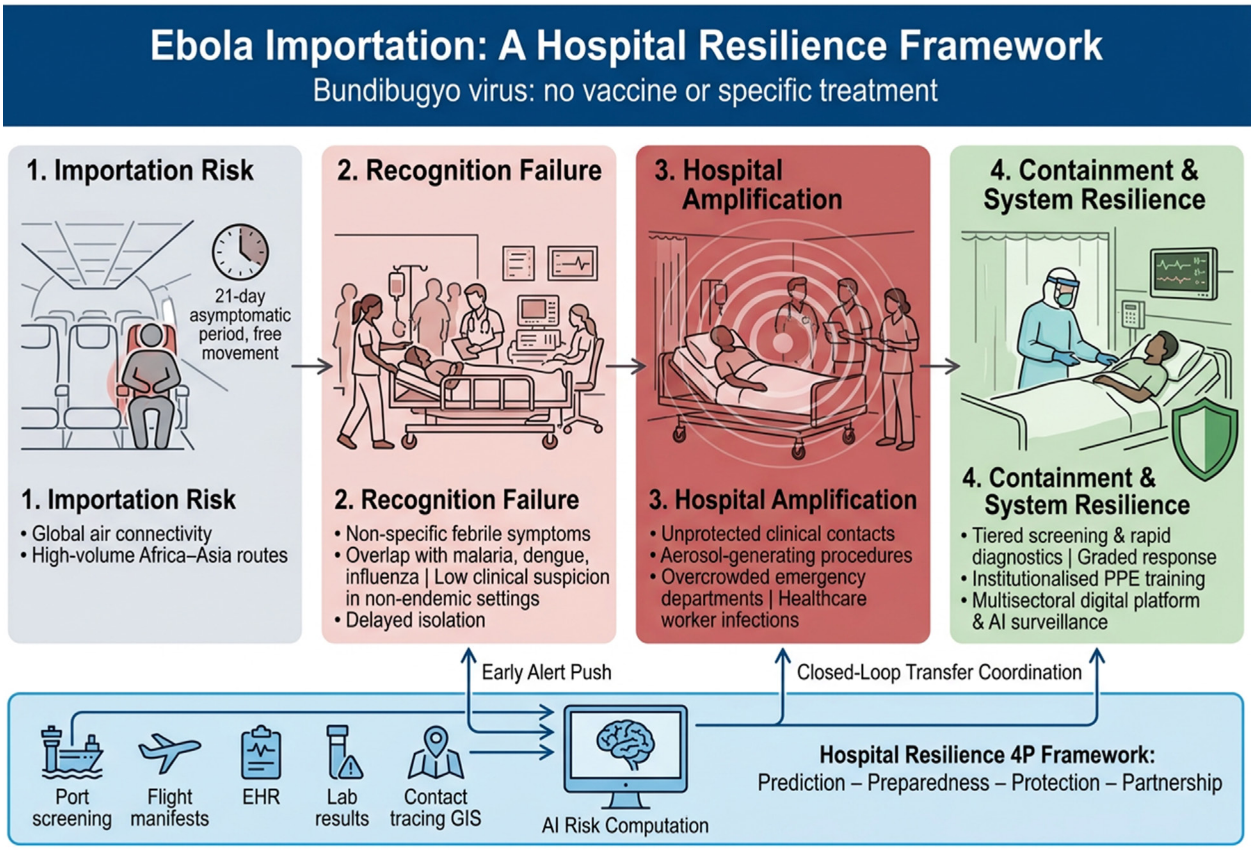

Figure 1. Mechanistic chain of hospital resilience against imported Ebola virus disease. This schematic shows the full-chain mechanism from importation to containment and the pillars of hospital resilience. An infected traveler enters via an international flight, undergoes an asymptomatic incubation period, and presents to the emergency department, where overlapping symptoms cause diagnostic delay. Placement in a general ward before diagnosis triggers hospital amplification, which is ultimately contained through a graded response, isolation, and a digital platform providing AI-driven early alerts and closed-loop transfer coordination.

laboratory confirmation, four health workers died within four days at Mongbwalu General Referral Hospital, and cross-border exportation was confirmed within days of the outbreak declaration, with two imported cases identified in Kampala, the second having no apparent epidemiological link to the first (*1*).

2.2. Drivers of hospital amplification in non-endemic settings

In non-endemic settings, the risk of hospital amplification is driven by several interlocking factors. First, the initial clinical presentation of EVD, which includes a fever, headaches, myalgia, and pharyngitis, is nonspecific and overlaps extensively with common febrile illnesses such as malaria, dengue, typhoid, and influenza (*4*). This syndromic overlap routinely delays diagnosis, and during this period patients are managed with standard rather than enhanced barrier precautions. The 2026 outbreak demonstrated this effect even in an endemic setting with prior outbreak experience, where a four-week gap occurred between symptom onset and laboratory confirmation. Second, emergency department overcrowding, a near-universal condition in urban hospitals globally, increases the probability of unrecognized exposure during the early symptomatic phase when viral loads may be rising. Third, high-risk bedside procedures, including venous catheterization and endotracheal intubation, are often performed before a definitive diagnosis is established, generating aerosols and posing significant occupational exposure risks (*12*). Fourth, Ebola virus can persist in immune-privileged sites, including the testes, ocular fluid, and central nervous system, and cause recrudescence months or years after recovery. The genomic link between the 2021 Guinea outbreak and the 2013-2016 West African epidemic strongly supports this mechanism of late reactivation as a source of new transmission chains (*10*).

2.3. Cross-border spread and the first point of healthcare contact

The 2026 outbreak also illustrates how local epidemiological conditions enable international dissemination. Ituri Province functions as a commercial and migratory hub that direct borders South Sudan and Uganda, with the Bunia Health Zone located less than 500 km from the Ugandan border. Cross-border exportation was confirmed within days of the declared outbreak, and the second imported case in Kampala had no apparent epidemiological link to the first, indicating that multiple exportation events can occur before an outbreak is officially recognized. This sequence, in which regional spread precedes official notification, defines the preparedness scenario that non-endemic countries must anticipate. For receiving countries, the first point of healthcare contact determines whether an imported case is contained or amplified into a nosocomial cluster.

3. The Hospital Resilience 4P framework

The Hospital Resilience 4P Framework organizes hospital preparedness around four interdependent pillars: Prediction, Preparedness, Protection, and Partnership. Unlike conventional preparedness models that focus predominantly on infection prevention and control protocols, this framework integrates anticipatory surveillance, workforce capacity building, environmental protection, and cross-sector governance into a unified resilience architecture. Each pillar was developed through structured engagement with stakeholders across clinical, administrative, and public health domains and was designed to address specific vulnerabilities identified through analysis of prior filovirus outbreak responses. Although the four pillars are presented sequentially here, their application in practice is neither linear nor strictly chronological. The components operate concurrently, and the relative emphasis on each pillar shifts in response to the evolving epidemiological context.

3.1. The recognition deficit in frontline settings

A recurring failure across filovirus outbreaks is the delayed recognition of cases at the point of first clinical contact. In settings where viral hemorrhagic fevers are not endemic, the non-specific early symptoms are frequently attributed to more common febrile illnesses, and transmission proceeds before any enhanced precautions are implemented. The 2026 Bundibugyo virus outbreak illustrated this pattern, with a four-week interval between symptom onset in the index case and laboratory confirmation occurring in a country with prior Ebola experience.

This diagnostic delay is compounded by persistent gaps in healthcare worker preparedness. A 2023 nationwide survey in Uganda found that fewer than 35% of emergency healthcare workers had received Ebola-related training in the preceding year (*13*). During the 2018-2020 DRC epidemic, only 16% of healthcare workers had completed formal Ebola training, and their awareness of key transmission pathways, including risks associated with traditional burial practices, ranged from 28 to 34% (*14,15*). These figures point to a structural deficit in training that has permitted nosocomial transmission to recur across multiple outbreak settings. The WHO's assessment of the 2026 event further underscored this concern, noting critical breaches in infection prevention and control protocols.

3.2. Pillar 1: Prediction through tiered screening and a graded response

Shortening the interval between presentation and isolation requires a systematic approach to case identification. The Prediction pillar establishes a three-tier screening pathway for emergency departments and fever clinics: first, ascertainment of epidemiological risk factors, defined as travel to or residence in an affected area within the preceding 21 days; second, use of a clinical risk prediction score; and third, deployment of rapid diagnostic testing for individuals meeting the clinical or epidemiological case definition. The evidence supporting each of these tiers has grown substantially. A pediatric Ebola risk score validated in West Africa resulted in an area under the curve (AUC) of 0.87, significantly exceeding the performance of the standard WHO case definition, which has an AUC of 0.56 (*16*). When embedded within a screening algorithm, such scores, combined with rapid diagnostic tests, have been shown to reduce unnecessary isolation while accelerating the identification of true cases in a cost-effective manner (*17*). Although rapid diagnostic tests for EVD have a pooled sensitivity of 86.1% and specificity of 97% (*18*), their value lies in enabling immediate risk stratification: patients testing positive are transferred directly to negative-pressure isolation, while those testing negative but presenting with a high-risk epidemiological or clinical profile enter a structured observation pathway. This approach limits the duration of potential exposure in general clinical areas.

Screening tools alone are insufficient in the absence of clear activation thresholds. A three-level response structure, aligned with the Alert, Suspect, and Confirmed categories recommended by the WHO, allows for graduated escalation. At the Alert Level, identification of an asymptomatic traveler from an affected area prompts health monitoring and verification of PPE stocks, without requiring immediate isolation. At the Suspect Level, a patient meeting the clinical case definition or whose rapid test result is positive triggers activation of the hospital incident command structure, preparation of the negative-pressure unit, enhancement of IPC measures across the facility, and initiation of contact tracing. At the Confirmed Level, laboratory confirmation of infection escalates the response to full emergency status: isolation zones are instituted, non-essential visits are suspended, all staff in affected areas transition to high-risk PPE, and the broader multisectoral coordination mechanism is activated. The value of this graduated structure lies in its proportionality; it avoids both the costs of over-reaction to low-risk events and the delays associated with indecision during genuine threats.

3.3. Pillar 2: Protection through environmental decontamination and healthcare worker safety

Environmental decontamination is a fundamental component of outbreak response, but the predominant modality - chlorine-based disinfection - has well-documented limitations. Organic matter rapidly inactivates chlorine, the compounds are corrosive to medical equipment, and prolonged exposure poses respiratory risks to staff, particularly in tropical environments where ventilation may be limited. Standard chlorine-based disinfectants have demonstrated virucidal activity against Ebola virus in complex matrices such as tripartite soil and whole blood (*19*), confirming their utility when correctly applied. However, the observation that Ebola virus can remain infectious on dry surfaces for up to 28 days (*20*) underscores the importance of thorough terminal decontamination and prompts the exploration of complementary methods of physical inactivation.

The protection of healthcare workers requires attention to factors that extend beyond the content of written protocols. Despite the existence of a well-established tiered PPE framework, breaches in PPE use are consistently implicated in healthcare worker infections. The deaths of health workers early in the 2026 Bundibugyo outbreak illustrate that protocol documentation alone does not ensure safe practice (*20*). Investigations of PPE failures consistently point to human-factor issues as the predominant cause: heat stress and fatigue degrade concentration during doffing, competency-based training is often inadequate, and supervision during high-risk procedures is frequently insufficient. Evidence from a study involving a simulated Ebola treatment unit demonstrated that performing clinical tasks in full PPE at an ambient temperature of 35°C significantly prolonged task completion times and increased physiological heat stress, with a quarter of participants reaching predefined health trigger thresholds (*21*). These data support the implementation of strict limits on shift duration, the adoption of active cooling strategies, and the design of training programs that replicate the thermal and psychological conditions of actual clinical work.

3.4. Pillar 3: Preparedness through institutionalized training

Transitioning from episodic training to sustained institutional competence requires a systems-level approach. Simulation-based training improves both safety awareness and willingness to work, but the relationship between training and performance is not linear. Excessive repetition can induce training fatigue and erode psychological readiness (*21*), suggesting that the frequency and intensity of training must be carefully calibrated. The East Africa Infection Prevention and Control Learning Network offers an instructive model. This collaborative initiative, spanning 20 tertiary hospitals across four countries, employed a combination of virtual and in-person training, structured mentorship, and collaborative quality-improvement projects to raise average hospital IPC compliance from 65 to 92% (*22*). Those results indicate that durable competence is built through sustained, networked capacity-building rather than through isolated instructional events. Extending this principle, the recognition and initial management of viral hemorrhagic fevers should be integrated into mandatory annual continuing education for all emergency, infectious disease, and critical care physicians, with competence verified through simulation-based assessment rather than passive knowledge tests.

3.5. Pillar 4: Partnership through multisectoral integration

The fourth pillar addresses the coordination deficit that has characterized many outbreak responses. Effective containment requires that port health authorities, public health agencies, and designated treatment hospitals operate as components of a single functional system rather than as independent entities. The operational mechanism for this integration is a shared digital platform that consolidates real-time data from customs declarations, flight manifests, electronic health records, laboratory information systems, and geospatial contact tracing. The 2026 outbreak response provided a clear demonstration of this need: the WHO's operational framework called for strengthened Point of Entry screening and cross-border coordination, with rapid response teams positioned at formal and informal border crossings, major transit routes, and pilgrimage corridors. The concurrent armed conflict, population displacement, and insecurity in Ituri Province further underscored the necessity of coordination structures that extend beyond governmental agencies.

However, technological infrastructure cannot substitute for social infrastructure. A cross-national analysis of the 2014-2016 West African epidemic demonstrated that regions characterized by higher levels of voluntary association participation and stronger social trust networks experienced significantly shorter outbreak durations (*23*). During the 2018-2020 DRC epidemic, the circulation of conspiracy theories, mistrust of public authorities, and perceptions that the Ebola response constituted a commercial enterprise drove patients away from formal healthcare facilities towards private or informal care, with measurable consequences for transmission dynamics and diagnostic delays (*24*). Effective multisectoral coordination therefore depends on the active involvement of community leaders and trusted local organizations, supported by transparent risk communication strategies.

For China, the Partnership pillar can draw on existing infrastructure established under the Belt and Road Initiative. Health-related cooperation within this framework already encompasses medical assistance, joint laboratory construction, and infectious disease surveillance activities in multiple African countries. These established channels could be adapted to support real-time sharing of outbreak signals between African health ministries and Chinese port health authorities, with the potential to reduce the interval between detection and cross-border notification. In parallel, large Chinese enterprises operating in Africa, and particularly in the construction, mining, and telecommunications sectors, manage substantial workforces that regularly rotate through aviation hubs in Guangzhou and Shenzhen. Integrating the health management systems of these enterprises with national public health surveillance architecture would address a critical information gap in the current preparedness framework.

Operationally, the Partnership pillar includes the closed-loop transfer of suspected cases *via* dedicated negative-pressure ambulances along predetermined routes to pre-alerted receiving hospitals, with escort personnel in full PPE. This is complemented by internationally recommended restrictions on international travel for confirmed cases and contacts, with exceptions only for medical evacuation, and by exit screening at international airports, seaports, and major land crossings for all individuals presenting with unexplained febrile illness consistent with potential Bundibugyo virus disease. The entire multisectoral system requires annual stress-testing through full-scale simulated exercises that cover the complete operational chain, from initial port detection through to terminal disinfection of the isolation facility. Structured after-action reviews following each exercise serve as the mechanism for turning identified gaps into systemic improvements (*22*).

4. Preparedness challenges in East Asian healthcare systems

Current EVD preparedness discourse has devoted limited attention to the specific vulnerabilities of East Asian healthcare systems. This gap is both analytically unwarranted and operationally consequential, given the region's deep economic ties with Africa, extreme airport density, and distinctive demographic profile. The rapid cross-border spread observed during the 2026 outbreak demonstrates how quickly an outbreak can generate multiple exportation events before containment measures are fully activated.

4.1. China's increased exposure through aviation and economic corridors

Within East Asia, China faces a uniquely increased exposure profile. The country is Africa's largest trading partner, and population mobility between the two regions has intensified substantially over the past two decades. Guangzhou Baiyun International Airport and Shenzhen Bao'an International Airport serve as the primary aviation gateways, operating direct flights to multiple African cities including Addis Ababa, Nairobi, Lagos, and Johannesburg. This high-volume, multi-directional mobility means that an individual infected during an Ebola outbreak in Central or West Africa could arrive in southern China within 24 to 36 hours of exposure. Unlike historical importation events in North America or Europe, which were sporadic and originated from a limited set of destinations, China's connectivity to Africa is both geographically broader and quantitatively more extensive, making repeated importation statistically probable over the long term.

4.2. Healthcare system vulnerabilities at the receiving end

Once an imported case arrives, the healthcare environment in Chinese megacities introduces additional challenges. Emergency departments in Guangzhou and Shenzhen, like those in other major East Asian cities, routinely operate at over 100% bed occupancy, leaving minimal surge capacity for the isolation and management of a high-consequence pathogen. The clinical workload, combined with limited familiarity with viral hemorrhagic fevers, which are not systematically covered in routine medical education or continuing professional development in China, creates a substantial recognition gap. Moreover, the healthcare-seeking behavior of returning Chinese workers and African residents in cities such as Guangzhou may differ from that of the general population. Studies on African migrants in Guangzhou have documented low healthcare utilization rates and significant barriers including language difficulties, fear of deportation, and cultural differences in health beliefs, all of which may contribute to delayed care-seeking for febrile illnesses (*25,26*). Hospital-based surveillance data also indicate that this population carries a high burden of infectious diseases and yet testing uptake remains suboptimal, creating conditions for imported pathogens to remain undetected (*27*).

Beyond China, several structural factors affect East Asian healthcare systems collectively. The healthcare workforce in Japan, South Korea, and China is aging rapidly; older healthcare workers face disproportionately higher risks of severe outcomes from EVD, while a shrinking workforce reduces surge capacity. PPE stockpiling, although substantially improved after the COVID-19 pandemic, remains oriented toward dealing with respiratory pathogens rather than the full-barrier ensembles required for filovirus care. Moreover, the density of intra-regional travel means that a single imported case can rapidly generate multi-country contact tracing requirements that challenge the interoperability of separate national surveillance systems.

4.3. Training and regional strategies as priority investments

For China, the institutionalization of healthcare worker training in EVD recognition is a more urgent priority than further material stockpiling. We recommend that EVD and other high-consequence infectious diseases be incorporated into the mandatory annual continuing medical education credit system for all emergency, fever clinic, and intensive care unit physicians and that regional simulation centers be established to provide standardized, high-fidelity training. Region-specific strategies, including pre-positioned isolation facilities at key hub airports, joint cross-border simulated exercises, and harmonized digital contact-tracing protocols, would substantially strengthen the regional preparedness architecture.

5. Future technologies: Promise, evidence gaps, and implementation realities

Emerging technologies can strengthen the preparedness chain, but rigorous evidence grading is essential to preventing overstatement.

5.1. Deep-ultraviolet laser air disinfection

A novel 266-nm deep-ultraviolet laser technology offers a potential shift from chemical to physical disinfection. Unlike chlorine-based agents with their documented toxicity and corrosion risks, this system operates through a purely physical process, achieving high single-pass inactivation efficiencies against surrogate viruses while presenting zero airflow resistance—a critical advantage over HEPA filters and conventional UV lamps that trade airflow rate for efficiency (*20*). The core module can be integrated into central ventilation systems, field hospitals, and mobile platforms. However, validation against aerosolized Bundibugyo ebolavirus under tropical conditions still needs to be done. Until such data are available, this technology is graded as conceptually and experimentally promising but not validated for an Ebola outbreak. Low-cost photodynamic approaches such as methylene blue photoinactivation, effective against coronaviruses for PPE reuse, also warrant investigation for Ebolavirus in resource-limited settings (*28*).

5.2. AI-driven risk surveillance

Deep learning models have been applied to social media sentiment analysis during Ebola outbreaks to guide risk communication (*29*), and machine learning has accelerated the screening of potential Ebola virus inhibitors (*30*). Computer vision algorithms can detect high-risk IPC events—breaches of safe distances, incorrect doffing, mask removal—and issue real-time alerts. Multi-source data fusion platforms integrating customs declarations, electronic health records, syndromic surveillance, and Internet-based health monitoring can compute spatiotemporal risk indices and trigger hospital alerts within minutes. These tools represent a shift from reactive IPC to algorithmically augmented safety, but none has been rigorously evaluated during an active, multi-country Ebola outbreak. They should be regarded as experimentally demonstrated but not outbreak-proven.

5.3. Differential serology for surveillance in a vaccine era

As ring vaccination with rVSV-ZEBOV expands, distinguishing natural infection from vaccine-induced antibody responses becomes essential. The "Ebola-Detect" assay targets conserved peptides from internal viral proteins absent from current vaccines, achieving a specificity > 94% and sensitivity > 96% (*31*). Although its immediate relevance to Bundibugyo virus is limited, this capability is critical for surveillance in co-endemic regions where ring vaccination is deployed and for avoiding misclassification of vaccine recipients. Integration into routine confirmatory algorithms is an achievable near-term priority.

5.4. Humanized PPE and ergonomic innovation

Future PPE designs incorporating active cooling, breathable membranes, augmented-reality face shields, and simplified doffing mechanisms promise to reduce heat stress, cognitive load, and error rates (*21*). Prototypes have demonstrated improved comfort and protocol adherence in simulations, but field data in high-consequence pathogen settings remain absent. These innovations are classified as the conceptual development stage and require end-user evaluation in endemic settings before operational deployment.

6. Limitations

Several limitations should be noted. First, the evidence base derives largely from previous Ebola outbreaks, predominantly Zaire ebolavirus, and Bundibugyo-specific data remain limited. Second, the 4P Framework has not been prospectively validated as a bundled intervention. Third, some emerging technologies discussed, including deep-ultraviolet laser disinfection and AI-driven surveillance, have not been tested under active outbreak conditions. Finally, this is a perspective article, and the selection and interpretation of evidence may reflect the authors' judgment. Despite these limitations, the framework offers a structured basis for preparedness planning that can be refined as new evidence emerges.

7. Conclusion

The 2026 Bundibugyo virus outbreak exposes a systemic vulnerability: global connectivity ensures that high-consequence pathogens will repeatedly test the preparedness of non-endemic countries. For China, which has direct flights from Africa to Guangzhou and Shenzhen that sustain high-volume population movement, repeated importation is a statistical certainty rather than a remote possibility. The Hospital Resilience 4P Framework - Prediction, Preparedness, Protection, and Partnership - offers a structured model for turning this exposure into operational readiness. The framework integrates tiered early warning and a graded response (Prediction), comprehensive infection prevention and human-factors - informed safety (Protection), simulation-based workforce training (Preparedness), and cross-sectoral coordination that capitalizes on existing Belt and Road health-related cooperation channels and corporate health management networks (Partnership). For Bundibugyo virus, for which no vaccine or antiviral exists, this non-pharmaceutical foundation constitutes the entire available defense, and the same logic applies to Marburg virus, Lassa fever, and future emerging pathogens for which medical countermeasures may also be unavailable. Emerging technologies can augment each pillar, but their integration must be governed by rigorous evidence. Embedding the 4P Framework into routine hospital preparedness, and particularly in cities at the terminus of high-volume Africa air corridors, would help ensure that imported cases are contained as clinical events rather than developing into outbreaks.

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