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A Public Health Emergency Preparedness Model for Displaced and Refugee Populations

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Abstract

Displaced and refugee populations face heightened vulnerabilities during public health emergencies due to overcrowded living conditions, inadequate sanitation, limited healthcare access, and weak infrastructure. This paper proposes a Public Health Emergency Preparedness (PHEP) model specifically tailored for displaced and refugee communities to enhance resilience, coordination, and response capacity during crises. The model integrates four critical components: risk assessment, resource mobilization, community engagement, and health system integration. Grounded in the principles of equity and inclusiveness, the model emphasizes a participatory approach that involves refugees, host communities, local authorities, and international partners in decision-making processes. The risk assessment phase focuses on identifying potential hazards, population health needs, and existing vulnerabilities using real-time data and community-based surveillance. Resource mobilization addresses the need for rapid deployment of medical supplies, trained personnel, and infrastructure support while fostering partnerships with governmental and non-governmental organizations. Community engagement ensures culturally sensitive communication, trust-building, and the active involvement of displaced populations in preparedness planning and implementation. Health system integration promotes continuity of care, coordination with national health strategies, and adaptability to diverse emergency scenarios, including infectious disease outbreaks, natural disasters, and conflict-induced displacements. The model also incorporates digital tools for early warning systems, mobile health interventions, and remote coordination, which are particularly vital in hard-to-reach or insecure environments. By aligning with the Sendai Framework for Disaster Risk Reduction and the International Health Regulations (IHR), the proposed model strengthens local capacity while contributing to global health security. Case studies from refugee camps in Sub-Saharan Africa and the Middle East demonstrate the model's applicability, revealing improvements in disease surveillance, vaccination coverage, and community resilience. This PHEP model provides a scalable and adaptable framework that can be applied across various settings to safeguard the health and dignity of displaced and refugee populations. It supports evidence-based policymaking and fosters a holistic, sustainable approach to emergency preparedness in humanitarian contexts.

Keywords: Public Health Emergency Preparedness, Refugee Health, Displaced Populations, Risk Assessment, Community Engagement, Health System Integration, Humanitarian Crisis, Global Health Security, Disaster Risk Reduction, Mobile Health

1. Introduction

The growing scale of global displacement has reached unprecedented levels, with millions of individuals forced to flee their homes due to conflict, persecution, climate change, and natural disasters. According to the United Nations High Commissioner for Refugees (UNHCR), over 110 million people were forcibly displaced worldwide by the end of 2023, including refugees, internally displaced persons (IDPs), and asylum seekers. These populations often reside in overcrowded, under-resourced, and unstable environments where access to basic services is severely limited (Adesemoye, *et al*., 2021, Ejibenam, *et al*., 2021, Komi, *et al*., 2021). In such contexts, the occurrence of public health emergencies ranging from infectious disease outbreaks to environmental hazards poses significant threats to already vulnerable communities. Public health challenges in displaced and refugee settings are multifaceted and exacerbated by systemic barriers. Poor sanitation, inadequate shelter, food insecurity, limited access to clean water, and disrupted health systems contribute to a high burden of communicable and non-communicable diseases. The transient nature of displacement and the strain on host communities further complicate the ability to deliver consistent healthcare services, implement surveillance systems, and respond effectively to health crises.

Language and cultural differences, legal status issues, and the psychosocial toll of displacement also hinder engagement with public health interventions (Adesemoye, *et al*., 2021, Halliday, 2021, Komi, *et al*., 2021).

Given these complexities, there is a critical need for a Public Health Emergency Preparedness (PHEP) approach that is specifically designed to address the unique realities of displaced and refugee populations. Traditional models often fail to account for the mobility, marginalization, and infrastructural limitations present in these communities. A tailored PHEP model can strengthen resilience, improve coordination among stakeholders, and enhance the capacity of health systems to prevent, detect, and respond to public health threats in humanitarian settings (Odeshina, *et al*., 2021, Odio, *et al*., 2021, Ogbuefi, *et al*., 2021).

This paper proposes a comprehensive Public Health Emergency Preparedness Model for displaced and refugee populations, with an emphasis on risk assessment, resource mobilization, community engagement, and integration with existing health systems. The model is grounded in the principles of equity, inclusiveness, and sustainability, and aims to provide a scalable, context-sensitive framework to improve health outcomes and safeguard dignity during emergencies.

2. Methodology

The study employed a multi-method integrative approach combining evidence synthesis, systems thinking, and conceptual modeling to design a comprehensive preparedness model tailored to displaced and refugee populations. Drawing from the scoping reviews and evidence frameworks described by Abbas *et al*. (2018), Belfroid *et al*. (2020), and Khan *et al*. (2018), a large-scale document analysis was conducted. This included over 100 scientific sources and international reports focusing on humanitarian response, infectious disease control, environmental hazards, and structural determinants of health in conflict and crisis zones. Articles were selected based on their relevance to vulnerability mapping, cross-sector health system responses, and resilience-building strategies.

Advanced data visualization methods, as discussed by Adesemoye *et al*. (2021), were used to analyze trends in displacement events, health service gaps, and systemic failures during emergencies. These insights were synthesized with insights from machine learning and AI-driven predictive frameworks (Adewoyin *et al*., 2020; Daraojimba *et al*., 2021) to ensure dynamic adaptability of the model in rapidly changing environments. Simulation and optimization methods were adapted from thermofluid system frameworks and low-carbon transition planning models (Adewoyin *et al*., 2021), recalibrated for public health infrastructure modeling.

To ensure the proposed model reflected real-world constraints and implementation challenges, a critical review of community engagement strategies (Greenhalgh *et al*., 2016; Komi *et al*., 2021) and ethical considerations in humanitarian healthcare (Krubiner & Hyder, 2014) was conducted. This was followed by a comparative analysis of preparedness indicators and tools from existing frameworks including WHO, CDC, and the National Academies (Martinez *et al*., 2019; Downey *et al*., 2020). The synthesized model integrates principles of equitable access, culturally responsive care, and mobile/remote delivery of services through telehealth and mobile clinics (Komi *et al*., 2021; Mesmar *et al*., 2016).

Finally, stakeholder mapping and resilience pathways were designed by merging systems-thinking approaches (Kapp *et al*., 2017; Luke & Stamatakis, 2012) with scenario-based forecasting, aligning with climate adaptation literature and displacement risk projections (Ahmad *et al*., 2017; Palinkas, 2020). The resulting model is a dynamic, modular, and scalable framework grounded in evidence and optimized for agility in emergencies affecting vulnerable, mobile, and structurally marginalized populations.

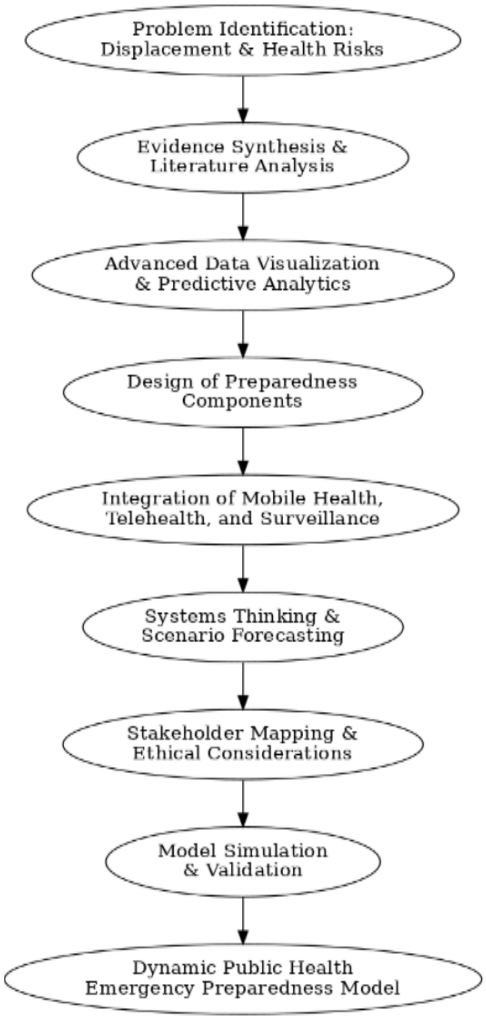

Fig 1: Flowchart of the study methodology

2.1 Conceptual Framework

Public health emergency preparedness (PHEP) refers to the systematic process through which individuals, communities, institutions, and governments develop the knowledge, capabilities, infrastructure, and strategies needed to anticipate, respond to, and recover from public health threats. In the context of displaced and refugee populations, PHEP encompasses a proactive and coordinated approach aimed at mitigating health-related risks during emergencies such as disease outbreaks, natural disasters, armed conflicts, and other crises that disproportionately impact vulnerable groups. Preparedness entails not only having resources on hand but also ensuring that systems, policies, and partnerships are in place to detect threats early, respond rapidly, and maintain continuity of essential health services.

For displaced and refugee populations, PHEP must be conceptualized through a lens that prioritizes human dignity and recognizes the intersecting vulnerabilities that shape their lived experiences. A preparedness model for such populations must adhere to four guiding principles: equity, inclusiveness, resilience, and sustainability. These principles are essential to addressing the systemic inequalities that often

render displaced individuals invisible in national and global emergency plans (Chamie, 2020; Gehlert & Mozersky, 2018).

Equity demands that all populations, regardless of their legal status, geographic location, or socio-economic conditions, have access to the same level of preparedness and protection during public health emergencies. Displaced populations are often excluded from national health systems or have limited access to formal healthcare services, making equitable inclusion a critical foundation of any preparedness model (Matthew, *et al*., 2021, Mustapha, *et al*., 2021, Nwaozomudoh, *et al*., 2021). Equity also requires disaggregated data collection and analysis to understand the differential impact of emergencies on subgroups such as women, children, the elderly, persons with disabilities, and LGBTQ+ individuals. Figure 2 shows Resilience Framework for Public Health Emergency Preparedness presented by Khan, *et al*., 2018.

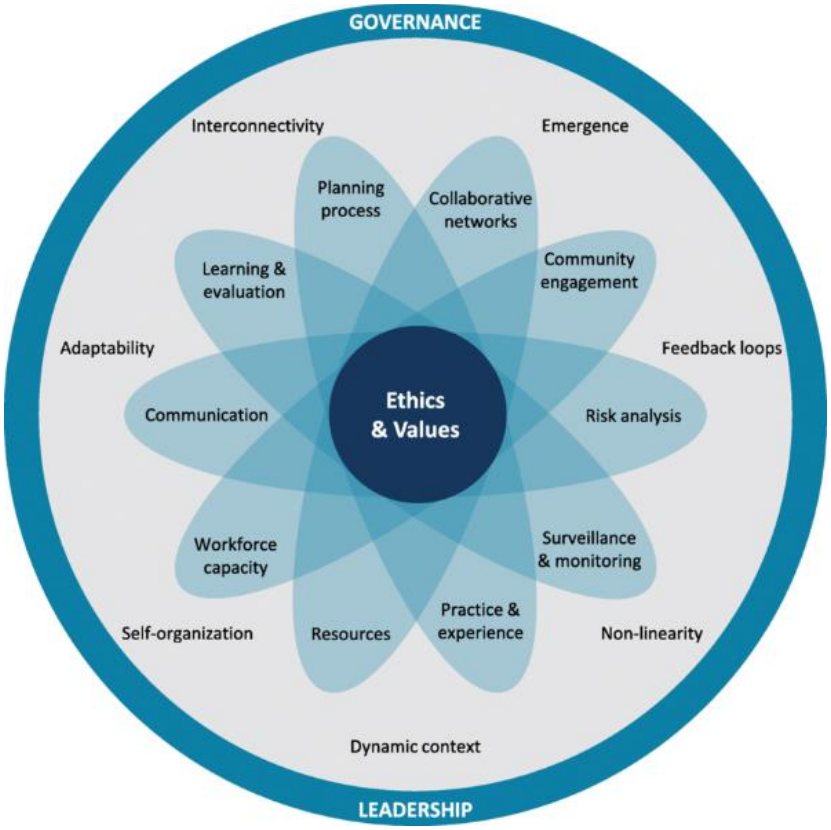

Fig 2: Resilience Framework for Public Health Emergency Preparedness (Khan, *et al*., 2018).

Inclusiveness ensures that the voices and perspectives of displaced individuals are actively incorporated into the design, implementation, and evaluation of emergency preparedness plans. Community engagement and participatory planning are vital components of inclusiveness, allowing affected populations to inform culturally appropriate interventions and build trust with health actors. This principle also acknowledges the importance of integrating refugee and IDP leadership, recognizing that communities themselves possess valuable insights, coping strategies, and organizational structures that can enhance preparedness efforts.

Resilience refers to the capacity of individuals and systems to absorb, adapt to, and recover from public health shocks. In refugee and IDP contexts, resilience is not solely the product of external aid but also stems from the internal strengths of communities, including social networks, indigenous knowledge, and self-organized support mechanisms (Adewoyin, 2021, Daraojimba, *et al*., 2021, Komi, *et al*., 2021). A preparedness model grounded in resilience encourages capacity building at all levels individual, community, and institutional through training, education, infrastructure development, and health systems strengthening. It also supports contingency planning, simulations, and continuous learning to adapt to evolving threats. Public health emergency preparedness and response analysis framework presented by He, *et al*., 2020 is shown in figure 3.

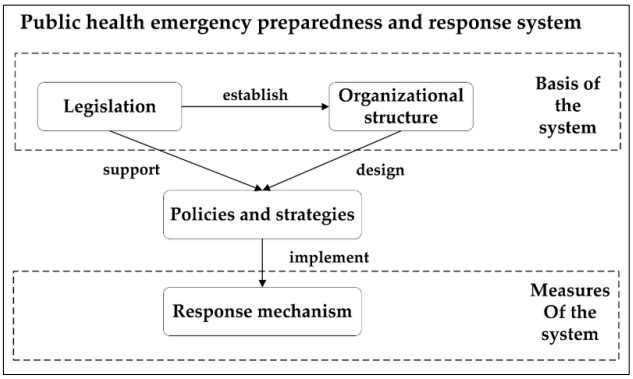

Fig 3: Public health emergency preparedness and response analysis framework (He, *et al*., 2020).

Sustainability underscores the need for long-term solutions that do not merely respond to emergencies but also build enduring public health infrastructure. This principle calls for investment in health systems that can function beyond the acute phase of a crisis, with an emphasis on environmental health, workforce development, supply chain management, and financial sustainability. A sustainable preparedness

model aligns with global development goals and fosters collaboration between humanitarian and development actors to create integrated, rather than fragmented, responses (Chiossi, Tsolova & Ciotti, 2021; George, Daniels & Fioratou, 2018).

The theoretical underpinnings of the proposed Public Health Emergency Preparedness Model for displaced and refugee populations draw from several internationally recognized frameworks. The One Health approach is a multidisciplinary strategy that recognizes the interconnection between human health, animal health, and the environment. This perspective is crucial in displaced settings where people often live in close proximity to animals and face environmental hazards such as water contamination, vector-borne diseases, and inadequate waste management (Adewoyin, *et al*., 2020, Mustapha, *et al*., 2018). Integrating One Health into the preparedness model promotes cross-sectoral collaboration, ensuring that zoonotic disease surveillance, environmental monitoring, and food safety are addressed alongside human health needs. Belfroid, *et al*., 2020 presented Public Health Emergency Preparedness cycle shown in figure 4.

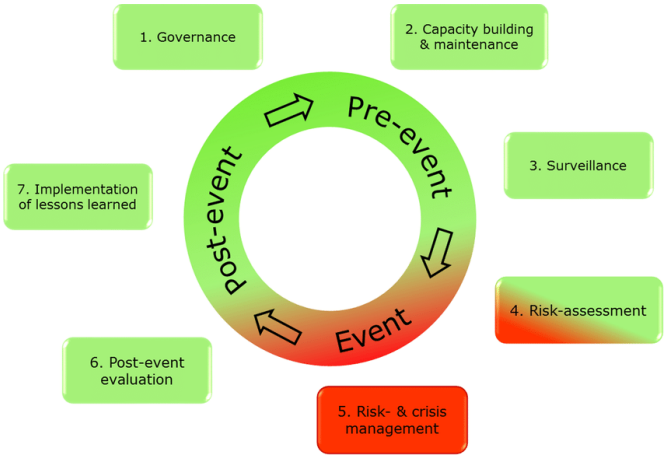

Fig 4: Public Health Emergency Preparedness cycle (Belfroid, *et al*., 2020).

Another critical framework is the Sendai Framework for Disaster Risk Reduction (2015–2030), which provides a global blueprint for reducing disaster risks and enhancing resilience. The Sendai Framework emphasizes understanding risk, strengthening governance, investing in risk reduction, and enhancing disaster preparedness for effective response. For displaced populations, this framework supports a comprehensive approach to risk management that includes early warning systems, risk communication, and contingency planning tailored to the context of displacement (Adewoyin, *et al*., 2020, Ogunnowo, *et al*., 2020). The Sendai Framework's focus on inclusivity, particularly its call to prioritize the needs of marginalized groups, aligns directly with the guiding principles of the proposed model.

The International Health Regulations (IHR 2005) constitute another essential theoretical foundation. These legally binding regulations, adopted by 196 countries, aim to prevent and respond to the international spread of diseases while minimizing interference with travel and trade. The IHR underscore the importance of early detection, reporting, and response to public health events of international concern. In the context of displaced and refugee populations, adherence to IHR principles reinforces the need for functional disease surveillance systems, cross-border collaboration, and transparent communication during emergencies (Adewoyin, *et al*., 2021, Egbuhuzor, *et al*., 2021, Komi, *et al*., 2021). Although many displaced individuals fall outside the jurisdiction of national systems, integrating IHR compliance into humanitarian operations ensures that health threats in camps and informal settlements do not go unreported or unaddressed, thus safeguarding both the affected populations and the broader public health ecosystem.

The intersection of these theoretical frameworks provides a robust foundation for designing a preparedness model that is context-sensitive, globally aligned, and operationally feasible. By synthesizing the ecological awareness of One Health, the risk-reduction priorities of the Sendai Framework, and the global health governance principles of the IHR, the model encourages an integrated, collaborative, and proactive approach to emergency preparedness (Cohen & Deng, 2012; Ghate, 2016).

This conceptual framework ultimately seeks to shift the paradigm from reactive emergency response to anticipatory planning and resilience-building. It moves beyond treating displaced populations as passive recipients of aid and instead positions them as active partners in their own protection. By embedding the model within international best practices and aligning it with ethical imperatives of equity, inclusiveness, resilience, and sustainability, it offers a scalable and adaptable solution to the complex public health challenges faced by displaced and refugee communities around the world.

2.2 Core Components of the Proposed PHEP Model

The core components of the proposed Public Health Emergency Preparedness (PHEP) model for displaced and refugee populations are built around the recognition that these communities face unique health vulnerabilities and are often situated in environments where public health infrastructure is either severely limited or entirely absent. This model integrates critical components necessary for reducing health risks and strengthening resilience through proactive and context-sensitive strategies.

The first component of the model is risk assessment and hazard identification. Displaced and refugee populations frequently reside in overcrowded camps, informal settlements, or transitional shelters where conditions such as poor sanitation, inadequate access to safe drinking water, and limited food availability contribute to heightened health vulnerabilities. Mapping these vulnerabilities forms the foundation of any effective preparedness effort. By identifying critical issues such as water, sanitation, and hygiene (WASH) deficiencies, malnutrition hotspots, and environmental hazards, health actors can prioritize interventions and allocate resources effectively. Health risk profiling is another crucial element, which relies on community-based surveillance systems designed to capture real-time health data at the grassroots level (Ajayi & Akanji, 2021, Bihani, *et al*., 2021, Komi, *et al*., 2021). These systems involve training community health workers and volunteers to detect symptoms, report unusual patterns, and monitor local disease trends, thereby creating a localized early warning mechanism. Scenario planning also plays a central role in preparing for a range of emergencies. Through simulations and predictive modeling, agencies can develop tailored response protocols for disease outbreaks, natural disasters, and conflict-related displacements, allowing for a multi-hazard approach that enhances overall preparedness.

The second core component of the model focuses on resource mobilization and infrastructure readiness. Effective public health emergency response in displaced settings requires the timely availability of essential supplies, medical equipment, and operational logistics. Stockpiling non-perishable medical

supplies, vaccines, water purification tablets, and protective equipment ensures that first-response activities are not delayed during the onset of an emergency. Logistics planning is equally important, requiring secure transport, cold chain maintenance, and decentralized storage facilities to prevent bottlenecks (Ogunnowo, *et al*., 2021, Ojika, *et al*., 2021, Okolo, *et al*., 2021). Human resource capacity is another critical aspect. This includes training and retaining local health workers, deploying emergency medical teams, and ensuring that frontline responders are equipped with the necessary knowledge to manage crises effectively. Moreover, strategic partnerships are vital to bridging gaps in capacity and funding. Collaborations between national governments, local health authorities, international non-governmental organizations (NGOs), and United Nations agencies such as the WHO, UNHCR, and UNICEF help to pool resources, align priorities, and coordinate activities to prevent duplication and maximize impact.

The third component emphasizes community engagement and communication, which are indispensable for building trust and ensuring the success of public health interventions. Displaced communities often come from diverse cultural, linguistic, and social backgrounds, and their engagement in preparedness planning must be meaningful and sustained. Participatory planning empowers community members to identify their own health priorities, contribute local knowledge, and develop culturally sensitive solutions that are more likely to be accepted and adopted. This participatory approach fosters ownership and enhances the relevance and effectiveness of preparedness strategies (Akpe, *et al*., 2020, Mgbame, *et al*., 2020, Omisola, *et al*., 2020). Risk communication strategies must be proactive, transparent, and adaptable to different literacy levels and cultural contexts. During public health emergencies, clear and accurate information dissemination about symptoms, transmission pathways, prevention measures, and available services is critical. Misinformation and rumors can spread rapidly in displaced settings, often exacerbated by fear and uncertainty, making effective communication a cornerstone of any preparedness plan. Community leaders and cultural mediators play an instrumental role in this regard. They act as bridges between health authorities and the displaced population, facilitating dialogue, translating public health messages into local dialects, and reinforcing behavioral change efforts. Their involvement not only strengthens communication but also reinforces community cohesion and resilience.

The fourth and final core component of the model is health system integration and continuity of care. Displaced and refugee populations are frequently excluded from national health systems or treated as temporary beneficiaries of parallel humanitarian services. This fragmentation undermines the sustainability and efficiency of healthcare delivery in emergency settings. Integration with national and local health systems allows displaced populations to access comprehensive and continuous care, including preventive, curative, and rehabilitative services (Komi, *et al*., 2021, Matthew, *et al*., 2021, Mgbame, *et al*., 2021). Establishing coordination mechanisms between humanitarian health providers and public health agencies ensures that displaced communities are included in national vaccination programs, maternal and child health initiatives, and disease surveillance systems. Essential health services delivery must be maintained even during acute phases of an emergency. This includes immunizations, reproductive health services, mental health and psychosocial support, and treatment of chronic conditions. Mobile clinics, community outreach programs, and task-shifting approaches are valuable tools for maintaining coverage in settings where static facilities are overwhelmed or inaccessible (Downey, *et al*., 2020; Gonzalez, *et al*., 2018). Additionally, robust emergency referral systems are necessary to facilitate access to higher levels of care for severe or complicated cases. This requires clear protocols, transportation arrangements, and communication pathways between primary and tertiary care facilities. A functional health information system is equally important for tracking patient data, monitoring service utilization, and supporting evidence-based decision-making. Digitizing these systems, where feasible, enhances real-time data analysis and coordination, especially in dynamic and high-turnover populations.

In sum, the core components of the proposed PHEP model for displaced and refugee populations reflect a holistic, context-specific approach that prioritizes early identification of risks, strategic mobilization of resources, meaningful community participation, and seamless integration with broader health systems. By addressing both the structural and operational dimensions of preparedness, this model aims to build a robust foundation for mitigating public health threats, improving health outcomes, and safeguarding the dignity and rights of displaced individuals during emergencies. Each component reinforces the others, creating a synergistic framework that can adapt to diverse humanitarian contexts and evolving global health challenges.

2.3 Enabling Technologies and Tools

Enabling technologies and tools play a transformative role in strengthening public health emergency preparedness (PHEP) for displaced and refugee populations. These populations often live in resource-constrained, remote, or insecure environments where traditional healthcare infrastructure is either non-existent or severely strained. The integration of digital innovations into the PHEP model bridges critical gaps in service delivery, surveillance, communication, and coordination, thereby enhancing the resilience and responsiveness of health systems operating in humanitarian contexts. Central to this digital transformation are mobile health (mHealth) and telemedicine solutions, early warning systems and digital surveillance mechanisms, and data management platforms for real-time monitoring.

Mobile health, or mHealth, represents the use of mobile devices such as smartphones, tablets, and basic mobile phones to deliver health services and information. For displaced and refugee communities, mHealth offers a lifeline for accessing healthcare in environments where formal facilities may be limited or overwhelmed. Health education, disease prevention messaging, appointment reminders, and medication adherence alerts can be delivered directly to individuals through SMS, voice calls, or mobile applications in local languages (Ogunnowo, *et al*., 2021, Ojika, *et al*., 2021, Onaghinor, *et al*., 2021). These services help ensure continuity of care, even when individuals are geographically mobile or unable to access fixed health posts. For example, mHealth platforms have been used to disseminate critical information on COVID-19 symptoms, hygiene practices, and vaccination schedules in refugee camps, thereby reducing misinformation and promoting protective behaviors.

Telemedicine further expands the reach of healthcare by enabling remote consultations between healthcare providers and patients. In emergency or protracted displacement settings where specialists are often unavailable, telemedicine facilitates diagnosis, treatment planning, and referrals without the need for physical travel. This is particularly valuable for managing chronic diseases, mental health

conditions, maternal health, and pediatric cases. Telemedicine can also support healthcare workers on the ground by offering real-time guidance from experts located in other regions or countries (Oluoha, *et al*., 2021, Onaghinor, Uzozie & Esan, 2021). By reducing the burden on limited local resources, telemedicine contributes to equitable access to quality care and helps maintain essential health services during crises.

Early warning systems and digital surveillance tools are indispensable for detecting and responding to health threats in a timely manner. In displaced settings, disease outbreaks can spread rapidly due to overcrowding, inadequate sanitation, and limited healthcare access. Digital surveillance systems use mobile data collection, geographic information systems (GIS), and cloud-based analytics to identify abnormal health events and track disease trends. These systems allow for early identification of symptoms indicative of potential outbreaks, enabling rapid mobilization of resources and containment measures (Ansari, M. 2021, Onaghinor, Uzozie & Esan, 2021). Community health workers equipped with mobile devices can enter data on symptoms, case numbers, and other relevant indicators, which are instantly transmitted to centralized platforms for analysis and visualization.

These early warning systems not only enhance situational awareness but also support targeted interventions and resource allocation. For example, if a spike in acute watery diarrhea cases is detected in a particular settlement, emergency WASH interventions can be deployed quickly to prevent escalation. Similarly, trends in respiratory infections may prompt isolation measures and increased distribution of hygiene supplies. The predictive capacity of digital surveillance systems, when coupled with machine learning algorithms, allows for the modeling of disease spread scenarios and estimation of potential impacts under different intervention strategies (Onaghinor, *et al*., 2021, Orieno, *et al*., 2021). This data-driven approach significantly improves preparedness, reduces response times, and saves lives.

Equally important are robust data management platforms that support real-time monitoring of health services, resource availability, and population health outcomes. In emergency settings, managing large volumes of health-related data can be challenging, especially when multiple stakeholders are involved. Digital platforms provide a centralized, secure environment for collecting, storing, analyzing, and sharing data across agencies and levels of the health system. These platforms enable tracking of vaccination coverage, availability of essential medicines, performance of health workers, and utilization of services (Ebata, Nisbett & Gillespie, 2020; Onaghinor, *et al*., 2021). Dashboards and visualization tools offer intuitive interfaces that allow decision-makers to quickly interpret data and make informed choices.

Real-time monitoring also supports accountability and transparency in humanitarian operations. Donor agencies, government bodies, and community representatives can access relevant metrics to evaluate the effectiveness of health interventions and identify gaps. This facilitates evidence-based adjustments to strategies and fosters a culture of continuous improvement (Hampton, 2014; Oyedokun, 2019). Additionally, the integration of biometric and digital identification systems ensures accurate patient tracking and minimizes duplication of services, particularly in settings with high population turnover. Electronic health records (EHRs), when used appropriately, allow for continuity of care even when individuals move between camps or countries, ensuring that critical medical history and treatment information is preserved.

These enabling technologies not only enhance the technical capacity of the PHEP model but also strengthen collaboration among stakeholders. Interoperable systems allow different agencies and actors to share data securely and coordinate efforts in real time. For instance, health data collected by NGOs can be integrated into national health information systems, supporting a cohesive response and ensuring that displaced populations are not excluded from national planning. Moreover, cloud-based platforms support remote access to data and communication among geographically dispersed teams, which is essential in emergency scenarios where field access may be restricted (Gopalan, *et al*., 2008; Jena, 2018).

Despite their transformative potential, the implementation of these technologies must consider ethical, legal, and operational challenges. Issues related to data privacy, informed consent, digital literacy, and equitable access must be addressed to prevent unintended harm or exclusion. Systems must be designed with user-friendly interfaces, language adaptability, and offline functionality to ensure usability in low-connectivity environments. Moreover, ongoing training and technical support are necessary to build local capacity and ensure the sustainability of digital solutions beyond the immediate emergency response (Gostin, *et al*., 2019; Kapur & Smith, 2010).

In conclusion, the integration of mobile health, telemedicine, early warning systems, digital surveillance, and real-time data management platforms into public health emergency preparedness represents a paradigm shift in humanitarian health responses. These technologies empower displaced and refugee populations to access timely, quality healthcare while enabling health systems to anticipate, respond to, and recover from emergencies more effectively. By embedding digital tools into the core of the PHEP model, stakeholders can overcome traditional barriers to service delivery, enhance resilience, and protect the health and dignity of some of the world's most vulnerable communities. The future of public health preparedness in displacement settings lies in leveraging these innovations to build smarter, faster, and more inclusive emergency response systems.

2.4 Implementation Strategies

The implementation of a Public Health Emergency Preparedness (PHEP) Model for displaced and refugee populations requires strategic planning, sensitivity to context, and a phased, inclusive approach. Given the complex and dynamic nature of displacement, successful implementation must be structured yet flexible, capable of adapting to diverse settings while addressing the specific needs of vulnerable groups. The proposed model emphasizes a phased approach that incorporates preparedness, response, and recovery stages, tailored to the realities of both urban and camp-based environments. Moreover, it promotes inclusivity by integrating gender, age, and disability-sensitive measures throughout all phases.

The phased approach ensures a systematic progression from risk anticipation to long-term recovery. In the preparedness phase, activities focus on building the capacity of communities, institutions, and systems to anticipate and withstand health emergencies. This includes conducting risk assessments, establishing surveillance mechanisms, training health workers, developing contingency plans, and stockpiling essential supplies (Greenhalgh, *et al*., 2016; Khan, *et al*., 2019). Community-based education and drills are vital during this phase, as they empower individuals with knowledge and skills to act appropriately in times of crisis.

Engagement with local leaders, host authorities, and displaced communities is critical to fostering trust, identifying specific vulnerabilities, and ensuring ownership of preparedness activities.

The response phase is activated once an emergency occurs. The primary goal at this stage is to contain health threats, minimize morbidity and mortality, and prevent further escalation. Rapid deployment of medical teams, distribution of supplies, activation of emergency referral systems, and dissemination of accurate information are key components of an effective response. Coordination among multiple actors, including government agencies, non-governmental organizations (NGOs), international bodies, and community groups, is crucial to avoid duplication of efforts and ensure efficient resource use (Hanlon, *et al*., 2017; Khan, *et al*., 2014). Real-time data collection and analysis guide decision-making, allowing interventions to be adjusted based on evolving needs. Maintaining essential health services such as maternal care, immunizations, and treatment of chronic illnesses remains a priority even during the acute emergency phase.

The recovery phase focuses on rebuilding health systems and restoring services to pre-emergency levels or higher. It includes evaluating the response, documenting lessons learned, strengthening infrastructure, and addressing mental health and psychosocial support needs. Recovery also offers an opportunity to institutionalize improvements, such as integrating displaced populations into national health systems, investing in digital health infrastructure, and fostering long-term partnerships. Sustainable recovery requires a shift from temporary humanitarian assistance to development-oriented planning, ensuring that displaced populations are not left behind as communities stabilize and rebuild (Hess, McDowell & Luber, 2012; Khan, *et al*., 2018).

Successful implementation of the PHEP model also demands contextual adaptation to the specific environments in which displaced populations reside. Displacement can take many forms, including formal refugee camps, informal settlements, and urban integration. Each setting presents distinct challenges and opportunities for public health preparedness.

In camp settings, health actors often have greater control over service delivery and population data. This centralized nature facilitates coordination, targeted outreach, and infrastructure development (Hill-Briggs, *et al*., 2020; Landau & Achiume, 2017). However, overcrowding, limited freedom of movement, and resource scarcity pose significant risks during health emergencies. Preparedness in camps should focus on maintaining WASH facilities, ensuring adequate shelter, and conducting regular health screenings and immunization campaigns.

In contrast, urban displacement involves more complex dynamics. Refugees and internally displaced persons (IDPs) living in cities are often dispersed, less visible, and face barriers to accessing public services. They may reside in slums, abandoned buildings, or with host families, making surveillance and outreach more difficult. Moreover, urban settings often involve overlapping jurisdictional authorities and fragmented service provision. Implementing the PHEP model in urban contexts requires collaboration with municipal authorities, integration into city health systems, and innovative outreach strategies (Hunting & Gleason, 2011; Leaning, Spiegel & Crisp, 2011). Mobile health units, community-based health workers, and digital platforms can bridge gaps in access and coverage. Urban preparedness efforts must also address xenophobia, legal status issues, and economic marginalization, which can hinder displaced persons from seeking or receiving care.

Another critical dimension of implementation is the inclusion of gender, age, and disability-sensitive measures. Emergencies do not affect all people equally; their impact is shaped by intersecting factors that influence individuals' vulnerabilities and capacities. Women and girls, for instance, often face increased risks of gender-based violence, loss of livelihoods, and restricted access to reproductive health services during emergencies. Pregnant women require specialized maternal care, and girls may be pulled out of school or forced into early marriage (Hutch, *et al*., 2011; Mafuta, *et al*., 2021). The PHEP model must therefore incorporate gender analysis into all stages of planning and implementation. Health facilities should be equipped to provide comprehensive sexual and reproductive health services, including antenatal care, emergency obstetric services, and access to menstrual hygiene products. Safe spaces for women and gender-based violence referral mechanisms must also be established as part of emergency preparedness.

Children represent another particularly vulnerable group. Their physical and emotional development can be severely affected by disruptions to health services, nutrition, education, and social support. Immunization programs, nutritional support, child protection services, and school-based health initiatives must be maintained throughout emergencies. Pediatric health professionals and child-friendly spaces are essential to provide age-appropriate care and psychosocial support.

Persons with disabilities face additional challenges, including physical inaccessibility of health facilities, communication barriers, and exclusion from planning processes. The PHEP model must ensure that facilities, information, and services are accessible to all, in line with universal design principles (Justo, *et al*., 2019; Martinez, *et al*., 2019). This includes providing information in braille, sign language interpretation, wheelchair-accessible infrastructure, and training health workers in disability-inclusive practices. Collecting disaggregated data by disability status enables more effective targeting of interventions and ensures that no one is left behind.

Across all contexts and phases, capacity building remains a cornerstone of implementation. Training for health workers, volunteers, and community leaders must emphasize inclusive and culturally sensitive approaches. Simulation exercises, refresher courses, and peer learning can enhance preparedness and foster a sense of shared responsibility. Mechanisms for community feedback and grievance redressal must also be embedded in the model to ensure accountability and continuous improvement (Kapp, *et al*., 2017; Mesmar, *et al*., 2016).

In addition to technical strategies, political commitment and sustained financing are vital for implementation. Governments must recognize the rights of displaced populations to health and safety, and include them in national emergency preparedness and response plans. Donors and development partners should adopt long-term funding models that support preparedness, not just crisis response. Strengthening local leadership and governance capacities ensures that preparedness efforts are owned and led by those closest to the affected communities (Kreisberg, *et al*., 2016; Mugabe, *et al*., 2021).

In conclusion, implementing a Public Health Emergency Preparedness Model for displaced and refugee populations involves a comprehensive and phased approach that is grounded in the realities of displacement. By adapting strategies to various settings, engaging all stakeholders, and embedding inclusive measures, the model not only enhances

preparedness and response but also promotes resilience, equity, and long-term health security. This multidimensional strategy transforms emergency response into a proactive, community-driven process that safeguards the health and dignity of vulnerable populations while reinforcing the capacity of health systems to manage future crises.

2.5 Case Studies and Applications

The application of a Public Health Emergency Preparedness (PHEP) model for displaced and refugee populations can be best understood through practical case studies and real-world experiences from regions with high refugee concentrations. These include Sub-Saharan Africa particularly countries like Uganda and Sudan and the Middle East, with notable examples from Jordan and Lebanon. Each of these contexts illustrates how the integration of preparedness principles and enabling systems can lead to improved health outcomes, including higher vaccination coverage, better outbreak control, and stronger community resilience. These case studies provide valuable lessons that can inform broader implementation of the PHEP model across other displacement settings globally.

In Uganda, the country's progressive refugee policy, which promotes integration rather than encampment, has played a central role in shaping its public health preparedness for emergencies. Uganda currently hosts over 1.5 million refugees, primarily from South Sudan and the Democratic Republic of Congo. The government, in collaboration with the UNHCR and various NGOs, has adopted an inclusive health system model that allows refugees to access public health services alongside host communities (Krubiner & Hyder, 2014; Palinkas, 2020). This policy has enabled the establishment of routine immunization programs and integrated disease surveillance systems that are responsive to both refugee and host populations. During the 2018 Ebola outbreak in neighboring Congo, Uganda activated its preparedness protocols at border entry points and within refugee settlements. This included health screenings, isolation units, and widespread community engagement. By training refugee health workers and utilizing mobile health teams, Uganda was able to maintain high vaccination coverage and prevent a single case from spreading into its territory, despite its proximity to the outbreak's epicenter. The success of Uganda's model highlights the value of inclusive policies, inter-agency coordination, and local capacity-building in mitigating public health risks.

In Sudan, which has faced prolonged conflict and political instability, the implementation of public health preparedness measures in camps for internally displaced persons (IDPs) has encountered both successes and setbacks. In Darfur, humanitarian organizations working under extremely challenging conditions have developed adaptable health preparedness strategies. Mobile clinics and early warning systems have been deployed in IDP camps to monitor disease outbreaks such as cholera and measles (Levesque, Harris & Russell, 2013; Puchner, *et al*., 2018). Despite frequent disruptions due to insecurity, these interventions have contributed to better surveillance and quicker responses. A key lesson from Sudan is the need for decentralized systems that can continue to function when central governance is weak or absent. For instance, community health volunteers trained in disease detection and first-line treatment have often acted as the first and only responders in remote or besieged areas (Schoch-Spana, Selck & Goldberg, 2015). Moreover, the use of solar-powered cold chain systems for vaccine storage has proven effective in maintaining immunization coverage, even in areas lacking consistent electricity. Sudan's experience illustrates that even in fragile settings, investments in community-based preparedness can lead to significant public health gains.

In the Middle East, Jordan stands out as a country that has effectively integrated public health emergency preparedness into its response to the Syrian refugee crisis. Hosting over 600,000 registered Syrian refugees, Jordan has developed a comprehensive strategy that blends humanitarian aid with national health system strengthening. In the Za'atari and Azraq refugee camps, health services are provided through a network of primary care clinics supported by international agencies (Liburd, *et al*., 2020; Schwarzenbach, *et al*., 2010). Importantly, Jordan has implemented digital health records for refugees, which facilitate continuity of care and contribute to real-time monitoring of health indicators. During the COVID-19 pandemic, these systems enabled the swift rollout of testing and vaccination campaigns. Refugees in camps and urban settings were included in the national COVID-19 vaccination plan, reflecting an inclusive approach to public health. Risk communication campaigns, delivered in Arabic and tailored to refugee contexts, further enhanced vaccine uptake and trust in the health system. Jordan's case demonstrates how digital tools, inclusive policies, and collaboration between humanitarian and national actors can effectively operationalize a PHEP model in a high-density refugee setting (Lima, 2019).

Lebanon, on the other hand, presents a more complex scenario, given its economic challenges and fragmented political landscape. Despite hosting over 1.5 million Syrian refugees, Lebanon has struggled with resource limitations and infrastructural strain. However, targeted health preparedness initiatives have yielded important results. The Ministry of Public Health, in partnership with international agencies, implemented the Early Warning, Alert, and Response System (EWARS) in both refugee settlements and Lebanese communities (Luke & Stamatakis, 2012; Tirado, *et al*., 2010). This system was instrumental in detecting and controlling outbreaks such as hepatitis A and measles. Health awareness campaigns and community mobilization efforts were central to these efforts, leveraging the role of local leaders and peer educators to disseminate prevention messages. Although the overall health system is under significant pressure, these localized interventions have demonstrated how adaptable and cost-effective preparedness strategies can protect vulnerable populations, even in highly constrained environments.

Across these case studies, measurable outcomes provide compelling evidence of the effectiveness of the PHEP model when thoughtfully applied. One consistent result has been improved vaccination coverage. In Uganda's refugee settlements, measles and polio immunization campaigns have achieved coverage rates above 90%, thanks to well-organized outreach programs and mobile teams. In Jordan, the integration of refugees into the national COVID-19 vaccination strategy led to more than 80% of adult refugees in camps receiving at least one dose of the vaccine by mid-2022. Such outcomes reflect the value of sustained investment in cold chain infrastructure, community engagement, and coordination with international partners (Castle, 2020; Maru, *et al*., 2014; Toscano, 2015).

Outbreak control is another key area where the model has demonstrated success. In Uganda, preparedness measures stopped the cross-border transmission of Ebola. In Lebanon, EWARS facilitated early identification of hepatitis outbreaks, allowing for timely medical intervention and containment. These examples underscore the importance of digital surveillance systems, real-time data sharing, and

trained personnel who can act quickly to mitigate risks. Outbreaks, when detected early, can be contained more effectively, reducing both mortality and broader public health impacts (Boyd, *et al*., 2017; Truelove, *et al*., 2020).

Community resilience is perhaps the most significant yet least tangible outcome of the model's application. In contexts like Sudan, where formal systems are weak or compromised, trained community health workers and volunteers become the backbone of emergency response. Their ability to identify health risks, provide basic care, and mobilize communities has not only improved immediate health outcomes but also built trust and social cohesion (Bernard, 2017; Tsapenko, 2021). In Jordan and Uganda, involving refugees in health governance such as through health committees or peer educator programs has strengthened local ownership of health initiatives and encouraged a culture of mutual responsibility.

In conclusion, the case studies from Sub-Saharan Africa and the Middle East reveal that a well-structured Public Health Emergency Preparedness model, when adapted to local contexts and executed with strategic partnerships, can significantly enhance the health security of displaced and refugee populations. The combination of inclusive policies, digital innovations, community engagement, and flexible service delivery mechanisms contributes to improved vaccination coverage, effective outbreak control, and the strengthening of community resilience. These outcomes provide a strong justification for scaling and institutionalizing the PHEP model across global humanitarian settings, ensuring that vulnerable populations are not only protected during emergencies but also empowered to shape their health futures.

2.6 Policy and Practice Implications

The development and implementation of a Public Health Emergency Preparedness (PHEP) model for displaced and refugee populations carries significant policy and practice implications. As forced displacement continues to rise globally due to conflict, environmental disasters, and political instability, the need for inclusive, resilient, and adaptive public health strategies becomes more urgent (Allen & Katz, 2010). This model is not merely a theoretical framework it has practical consequences for how governments, humanitarian actors, and global health institutions approach emergency preparedness, health systems strengthening, and human rights protection. The effective operationalization of such a model requires a coherent set of policy directives, cross-sectoral coordination, and robust systems for monitoring and evaluation.

For policymakers and health actors, the first and foremost recommendation is to formally recognize displaced and refugee populations as a priority group within national health strategies. In many countries, these populations exist in legal and institutional limbo, excluded from mainstream health services and overlooked in emergency planning. A shift in perspective is needed, one that frames the health of refugees and displaced persons not as a temporary humanitarian issue, but as a critical component of public health and national security. Policymakers should develop legal frameworks and policy instruments that guarantee access to essential health services, irrespective of legal status or geographic location (Alameddine, *et al*., 2019; Unicef & Unicef. (2016). This includes removing administrative and financial barriers that hinder access to care and ensuring that displaced persons are included in vaccination campaigns, surveillance systems, and disease reporting protocols.

A second recommendation is to foster collaboration between national governments, humanitarian agencies, civil society organizations, and international partners. Preparedness for public health emergencies in displacement contexts cannot be achieved by any single actor. Multi-stakeholder coordination platforms should be established at national and sub-national levels to develop joint emergency preparedness plans, share data, allocate resources, and align interventions. Health actors, including public health departments, hospital networks, and community health organizations, must be trained to deliver culturally competent and trauma-informed care tailored to the needs of displaced populations. Integration of services and roles must be clearly delineated to prevent overlap and ensure the efficient use of limited resources. Furthermore, governments should work closely with refugee-led and community-based organizations, which are often the first responders in emergencies and hold valuable local knowledge (Akik, *et al*., 2019; Workman, *et al*., 2021).

Integrating the PHEP model into national emergency preparedness plans is another critical policy implication. Displaced and refugee populations should not be treated as an afterthought or an add-on to existing plans. Instead, preparedness for health emergencies in humanitarian settings must be embedded within national disaster risk reduction strategies, public health frameworks, and development agendas (Akbarzada & Mackey, 2018). This requires the incorporation of displacement-specific risk assessments into national vulnerability mapping exercises, with clear protocols for health service delivery during emergencies. Governments must also allocate specific budget lines within national and local emergency preparedness plans to support refugee and IDP health programs, ensuring that financial constraints do not undermine response capacity during crises.

A key element of integration involves harmonizing data systems to include information on displaced and refugee populations. Many national surveillance and health information systems do not disaggregate data by displacement status, making it difficult to monitor health trends or allocate resources effectively. National health information platforms should be updated to collect and report on indicators specific to refugee and IDP health, including disease prevalence, vaccination coverage, and access to services (Aiyar & Pingali, 2020; World Health Organization. (2021). This data should be accessible to all relevant stakeholders, while safeguarding the privacy and protection of vulnerable individuals. Interoperability between humanitarian health data systems and national databases is essential to support continuity of care and accurate public health reporting.

Equally important is the development and application of comprehensive monitoring and evaluation (M&E) frameworks to assess the performance of the PHEP model in displaced settings. Effective M&E allows for real-time decision-making, identification of gaps, and continuous quality improvement. Indicators should be developed to measure both process and outcome variables. Process indicators may include the number of preparedness training sessions conducted, the percentage of refugee-serving facilities with stockpiles of essential supplies, or the functionality of early warning systems (Ahmad, *et al*., 2021). Outcome indicators, on the other hand, could include rates of disease detection, time-to-response metrics, vaccination coverage rates, morbidity and mortality trends, and levels of community satisfaction with health services.

In developing these indicators, it is important to ensure alignment with international standards, such as those provided by the Sphere Handbook, the Inter-Agency

Standing Committee (IASC), and the World Health Organization's International Health Regulations (IHR). Moreover, indicators should be disaggregated by gender, age, and disability to uncover disparities and ensure that no subgroup is left behind. Community involvement in the monitoring and evaluation process also enhances accountability and trust. Participatory methods such as focus group discussions, community scorecards, and feedback mechanisms allow displaced persons to voice their experiences and influence program improvements.

Furthermore, governments and international agencies must invest in building the capacity of local institutions to undertake these monitoring and evaluation functions. This includes training public health professionals in humanitarian settings, supporting the development of local data systems, and funding operational research to generate evidence on what works. Evaluation findings should be shared transparently and used to inform adaptive management and policy reform. For instance, if vaccination campaigns are found to have low uptake in a particular refugee camp, M&E data can guide the development of targeted communication strategies, mobile outreach efforts, or partnerships with community leaders to address vaccine hesitancy (Ahmad, *et al*., 2017).

Another important policy consideration is the legal and ethical dimension of emergency preparedness for displaced populations. Governments must ensure that preparedness plans are in line with international human rights norms and humanitarian principles. Health interventions should be designed and implemented in a manner that respects the dignity, agency, and cultural values of affected populations (Agol, Latawiec & Strassburg, 2014). Legal protections should be established to prevent discrimination, coercion, or neglect during emergency responses. Special attention must be paid to ensuring the safety and security of women, children, persons with disabilities, and other marginalized groups, who often face heightened risks during emergencies.

Finally, the broader policy landscape must support long-term resilience and sustainability. Emergency preparedness should be linked to broader development goals such as universal health coverage, health systems strengthening, and climate resilience. Integrating the PHEP model into these long-term agendas ensures that emergency interventions are not just reactive but contribute to building stronger, more inclusive health systems. Donor agencies must move beyond short-term humanitarian funding cycles and support multi-year investments in public health preparedness for displaced populations (Abbas, *et al*., 2018). This will enable the transition from emergency response to recovery and development, allowing for sustained health improvements and social integration of displaced persons.

In conclusion, the Public Health Emergency Preparedness model for displaced and refugee populations offers a comprehensive roadmap for addressing one of the most pressing humanitarian challenges of our time. Its successful implementation requires bold policy action, strategic integration into national frameworks, and a robust system of monitoring and evaluation. By adopting inclusive policies, fostering multi-sectoral partnerships, and investing in local capacity, governments and health actors can transform public health preparedness into a powerful tool for equity, resilience, and global health security. The lives and dignity of millions of displaced people depend on turning these principles into practice.

3. Conclusion

A Public Health Emergency Preparedness (PHEP) model for displaced and refugee populations offers a critical framework for addressing the complex health challenges faced by some of the world's most vulnerable communities. By integrating risk assessment, resource mobilization, community engagement, and health system integration, the model presents a comprehensive and adaptive approach tailored to the dynamic realities of displacement. Its strengths lie in its inclusiveness, context sensitivity, and scalability. The model emphasizes proactive planning, localized implementation, and the strategic use of enabling technologies to strengthen surveillance, service delivery, and coordination across stakeholders. Grounded in principles of equity, resilience, and sustainability, it not only enhances emergency response capacity but also lays the groundwork for long-term health system strengthening and social inclusion. The positive outcomes observed in diverse contexts from effective outbreak control in Uganda to integrated digital systems in Jordan demonstrate the model's viability and impact when supported by strong political will and coordinated implementation.

However, the full potential of this model can only be realized through sustained global collaboration and investment. As displacement trends continue to rise, driven by conflict, environmental stress, and socioeconomic instability, the need for comprehensive emergency preparedness becomes increasingly urgent. Governments, humanitarian organizations, development agencies, and the private sector must work together to integrate displaced populations into national health systems, share data and best practices, and align funding mechanisms with long-term preparedness goals. This includes moving beyond short-term emergency responses to support resilience-building efforts, infrastructure development, and inclusive policy reform. Adequate and predictable financing is essential to operationalize this model, build local capacity, and ensure continuity of care in the face of crisis. Now is the time for a unified global commitment to protect the health and dignity of displaced people, recognizing that preparedness for the most vulnerable strengthens health security for all. By investing in and institutionalizing this model, the international community can take a decisive step toward a more equitable, responsive, and resilient public health future.

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