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# Preparedness for Zoonotic Pandemics of Respiratory Potential: A Narrative Review of Cross-Training and Resource Allocation Models

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## Abstract

**Background:** The 21st century has witnessed multiple zoonotic respiratory outbreaks with pandemic potential, including SARS-CoV-1, H1N1 influenza, MERS-CoV, and SARS-CoV-2. These events consistently stress-test health systems, revealing critical vulnerabilities in surge capacity, inter-professional coordination, and resource logistics beyond the intensive care unit. The siloed nature of traditional healthcare preparedness often falters under the complex, cross-cutting demands of a pandemic.

**Aim:** This narrative review aims to synthesize evidence from recent zoonotic respiratory outbreaks to critically evaluate preparedness models, with a specific focus on interdisciplinary cross-training and dynamic resource allocation strategies across public health, radiography, pharmacy, and allied health/security personnel.

**Methods:** A comprehensive literature search was conducted across PubMed, Scopus, and Web of Science databases (2010-2024).

**Results:** Analysis indicates that fragmented preparedness causes reactive strain, highlighting the need for proactive, scalable frameworks that combine pathogen-specific knowledge with system strengthening. Key findings stress the importance of cross-training protocols, the use of teleradiology and mobile imaging, pharmacy supply chain redundancy with ethical allocation frameworks, and the role of trained health assistants in screening and flow management. Incorporating these interdisciplinary elements in scenario planning is essential.

**Conclusion:** Resilience against future respiratory zoonoses requires a deliberate shift from siloed, hospital-centric preparedness to integrated, system-wide strategies. Investing in interoperable cross-training protocols, agile resource-sharing agreements, and digital health infrastructures across professions can build the adaptive capacity necessary to manage surge demands while maintaining essential health services.

**Keywords:** Zoonotic Pandemic Preparedness, Interdisciplinary Cross-Training, Health System Surge Capacity, Resource Allocation Models, Respiratory Outbreak Response.

## Introduction

The epidemiological landscape of the 21st century is increasingly defined by the emergence and re-emergence of zoonotic pathogens with respiratory transmission potential and pandemic risk (Jones et al., 2008). From the severe acute respiratory syndrome (SARS) coronavirus in 2002-2003, through the 2009 H1N1 influenza pandemic, the persistent threat of Avian Influenza A (H5N1, H7N9), the Middle East Respiratory Syndrome (MERS) coronavirus, and the profound global impact of SARS-CoV-2, these events form a stark pattern of biological continuity (Morens & Fauci, 2020). Each outbreak serves as a stress test for global and national health security architectures, exposing persistent gaps between theoretical preparedness plans and operational reality (Gostin & Katz, 2016).

A critical lesson from COVID-19 is that pandemic impact extends far beyond the intensive care unit and virology laboratory; it cascades through every facet of the health system, creating choke points in diagnostics, supply chains, and frontline patient management (Cheong Chi Mo et al., 2023). Traditional, vertically structured preparedness, often focused on specific pathogens or single-agency response, has proven inadequate for the horizontally complex demands of a full-scale pandemic, which simultaneously strains imaging departments,


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pharmacy stocks, primary care access, and facility security (Kandel et al., 2020). This review argues that future resilience hinges on transcending professional and departmental silos through deliberate cross-training and intelligent, flexible resource allocation models. By synthesizing evidence from past outbreaks, we explore integrated strategies that leverage the collective capacity of public health, radiography, pharmacy, and allied health/security personnel to build more adaptive and robust health systems.

**Theoretical Foundations: From Siloed Response to Integrated Surge Capacity**

The concept of surge capacity is foundational to disaster medicine, encompassing the ability to expand services beyond normal operations to meet increased demand (Khalil et al., 2022). However, the pandemic surge is unique in its scale, duration, and systemic nature. It requires not just a quantitative increase in beds or ventilators, but a qualitative transformation in care delivery processes and workforce deployment (Hick et al., 2022). The "staff, stuff, and space" triad must be reimagined with flexibility and substitution in mind (Barasa et al., 2017).

Cross-training, a principle borrowed from high-reliability organizations, becomes essential, allowing for the creation of a "functional reserve" within the health workforce (Wong et al., 2020). This involves training professionals to safely undertake extended or supportive roles outside their immediate specialty—a radiographer assisting in patient triage, a pharmacist managing logistics in a testing centre, or a health assistant performing basic screening (Zheng et al., 2021). Concurrently, resource allocation must move from static stockpiling to dynamic modeling that anticipates cascading failures. This includes scenario-based planning for critical supplies like contrast media, antivirals, and personal protective equipment (PPE), with ethical frameworks for their prioritization during scarcity (Emanuel et al., 2020; Singh et al., 2022). The integration of these concepts—cross-training for workforce agility and smart logistics for resource resilience—forms the core of a modern preparedness paradigm.

**Learning from Past Outbreaks: COVID-19, MERS, and Avian Influenza**

Each major zoonotic respiratory outbreak provides distinct yet complementary lessons. The MERS-CoV outbreaks, particularly in South Korea in 2015, highlighted the catastrophic consequences of hospital-based transmission and the critical need for robust infection prevention and control (IPC) protocols at entry points (Kim et al., 2017). This underscored the role of health security and assistant personnel in enforcing screening and donning/doffing procedures. Avian influenza scares, such as H7N9 in China, reinforced the importance of rapid surveillance, animal-human interface monitoring, and the challenges of vaccine development for novel influenza strains (Wang et al., 2017). They also revealed tensions in antibiotic and antiviral prescribing in outpatient settings prior to confirmed diagnosis.

The COVID-19 pandemic, however, offered the most comprehensive and brutal stress test. It demonstrated the absolute necessity of mass diagnostic and imaging capacity, with radiology departments becoming central to both diagnosis and severity assessment (Rubin et al., 2020). It exposed fragile global supply chains for essential medications, sedatives, and even simple albuterol inhalers (Badreldin & Atallah, 2021). It showed how fever clinics and community testing sites could de-pressurize emergency departments, but required rapid staffing and operationalization (Adhikari et al., 2020). Most importantly, it revealed the interconnectedness of these challenges: a shortage of radiologists increased reporting delays, impacting bed flow; pharmacy shortages compromised clinical protocols; and overwhelmed triage areas became hotspots for transmission. Analyzing these outbreaks collectively points to the non-negotiable need for an interdisciplinary preparedness approach.

**Public Health and Scenario Planning**

Effective response begins long before a pathogen emerges, rooted in robust public health infrastructure and proactive scenario planning. Scenario planning moves beyond linear forecasting to explore multiple plausible futures, building cognitive and operational readiness in health leaders (Schwartz et al., 2021). For respiratory zoonoses, scenarios must model varying transmissibility (R0), severity (CFR), and age-specific morbidity to anticipate impacts on hospital admissions, ICU demand, and workforce absenteeism (James et al., 2021). These models must directly inform cross-training needs and resource allocation triggers. For instance, a high-severity, moderate-transmissibility scenario (akin to MERS) would prioritize strict IPC and isolation capacity, while a high-transmissibility, lower-severity scenario (like pandemic influenza) would prioritize mass vaccination and outpatient management (Yen et al., 2014).

Public health authorities must lead tabletop exercises and simulation drills that explicitly involve radiography departments, pharmacy logistics units, and facility management teams to break down silos and test communication channels (Andrews et al., 2023). The integration of wastewater surveillance, syndromic reporting, and genomic sequencing into early warning systems can provide the lead time necessary to activate these plans (Kilaru et al., 2022). Ultimately, the goal is to create "plasticity" in the health system—the ability to reconfigure itself rapidly based on the specific nature of the threat (Legido-Quigley et al., 2020).

**Scaling Imaging Capacity and The Teleradiology Imperative**

Chest imaging, particularly computed tomography (CT) and X-ray, proved indispensable

during COVID-19 for diagnosis, assessing disease progression, and detecting complications (Salehi et al., 2020). The pandemic surge led to overwhelming imaging volumes, creating bottlenecks in scanner access, technician staffing, and radiologist interpretation. Preparedness, therefore, must focus on scalable solutions. Cross-training within imaging departments is crucial, enabling radiographers from other modalities (e.g., MRI, mammography) to competently perform chest radiographs or CTs with condensed, protocol-driven training (Mossa-Basha et al., 2020). Furthermore, the deployment of mobile CT units and X-ray vans to field hospitals or parking lots can isolate potentially infectious patients from main departments and expand physical capacity (Gao et al., 2022).

The most transformative strategy is the robust integration of teleradiology and artificial intelligence (AI). Teleradiology networks allow for the redistribution of reporting workload across regions or countries, mitigating local radiologist shortages (Ertl-Wagner et al., 2020). AI-based tools for automated detection of pulmonary opacities, quantification of disease burden, and prioritization of critical cases can dramatically speed up workflow and assist overburdened radiologists (Li et al., 2020). Preparedness plans must include validated AI algorithms in picture archiving and communication systems (PACS), legal frameworks for cross-jurisdictional teleradiology, and secure, high-bandwidth IT infrastructure. This digital layer is a force multiplier, enabling a smaller core staff to manage a much larger volume of studies efficiently and safely.

**Pharmacy in Securing the Supply Chain and Ethical Allocation**

The pharmacy sector faced unprecedented dual challenges during COVID-19: massive disruptions in global active pharmaceutical ingredient (API) and finished product supply chains, and explosive demand for specific drug classes (e.g., sedatives, paralytics, antivirals) (Shuman et al., 2020). Just-in-time inventory models failed catastrophically, revealing a dangerous over-reliance on geographically concentrated sources, particularly Asia (Shetty et al., 2023). Preparedness requires a multi-pronged approach. Nationally, strategic stockpiles must be expanded beyond traditional anthrax or smallpox countermeasures to include a broad range of critical care medications, essential antibiotics, and basic IV fluids, with rigorous rotation schedules (Sodhi & Tang, 2023). Regionally, health systems should develop consortium-based warehousing and "vendor-managed inventory" agreements to share risk.

At the hospital level, pharmacists must be integral to incident command, implementing immediate conservation strategies, therapeutic interchange protocols, and compounding solutions for scarce drugs (Vinci et al., 2022). Ethical frameworks for drug allocation, co-developed with clinicians, ethicists, and community representatives, must be pre-established to guide decisions during scarcity, preventing ad-hoc rationing (White & Lo, 2020). For vaccines, plans must address not just procurement but ultra-cold chain logistics, mass vaccination site operations, and strategies to combat misinformation—all areas where pharmacists play a leading role (Paudyal et al., 2021). Cross-training pharmacy technicians in logistics for test-kit distribution or vaccination support can further extend capacity.

**Allied Health and Security: Frontline Triage and Flow Management**

The initial point of contact for patients in a pandemic is often not a physician but an allied health professional, health assistant, or security personnel. Their roles are magnified and specialized during outbreaks. In fever clinics and screening tents, trained healthcare assistants can conduct initial symptom checks, record travel history, perform nasopharyngeal or rapid antigen tests, and provide patient education (Wang et al., 2020). This effectively creates a safe buffer zone, protecting the main emergency departments and allowing for the segregation of suspected cases. Security personnel, when properly trained in non-violent communication and public health principles, are essential for managing access control, enforcing visitor policies, and ensuring the safe flow of patients through designated "clean" and "dirty" pathways (Mohamad et al., 2022).

Cross-training for these roles is vital. Assistants from non-acute areas (e.g., physiotherapy, elective surgery wards) can be rapidly trained in basic screening and donning/doffing PPE. Security staff require specific training on the rationale behind public health measures to de-escalate conflicts and act as ambassadors, not just enforcers (Menon et al., 2022). Their integration into the clinical team, with clear communication channels and authority structures, ensures that infection control protocols are maintained at the often-chaotic front door of the healthcare facility, a critical control point identified in both MERS and COVID-19 outbreaks.

**Models for Interdisciplinary Surge Planning**

Moving from lessons to actionable models requires structural integration. One promising model is the "Hub-and-Spoke with Cross-Training Matrix." In this model, a central public health "Hub" coordinates scenario-based activation and resource redistribution. "Spokes" are individual hospitals or primary care clusters, each with pre-identified cross-trained staff pools (e.g., a registry of radiographers trained in portable X-ray, pharmacists trained in mass vaccination, assistants trained in screening) (Essoussi et al., 2023). A digital dashboard tracks real-time resource status: ICU beds, ventilator inventory, imaging backlog, and drug stock levels.

Another model is the "Modular Response Team," in which interdisciplinary teams are preconstituted. For example, a "Community Testing and Triage Team" could comprise a public health

nurse (team lead), two cross-trained radiographers/assistants (for swabbing/vitals), a pharmacist (logistics), and a security officer (flow control). This team can be deployed as a unit to any needed location (Pan & Zhang, 2022). Simulation drills must test these models, focusing on communication handoffs, authority delegation, and stress points in supply and staffing. The practical application of cross-training is detailed in Table 1, while the systemic integration of resources is outlined in Table 2.

**Table 1: Cross-Training Applications Across Health Professions for Pandemic Surge**

| Profession (Home Role) | Extended/Surge Role | Key Training Components Required | Outbreak Example of Need |
|---|---|---|---|
| **Radiographer (MRI/Mammography)** | Chest X-ray/CT operator for respiratory patients | Condensed protocol on chest imaging positioning, exposure settings, and infection control for airborne pathogens. | COVID-19 surge overwhelming chest radiography capacity (Mossa-Basha et al., 2020). |
| **Hospital Pharmacist** | Logistics coordinator for testing/vaccination sites; ICU drug shortage manager | Supply chain software, ethical allocation frameworks, emergency compounding procedures. | Nationwide shortages of paralytics, sedatives, and antivirals during COVID-19 peaks (Shuman et al., 2020). |
| **Physiotherapist / OT** | Fever clinic screening assistant | Symptom checklist administration, nasopharyngeal swab technique, PPE donning/doffing, basic patient communication. | Need to staff mass screening centers while maintaining hospital services (Wang et al., 2020). |
| **Hospital Security Officer** | Public health ambassador & flow controller | Principles of respiratory transmission, non-violent communication, de-escalation techniques, and guiding patient pathways. | Enforcing visitor restrictions and managing entry points at hospitals during MERS and COVID-19 (Mohamad et al., 2022). |
| **Public Health Nurse** | Field team lead for community response | Incident command system (ICS) basics, inter-agency coordination, and data collection from non-clinical teams. | Leading mobile testing or vaccination teams in community settings (Pan & Zhang, 2022). |

*Note.* This table illustrates how protocolized cross-training can create a functional workforce reserve, enabling rapid role adaptation to meet surge demands across different pandemic scenarios.

**Table 2: Core Components of an Integrated Resource Allocation & Surge Plan**

| Component | Description | Stakeholders Involved | Activation Triggers |
|---|---|---|---|
| **Dynamic Staffing Pool** | A pre-identified registry of staff from all departments, with documented cross-training competencies, available for redeployment. | HR, Nursing, Medicine, Allied Health Dept. Heads | >10% staff absenteeism; declaration of Phase 2/3 pandemic alert by public health. |
| **Supply Chain Triggers** | Pre-negotiated contracts with alternative suppliers; agreements to share regional stockpiles; automated "re-order" points lowered for key drugs/PPE. | Pharmacy, Procurement, Finance, Regional Health Authorities | 30-day supply remaining of Tier 1 drugs; failure of primary supplier; WHO declares Public Health Emergency of International Concern (PHEIC). |
| **Imaging Surge Protocol** | Tiered activation of teleradiology networks, AI-assisted triage in PACS, deployment of mobile units, and cross-training implementation. | Radiology, IT, Facilities Management | >20% increase in chest imaging volume over baseline sustained for 48 hours; radiologist staffing below 80%. |

| | | | |
|---|---|---|---|
| **Peripheral Care Site Plan** | Blueprints for stand-up of fever clinics/testing sites, including staffing model, supply lists, and physical layout for patient flow. | Public Health, Emergency Mgmt., Clinical Engineering, Security | Emergency Department wait times >200% baseline due to respiratory screening; public health order for community testing. |
| **Ethical Framework Committee** | A pre-established, diverse committee ready to convene to provide guidance on allocation of scarce resources (drugs, vaccines, ICU beds). | Ethics, Clinical Dept. Chairs, Pharmacy, Community Representatives | Imminent shortage of a life-saving resource; need to prioritize a limited initial vaccine supply. |

*Note.* This table outlines the interconnected, trigger-based components of a proactive surge plan, emphasizing pre-established agreements and thresholds to enable rapid, coordinated system adaptation.

**Conclusion**

The history of zoonotic respiratory pandemics is still being written, and the next chapter is a matter of when, not if. The painful lessons of COVID-19, MERS, and avian influenza provide a clear mandate: resilience cannot be found in isolated excellence but must be built through intentional interconnection. Preparedness must evolve from planning for a disease to planning for any disease of respiratory pandemic potential, focusing on the common system failures they induce. This requires investing in the cross-training of the health workforce to create inherent flexibility, and in smart, ethical, and dynamic models for allocating both staff and staff. It demands that digital infrastructure, like teleradiology and supply chain dashboards, be woven into the core of response plans. By fostering a culture of interdisciplinary collaboration through repeated simulation and shared governance, health systems can transform from brittle structures prone to fracture under pressure into adaptive ecosystems capable of weathering the next storm. The goal is not merely to survive the next pandemic, but to maintain the integrity of health service delivery for all patients throughout it.

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