

Pediatric Vaccination and Pandemic Preparedness in Humanitarian Settings



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KEYWORDS

- Pediatric immunization • Zero-dose children • Pandemic preparedness • One health
- Vaccine equity • Infodemic management • Last mile • Health system resilience

KEY POINTS

- Humanitarian crises amplify pediatric vulnerability to infectious diseases due to disrupted systems and social determinants.
- Zero-dose children are concentrated in fragile and conflict-affected settings, necessitating targeted immunization strategies.
- Community engagement, trust, and infodemic management are central to vaccination success.
- Health system resilience depends on integrated services, adaptive logistics, and robust surveillance.
- Ethical, data-driven, and One Health approaches are essential for future pandemic preparedness.

INTRODUCTION

The magnitude and frequency of disease outbreaks have escalated in recent decades, highlighting the complex dynamics contributing to emerging and reemerging pediatric infectious diseases.¹ Many contributing factors are in and of themselves major challenges, ranging from climate change and geopolitical tensions to deeply entrenched systemic disparities restricting access to health care. Childhood immunization and

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Abbreviation
CDE common data element

outbreak prevention hold enormous potential to reduce morbidity and mortality in crisis-affected populations. Despite their proven efficacy, vaccine coverage and outbreak response in many humanitarian settings remain suboptimal, presenting major challenges for child health protection.^{2,3}

CONTEXT AND BURDEN IN HUMANITARIAN SETTINGS

In 2024, there were 14.3 million children globally who did not receive a single vaccine. Recent studies suggest a significant portion of the world’s zero-dose children, or those who have not received a single dose of a routine vaccine, are located in conflict zones or humanitarian contexts. Among lower-income countries, nearly 30% (~2.9 million) of zero-dose children live in fragile and conflict-affected settings.^{4–7} With approximately half a billion children exposed to armed conflict, natural disasters or humanitarian crises, recognition of the destabilizing impacts of these environments is critical to maintain effective infectious disease prevention and control.^{8–10} In these fragile contexts, the vulnerability of children to communicable diseases is dramatically increased due to disrupted health systems, population displacement, and reduced access to essential services. Armed conflicts systematically destroy the social determinants of health that protect children from infectious diseases.^{11,12} Children’s immature immune systems, dependence on adult caregivers, and elevated metabolic needs place them at increased risk when facing conditions such as malnutrition, overcrowding, and poor sanitation, all of which contribute to increased transmission risk and disease severity.

In an era of escalating armed conflicts and increasingly protracted humanitarian crises, safeguarding children from infectious disease threats requires an understanding of the complex intersection between environmental, socioeconomic, and health determinants in these settings. Prioritizing immunization and pandemic preparedness is not only a public health necessity but an ethical imperative to upholding the fundamental right to health for all children, regardless of where they live.¹³ This article examines the critical components necessary to advance these goals and highlights strategies to strengthen vaccination systems and pandemic preparedness in humanitarian contexts.

DISEASE THREAT LANDSCAPE

Several emerging and reemerging viral threats demand attention in humanitarian pediatric settings. These include: measles, which has seen concerning resurgence globally since 2016 due to declining vaccination coverage; polio, which continues to defy eradication efforts in conflict-affected regions; and various arboviral diseases like Zika, dengue, and chikungunya, whose vector ecology is predicted to expand with climate shifts. Each presents unique challenges for public health programs in humanitarian settings, requiring tailored approaches for prevention and control. The role that children play in disease transmission is often underestimated, and identification of illness in children can be challenging in regions lacking pediatric-trained health care workers. Additionally, the ever-present specter of *Disease X*, a hypothetical pathogen with pandemic potential, underscores the need for preparedness measures that anticipate the emergence of new or unknown diseases.¹

COMMUNITY ENGAGEMENT

Equitable community engagement has proven to be a foundational unifying mechanism for improving vaccination outcomes across nearly all intervention types in humanitarian settings. The most effective strategies involve engagement across multiple levels and sectors. Engaging local leaders, recruiting community mobilizers, and addressing context-specific concerns about vaccines have demonstrated success in building trust and increasing demand. This is particularly important in settings where distrust of authorities may be high due to ongoing conflict or historical grievances. Effective community engagement goes beyond simple information dissemination to include meaningful participation of affected populations in program planning and implementation.¹⁴ Acknowledgment of local priorities is paramount: many communities will be dismissive of vaccination efforts alone if they perceive that their more immediate suffering is being disregarded. However, while addressing upstream social determinants of health is crucial, this must be balanced with the moral imperative to provide highly effective technical interventions, including immunizations and life-saving medications.¹²

As with any public health campaign, vaccination and pandemic prevention efforts must be built atop a bedrock of trust and respect between local leaders, community members and public health officials. Trust-building can become complicated in situations of political instability, and international public health teams are encouraged to recognize the legitimacy and authority of adversarial factions when possible, since the denial of their authority will often cease all cooperation.

INFODEMIC MANAGEMENT

An additional component of trust involves agreement upon a shared set of facts. Misinformation encompasses both incorrect information that is spread inadvertently as well as disinformation or false information that is intentionally distributed. When applied to an infectious disease outbreak, the World Health Organization refers to this phenomenon as an infodemic. Efforts to combat this have centered on 2 areas: communication training for public health officials and health care workers (Table 1) and media literacy training for laypeople (Table 2), which can be incorporated into formal educational curricula or shared on an individual level. Arming communities with correct information and critical thinking skills before they are introduced to misinformation, also known as *prebunking*, is generally accepted to be most effective.¹⁵ Medical communities are encouraged to proactively prioritize messaging when constructing disease mitigation strategies.

HEALTH SYSTEM RESILIENCE

Vaccination delivery in humanitarian contexts requires adaptive approaches that can function despite compromised security, damaged infrastructure, and mobile populations. Evidence suggests that vaccination campaigns remain a foundation of adaptive crisis response. Among these campaigns, the most successful initiatives employing multifaceted approaches leveraging a range of service delivery pathways alongside targeted recruitment and training of health care personnel.¹⁴ Periodic Intensification of Routine Immunization (PIRI) has shown promise in boosting vaccination coverage in fragile contexts. This strategy typically involves scheduled, short-term vaccination campaigns through outreach or mobile teams. Though often short-term interventions, they can build on existing health system capacities to enhance resilience over time. For example, polio eradication infrastructure has been successfully leveraged in

Table 1 Health professionals' communication strategies^{15–23}	
Topic	Description
Risk communication basics	Use plain, audience-centered language and empathy to acknowledge concerns. Explain what is known/unknown and how guidance may change. Develop message maps so every spokesperson delivers the same 2–3 key points.
MI & presumptive recommendation	Open the conversation with a confident, routine recommendation (<i>you're due today</i>). Use ask–tell–ask and reflective listening to surface specific barriers. Affirm values, address risk perceptions with simple visuals, and close with a clear next step or follow-up.
Evidence-based debunking	Lead with the fact, briefly note the myth <i>without</i> repetition, and immediately explain why it's false using a simple causal story. Pair text with a single reinforcing graphic and a concrete action (where/when to vaccinate).
Infodemic management function	Stand up a small, multidisciplinary team linked to the clinical environment that continuously listens, analyzes, coordinates responses, and evaluates impact. Define roles, escalation paths, and decision rights so rumors are triaged and acted on quickly.
Ethical social listening & rumor logs	Follow circulating questions and rumors in addition to health behaviors and downstream health effects. Log items with date/source/harm potential and produce weekly insight briefs that inform messaging.
Diagnose barriers with BeSD analysis	Use standardized tools to measure drivers of vaccine uptake: opinions about vaccines, social processes, motivation to seek vaccination, and practical barriers. Tailor interventions (eg, clinic hours, messengers, frame) to the specific BeSD profile of each community.
Trusted 2-way channels	Deploy low-bandwidth, high-trust options such as WhatsApp or IVR chatbots, call centers, and clinic desk scripts that give consistent answers, capture new questions, and route complex cases.
Media/platform partnerships	Prerenegotiate <i>fast lanes</i> with local media and platform reps for rumor escalation and corrective PSAs. Publish transparent situation updates (what changed and why) to sustain trust during evolving evidence.
Measurement & rapid learning	Track a small KPI set (ie, detection-to-response time, resolution rate, reach/recall, sentiment, BeSD shifts, and vaccine uptake) and run A/B tests on frames and messengers. Feed results into weekly ops huddles to adapt tactics.
Preparedness assets	Prebuild FAQ banks and message maps for priority pathogens and vaccines. Cocreate messages with faith/youth leaders, midwives and other community members. Ensure materials reflect local languages, norms and practical barriers (travel time, childcare, and so on).

Abbreviations: BeSD, behavioral and social drivers; FAQ, frequently asked question; IVR, interactive voice response; KPI, key performance indicator; MI, motivational interviewing; PSA, public service announcement.

Table 2
Community member education strategies^{15,24–27}

Topic	Description
Media & health literacy microlessons	Learn quick checks like lateral reading (open a new tab, check <i>About</i> pages), verify sources and dates, and look for scientific consensus rather than single influencers. Practice using local examples and short role-plays
Prebunking: spotting manipulation	Share brief <i>inoculation</i> lessons that reveal common misinformation tactics such as scapegoating, false dichotomies, or fake experts, so people recognize them when you see them. Reinforce via short videos or social stories before major campaign pushes
<i>Pause-before-share</i> accuracy prompts	Encourage the use of simple reminders to think about accuracy before reposting. Take 30 s to check the headline against the article and see if other reputable sources confirm the claim
Where to find verified info	Bookmark official MOH/WHO channels and local hotlines/ WhatsApp services. When in doubt, call or message to confirm rather than relying on forwarded posts or screenshots
How to report rumors	Establish a simple <i>see-something, say-something</i> workflow: have them send a voice note or hotline message with the claim, where they heard it, and their question, thereby allowing responders to verify and get back to the community with accurate info
Protect yourself from online harms	Educate how to spot bots/trolls, set privacy controls, avoid sharing personal health data in public groups, and mute or report accounts that target or harass community members discussing vaccination

several contexts to support delivery of other antigens, demonstrating how disease-specific initiatives can strengthen broader immunization systems. While this has proven efficacious as a stopgap measure, further research is required to evaluate long-term efficacy and effectiveness in conflict-affected populations.²⁸

Novel financing mechanisms such as community-based health insurance, *cash transfers* consisting of payment by formal or informal institutions directly to populations in need, and performance-based financing have potential to address some of the funding challenges inherent to protracted crises. However, their impact on health and well-being are often most successful when part of a wider set of health system reforms.^{14,29} Decentralization of government decision-making and basic infrastructure to preserve transportation, communication and disease surveillance could empower more accurate and immediate monitoring of and response to outbreaks, especially in fragile settings and regions of evolving conflict.^{11,28} However, evidence for these transformative interventions remains limited, underscoring the need for continued research and documentation of innovative approaches.

SERVICE INTEGRATION

Service integration can effectively improve vaccination coverage and overall health system resilience to disease outbreaks in crisis settings. Studies from South Sudan and other conflict-affected regions show that integrating immunization with nutrition

services can substantially increase the number of children reached with vaccines through localized service delivery and the strategic use of existing community trust.¹⁴ Similarly, integration with complementary sectors such as water-sanitation-hygiene can directly impact a community's ability to manage outbreaks through simultaneous reduction in vector transmission.³⁰ Importantly, these multifaceted campaigns can not only leverage existing trust within communities but also inspire new confidence when their immediate quality of life is improved.

LAST MILE LOGISTICS

Because many vaccines require refrigeration from creation to injection, vaccine supply chain logistics, often referred to as cold chain, are highly sensitive to disruptions.³¹ The Last Mile denotes the final, often most challenging segment of vaccination delivery due to a myriad of destabilizing effects. Recent synthesis reviews confirm that Last Mile efforts are increasingly shaped around the realities of conflict, displacement and fragility.³² Efforts like the Global Alliance for Vaccines and Immunization's Zero-Dose Immunization Program explicitly target complex emergencies.³³

Mobile health teams and drone delivery of vaccinations have shown effectiveness in improving access, particularly among marginalized communities where security concerns limit fixed-site service delivery.^{14,34} These approaches create important collateral channels, bringing vaccines and potentially other resources to populations that might otherwise remain unreached. Looking forward, current and future research efforts devoted to heat-stable vaccinations could reduce many of the present-day barriers posed by cold chain logistics. Needle-free formulations have been promoted by the Coalition for Epidemic Preparedness Interventions due to offering a thermostable solution that simultaneously overcomes the barrier of needle-aversion.^{35,36}

SURVEILLANCE, DATA, AND CROSS-BORDER COORDINATION

Building truly resilient vaccination and disease monitoring systems in humanitarian contexts requires moving beyond adaptive responses toward actively strengthening underlying health system capacities.¹⁴ Timely monitoring that is consistent across countries and regions is imperative for early recognition, rapid epidemiologic analysis, targeted response and mitigation of spread. Health information systems that facilitate real-time monitoring and decision-making are especially valuable in unstable environments, allowing for rapid adjustment of strategies as conditions change.³⁷ Additionally, cross-border coordination has shown promise in improving vaccination coverage among mobile populations.³⁸

To standardize clinical research metrics as well as operational frameworks, various members of the international community have developed common data elements (CDEs) and communities of practice on vaccination and disaster response. CDEs, or a set of variables where standardized questions are met with specified responses, can enhance multicountry coordination, thereby improving outcomes.³⁷

The World Health Organization (WHO) and United Nations Children's Fund (UNICEF) have established one of the most comprehensive global systems for immunization data collection through the electronic joint reporting form. This online data collection portal tracks annual vaccination data from all WHO Member States, Reporting Entities and Associate Members and covers a wide range of domains including standard performance indicators, financial data and quality metrics. These comprehensive data allow for monitoring of global and regional implementation strategies, informing vaccine-preventable disease burden estimates, and contributing to national immunization coverage estimates.³⁹

The Immunization Agenda 2030 Data Action Framework, a similarly broad data set, reflects the international community's shift toward data-driven vaccination strategies, while also emphasizing flexibility to respond effectively to emerging challenges.⁴⁰

The ISARIC-WHO Clinical Characterization Protocol monitors emerging pathogens and is used in conflict zones.⁴¹ The WHO Early Warning, Alert and Response System Minimum Dataset includes case definitions and minimal variables to expedite outbreak detection. Designed for conflict and other humanitarian emergencies, these field kits allow teams to begin surveillance within 48 hours, regardless of access to internet.⁴²

While current models have vastly improved the international community's capacity for coordination and access to high-quality data, challenges persist in achieving harmonization across crises. More attention must be paid to the rising prevalence of violence and other disruptive factors directly influencing vaccine access and disease outcomes.

PREPAREDNESS AND RESPONSE

The disaster cycle of preparedness, response, recovery, and mitigation becomes severely compromised in settings where governance structures have collapsed or become actively hostile to civilian populations. Inappropriate diagnosis and drug regimens can contribute to pathogen resistance, and international spread of diseases can be accelerated by movement of refugees, international aid workers and animals.^{37,38,43} Building capacity for pediatric pandemic preparedness requires strategic investment in key areas. Health care workers require pediatric-specific training, and strong infrastructure capable of supporting pediatric care during pandemics must be sustained, even during active conflicts.³⁷ This includes maintaining reserves of pediatric-specific supplies and developing protocols for the safe evacuation of critically ill children when local capacity is exceeded.

LESSONS FROM COVID-19

The COVID-19 pandemic introduced additional layers of complexity to vaccination delivery in humanitarian settings. While the pandemic disrupted routine immunization services worldwide, it also catalyzed innovations in service delivery and highlighted the critical importance of building system resilience. The rapid development and deployment of SARS-CoV-2 vaccines demonstrated both the potential of modern vaccine technology and the persistent inequities in global vaccine access as well as personal protective equipment and life-saving medical interventions. Children in humanitarian settings have been particularly affected by these disparities, with many crisis-affected countries struggling to return to prepandemic routine vaccination levels.^{7,39,44}

ONE HEALTH/PLANETARY HEALTH

The adoption of a One Health/Planetary Health approach is an integrated framework for addressing the interconnected challenges of emerging infectious diseases in humanitarian contexts. By acknowledging the linkages between human, animal, and ecosystem health, attention can be focused on preventing zoonotic spillover events that can lead to new outbreaks.⁴⁵ Crisis-affected communities are often disproportionately exposed to environmental risks, and this framework can enhance both equity and resilience by addressing root causes of disease emergence rather than simply responding to outbreaks after they occur.¹

GLOBAL GUIDANCE & GOVERNANCE QUALITY

While there has been a proliferation of guidance documents by multilateral organizations and national governments, critical appraisal suggests many of these resources would benefit from improved scientific rigor both in their creation and postimplementation assessment. Both transparency in their evidence selection and accountability in the development process are essential to reinforcing the credibility of these resources, a major driver of adherence by target groups.³ Moreover, embedding mechanisms for continuous revision based on emerging evidence is vital to maintaining their relevance and effectiveness in rapidly evolving humanitarian and public health contexts.

ETHICAL CONSIDERATIONS

Ethical considerations must guide all aspects of pediatric vaccination and pandemic preparedness in humanitarian settings. The key ethical principles guiding clinical medicine and public health establish the framework informing decisions made in times of crisis, namely: beneficence, nonmaleficence, distributive justice, and autonomy in the form of consent. Tension between individual good and the common good can manifest in many ways: the prioritization of limited resources during acute crises, prevention of unactualized harm versus the consequences of inaction, and considerations of autonomy and consent each present nuanced ethical challenges.⁴⁶ A robust understanding of the risk of contagion of various diseases and local vaccination coverage is necessary for strategic vaccination selection. This requires not only adequate funding and political will but also calls for vaccine formulations and delivery strategies appropriate to crisis settings, such as simplified dosing schedules.

FUTURE RESEARCH PRIORITIES

Looking ahead, preparation for future pandemics in humanitarian settings will require sustained investment in vaccination delivery systems capable of absorbing, adapting to, and transforming in response to acute and protracted shocks. Strengthening the evidence base through targeted research remains critical, with particular emphasis on pediatric vaccination strategies, the integration of immunization with other essential health services, and approaches to reaching mobile and displaced populations. Additional research is needed on the application of digital tools for vaccine tracking and surveillance, the design of cross-sectoral coordination mechanisms that align health, humanitarian, and development efforts, and the education and capacity-building of health care workers to recognize pediatric presentations of disease and sustain immunization activities under crisis conditions. Innovation in vaccine technologies will be pivotal to advancing equitable access in challenging environments. This research agenda is essential to improving the sustainability, effectiveness, and equity of future preparedness and response efforts.

SUMMARY

In conclusion, safeguarding children from infectious diseases in humanitarian settings demands agile, multifaceted strategies capable of addressing both immediate needs and fostering long-term system resilience. In the face of dynamic challenges inherent to complex humanitarian crises, integration of evidence-based delivery approaches, robust community engagement, comprehensive service models, and adaptive governance structures is essential. As global threats from emerging and reemerging infectious diseases continue to intensify, strengthening these systems is not only a humanitarian imperative but also a cornerstone of global health security. Sustained

investment and coordinated global action are required to ensure that the world's most vulnerable children are afforded the protection they rightfully deserve against preventable diseases.

INSIGHTS TO ACTION

- Trust and recognition of a community's priorities are integral to any successful vaccination campaign.
- There are proven strategies to combat misinformation, but these tactics often require coordination among team members and proactive outreach.
- Integrating vaccination and pandemic preparedness with other public health efforts such as nutrition services can dramatically increase effectiveness.

DECLARATION OF AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors used ChatGPT to assist with synopsis preparation, collation of strategies to address misinformation, and preliminary scoping of gray literature, publicly available toolkits and data sources. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

DISCLOSURE

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