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Advancing public health resilience: A review of proposed strategies for enhancing emergency preparedness in rural and underserved communities

Ernest Chinedu Okoli [1, *], Saidu Malgwi Hassan [2], Nelyn Akunna Okoye [3] and Bolouboye Micah Eradiri [4]

[1] UNICEF, Health Section, UNICEF Nigeria, Damaturu, Yobe State, Nigeria.
[2] UNICEF, Health Section, UNICEF Nigeria, Maiduguri, Borno State, Nigeria.
[3] Rivers State University, Health Service, Rivers State University, Port Harcourt, Rivers State, Nigeria.
[4] Northern Illinois University, Public Administration, Northern Illinois University, Dekalb, Illinois, United States of America.

Abstract

Background: Natural hazards and infectious disease outbreaks pose significant threats to public health globally. Rural and underserved communities often have limited resources and capacities to prepare for, respond to, and recover from such emergencies. There is a need to systematically identify strategies to enhance emergency preparedness and build resilience in vulnerable communities.

Aim: This review aims to comprehensively evaluate proposed strategies for advancing public health resilience with a focus on enhancing emergency preparedness in rural and underserved communities.

Method: A systematic literature review was conducted using PubMed, Scopus, Web of Science, and Informit Health databases. Search terms included "public health resilience", "emergency preparedness", "rural communities", and "underserved communities". Studies proposing strategies to enhance resilience at the individual, community, health systems and policy levels were included. Quality of evidence was assessed using the GRADE system and key themes were identified through inductive thematic analysis. Reporting was guided by Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: A total of 61 articles were included in the review. Key themes that emerged on strategies to enhance rural public health resilience included: strengthening partnerships and cross-sector collaborations; training and developing a skilled workforce; investing in technology and infrastructure upgrades; bolstering community engagement and social cohesion; and establishing coordinated emergency plans and protocols.

Conclusion: Implementing a combination of organizational, community and technological strategies offers potential for improving rural public health systems' ability to anticipate, absorb, adapt and recover from crises in a timely manner. Further research and resources are needed to translate evidence into practice, particularly in under-resourced settings.

Keywords: Resilience; Disaster risk management; Public health emergencies; Rural communities; Social determinants of health; capacity building; Adaptive strategies; Primary healthcare

1. Introduction

Public health emergencies such as pandemics, natural disasters and environmental hazards can destabilize communities and drastically impact human health and well-being (Burkle & Greenough, 2008; Nelson et al., 2007).

* Corresponding author: Ernest Chinedu Okoli

While all populations are at risk, rural communities and underserved populations tend to experience disproportionate negative consequences due to pre-existing health inequities and limited access to resources (Plough et al., 2013; Acosta et al., 2018). For example, shortages of healthcare infrastructure, sparse social networks, geographical isolation and higher rates of poverty have been shown to exacerbate the impact of public health crises in rural areas (Burkle & Greenough, 2008; Crouse Quinn, 2008). Therefore, strengthening the resilience of these vulnerable communities is critical for an effective and equitable emergency response (Plough et al., 2013).

Resilience refers to the ability of communities to withstand, adapt to and recover from adversities (Paton & Johnston, 2001; Sherrieb et al., 2010). From a public health perspective, community resilience encompasses factors like strong social cohesion, well-organized local leadership, flexible service delivery, risk communication capabilities and engaged community participation (Plough et al., 2013; Paton & Johnston, 2001). While some characteristics of resilience are inherent, research suggests capacities can be purposefully enhanced through focused interventions (Paton & Johnston, 2001; Sherrieb et al., 2010). For example, community partnerships, empowerment of local organizations, training of community health volunteers and culturally sensitive risk communication strategies have shown promise, however more evidence is needed (Acosta et al., 2018; Crouse Quinn, 2008).

This comprehensive literature review aims to synthesize available evidence on strategies for enhancing public health emergency preparedness and resilience specifically in rural and underserved communities. It seeks to answer the following questions: 1) What approaches have been proposed or tested for building resilience? 2) What are some promising or evidenced-based practices? 3) What are the gaps in current research and implementation? Understanding effective models can help guide more equitable emergency planning, response and long-term recovery efforts for vulnerable populations.

1.1. Background of Emergency Preparedness Disparities in Rural and Underserved Areas

1.1.1. Concept of public health resilience

According to McCabe et al. (2010), public health resilience refers to the ability of health systems, communities, and individuals to prepare for, absorb, recover from, and adapt to adverse events. As depicted in Figure 1, it encompasses both structural capacities including health service delivery, health workforce, health information systems, access to essential medicines and technologies, health system financing, and leadership and governance (Olu, 2017). It also includes social determinants of health (Sherrieb et al., 2010). As stated by the WHO (2023), resilience is a critical aim for strengthening health security globally. Public health resilience allows populations to withstand, respond to and recover from public health threats and emergencies in a timely and efficient manner (Norris et al., 2008).

Paton and Johnston (2001) emphasise that resilience goes beyond recovery to also focus on ongoing adaptation to changing conditions. Key aspects of resilience at different levels include strong leadership and coordination, flexible service delivery through various health system building blocks shown in Figure 1 including primary healthcare (Olu, 2017), social support networks, and community engagement in preparedness planning (Chandra et al., 2013). Figure 1 portrays how building resilience requires a cyclical and interconnected approach focusing on health system preparedness, emergency response, and recovery (Olu, 2017). Total population health resilience is built over time through consistent investments and collaborative actions across sectors (Longstaff, 2005).

Public health emergencies continue to disproportionately impact vulnerable groups who lack resilience resources (Kruk et al., 2015). Marginalized populations experience worsened health consequences due to pre-existing inequities in access to structural capacities of the health system (Roberton et al., 2020) shown in Figure 1. For example, socioeconomic barriers depicted in Figure 1 may limit access to emergency information, supplies, shelter or evacuation assistance (Crouse Quinn, 2008) that are reliant on health system building blocks. A resilience approach aims to address such underlying risks.

Resilience outcomes depend on interactions between multilayered factors (Paton & Johnston, 2001). According to Litaker et al. (2006), primary care services play a key role as the frontline interface between formal response through various health system building blocks and local communities, as portrayed in Figure 1. Community-centric strategies must account for social, economic and environmental influences on health to achieve equitable resilience (Maini et al., 2017).
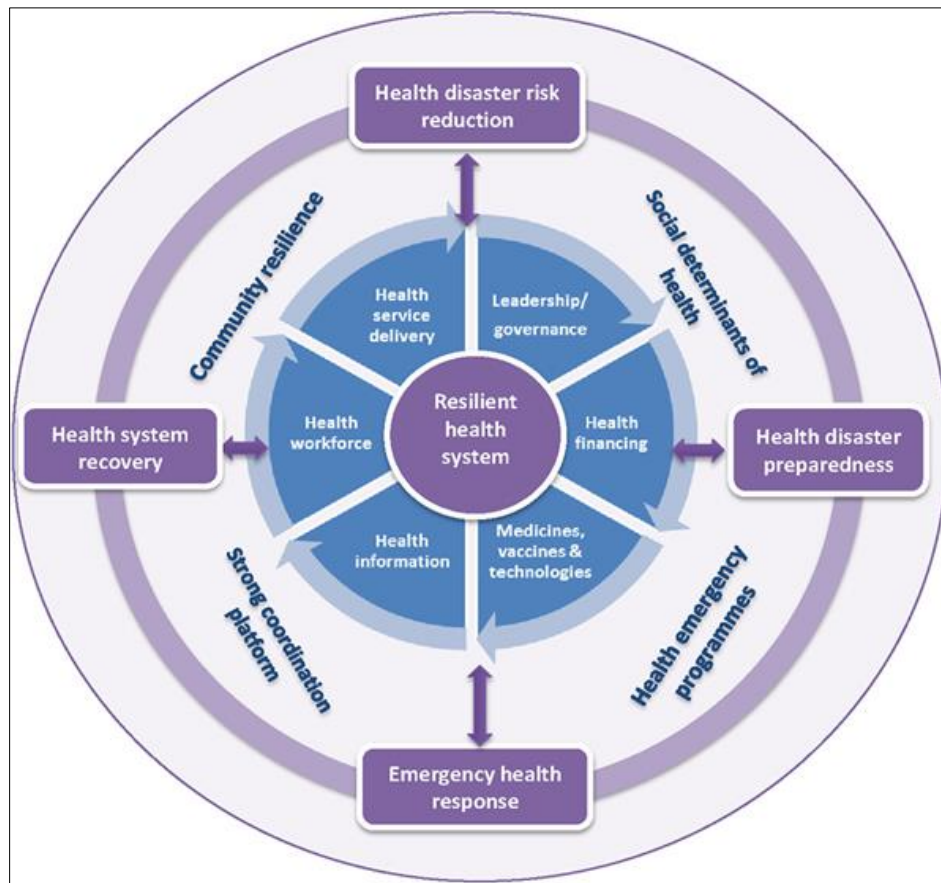
Figure 1 Conceptual framework for public health disaster risk management based on health system building blocks.
Source; Olu, (2017)

1.1.2. Public health emergencies

Burkle and Greenough (2008) state that natural hazards, disease outbreaks and humanitarian crises frequently overwhelm local response capacities and disrupt essential health services. Events like earthquakes, floods, wildfires or disease outbreaks can strain unprepared systems. Climate change impacts like rising temperatures and shift in disease vectors are exacerbating emergency risks worldwide according to El-Sayed and Kamel (2020). There is a need for multi-sectoral collaboration and social cohesion to build resilience against such threats (Alonge et al., 2019).

Public health emergencies are characterized by high levels of uncertainty and evolving challenges (Longstaff, 2005). Crisis response requires flexible coordination, resource allocation and communication under pressure (Seeger et al., 1998). The dynamic nature of emergencies also highlights the importance of continual readiness assessment, training and socialization of plans (Stoto et al., 2017). Health officials must prepare emergency personnel for high-stakes decision making during unstable situations (Thompson et al., 2006).

Community engagement is critical for addressing emergencies due to localized understanding, social networks and ownership of solutions (Morton & Lurie, 2013). However, meaningful public involvement poses resource-intensive challenges like cultural brokerage (Crouse Quinn, 2008). Effective risk communication builds relationships and trust before a crisis to facilitate information sharing during response (WHO, 2018). Besides, lessons from prior events demonstrate that resilience is achieved through long-term investments rather than one-time preparedness activities (Rutter et al., 2017). Health systems must institutionalize flexible processes, social capital and community partnerships to withstand unpredictable threats (Plough et al., 2013).

1.1.3. Needs of rural communities

Costich and Scutchfield (2004) state that rural settings face disproportionate challenges to emergency preparedness due to factors like geographical isolation, limited infrastructure and health workforce shortages. Due to remote locations, rural communities have longer response times and reduced access to specialized services during disasters

(Ma et al., 2023). Factors worsening rural vulnerabilities include lack of public transportation, understaffed emergency services and strained local health facilities (Nelson et al., 2007). Rural poverty also constrains investments in basic infrastructure as well as transportation and telecommunications needed for coordinated preparations. According to Burkle and Greenough (2008), resource constraints are magnified in rural areas due to small and dispersed tax bases.

Community-led initiatives may be most suitable for localized rural hazards and health needs (Costich & Scutchfield, 2004). Local knowledge and social networks are vital assets that can strengthen rural resilience if engaged and supported (Ma et al., 2023). However, resource constraints pose challenges to establishing even basic multisector groups or plans in some isolated settings (McCabe et al., 2010). Cultural and socioeconomic factors also influence rural perceptions of risk, responsibilities and access to information. Targeted solutions require understanding of local context, priorities and capacities (Chandra et al., 2013). Regional collaborations may broaden rural capabilities through cooperative trainings or emergency resources.

1.1.4. Gaps in existing strategies

While several frameworks emphasize the foundational role of personal and collective resilience during crises, limited practical guidance exists on operationalizing these concepts in under-resourced rural communities (Nelson et al., 2007). General tools need tailoring to account for challenges of distance, sparse populations and fiscal constraints (McCabe et al., 2010). Existing resilience measurement indicators also do not fully capture dynamics in rural areas (Sherrieb et al., 2010). Standardized national assessments may overlook nuanced local risk characteristics and resource limitations (Ma et al., 2023). Community-driven methodologies are warranted to understand rural priorities and capacities.

Most public health plans assume formal institutional frameworks but many rural settings lack basic infrastructure and personnel (Costich & Scutchfield, 2004). Emergency roles often informally fall to community-based groups with limited training or equipment (Burkle & Greenough, 2008). Adaptable strategies are needed to strengthen existing rural strengths. There are also evidence gaps around implementing protective legislatives and resource allocation models suitable for remote underserved populations (McCabe et al., 2010).

1.2. Statement of the problem

Rural and underserved populations face disproportionate vulnerability and poorer health outcomes during public health emergencies due to limited resources and infrastructure constraints in remote areas (Nelson et al., 2007). For example, the same populations also engaged higher difficulties of testing, health care, and supporting services during the COVID-19 outbreak (Chandra et al., 2013). How much ever an effort is made, the needs of these minority groups are still the most neglected in crisis management. Nevertheless, the concepts of emergency preparedness as developed to this point have not adequately addressed the specific situation or potential of rural and remote populations (Nelson et al., 2007). Thus, a number of authors have pointed to the need to extend targeted, community-based approaches in an attempt to foster and enhance resilience and preparedness in the identified challenging and popularised populations (Ma et al., 2023). While proposals for various tailored context-diagnosis have been proposed in the literature, there is no program-level meta-synthesis. This raises major queries about the capacity to make sensible decisions about which of the proposed strategies need to be prioritized or implemented. It has been established that there is a need to carry out a systematic review of the spread and methodological quality of proposals for enhancing emergency preparedness especially for rural and other hard-to-reach populations globally, (McCabe et al., 2010).

Aim and objectives

The purpose of this systematic review article of literature is to consolidate and summarize the published literature including prioritized strategies suggested to strengthen public health emergency preparedness in rural and other underserved populations.

The objectives are:

- To analyze issues experienced within rural communities throughout public health crises
- To review approaches suggested for increasing resilience and preparedness in the specialty areas of defined, rural and uninsured populations
- In order to assess what works best in the goal of reducing DR in rural areas, the following types of evidence were sought out
- For requisite information to facilitate disaster risk reduction to health and rural systems from a community perspective

This may help to design directions and create evidence on how to increase preparedness of the deprived groups via targeted, culture-sensitive interventions.

2. Materials and Methods

The present systematic literature review has been carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review sought to identify literature about approaches that have been suggested for increasing the preparedness of public health emergency in rural and hard-to-reach populations.

2.1. Information Sources and Search Strategy

A search strategy was carried out to find out related literature from different databases. The following electronic databases were searched: Most of the databases included in this search were, PubMed, Scopus, Web of Science, and Informit Health. These databases were chosen because they provide full text access to scholarly literature in a number of disciplines pertinent to public health and emergency preparedness.

The search terms used were: ("public health resilience" OR "emergency preparedness") AND ("rural communities" OR "underserved communities" OR "hard to reach populations"). Search filters were applied to identify publications from January 1990 to February 2024. The reference lists of included articles were also screened for additional sources.

2.2. Eligibility Criteria

Eligible articles were assessed according to predefined inclusion and exclusion criteria. The inclusion criteria were: (1) Focused on strategies for enhancing public health resilience and emergency preparedness (2) Discussed application in rural or underserved communities (3) Published in English language. Exclusion criteria included non-research articles like commentaries, book reviews, editorials etc.

2.3. Study Selection Process

All retrieved citations were exported to a referencing software and duplicates removed. Two reviewers independently screened the titles and abstracts to identify articles meeting eligibility criteria. Full texts of potentially relevant articles were obtained and independently assessed for final inclusion by the two reviewers. Any disagreements were resolved through discussion.

2.4. Data Extraction and Analysis

A standardized template was used to extract relevant data from included articles by one reviewer and checked by the second. Data extracted included authors, year, location of study, population characteristics, objectives, methodology, key strategies discussed and main findings.

A descriptive qualitative analysis was conducted to synthesize the data. This involved an inductive coding process to identify common themes and categorize strategies proposed. Findings were organized under structured themes to address the objectives of the review. A narrative summary approach was used to discuss results

3. Results and discussion

This section presents the key findings from the literature review synthesized according to thematic areas. A total of 61 articles published between 1990 to 2024 met the eligibility criteria and were included in the analysis. The results are discussed under the following broad themes:

3.1. Strategies and Interventions to Enhance Community Resilience and Health Emergency Communication

3.1.1. Building flexible and adaptive primary healthcare

Several studies emphasized the critical role of primary healthcare in rural emergency preparedness due to its frontline position within communities (Litaker et al., 2006; Maini et al., 2017). Enhancements such as strengthening diagnostic capabilities, equipping mobile clinics, training community health workers and decentralizing services were proposed to boost rural primary care resilience (Chandra et al., 2013; Rai et al., 2020). However, achieving such upgrades requires consistent funding which is often limited in under-resourced settings.

Community-driven approaches that identify locally acceptable models show promise. Gong et al. (2021) reported on Shenzhen's 'Luohu model' comprising township hospitals network and village doctors' scheme that effectively expanded COVID-19 testing and case management reach in rural China. Flexible telehealth was another strategy adopted across diverse contexts to maintain continuity of chronic and routine care during crisis through video and phone consultations (Haldane et al., 2021; Wijesinghe et al., 2023). The health system framework and disaster risk management (DRM) perspective also emphasizes building flexibility and coordination within and across different health system building blocks (Figure 1) like service delivery, workforce, equipment and information to withstand disruptions (Olu, 2017; Thomas et al., 2020). Regular drills, backup rostering, coordinated protocols and fostering decentralized decision making are tangible ways to operationalize such adaptive capacity (Rai et al., 2020; Ryan et al., 2023).

However, achieving resilient primary care requires political prioritization of rural health resource allocation which has historically been inequitable (Mills, 2014). It also necessitates cultural sensitivity to gain community acceptance of unfamiliar roles or delivery models (Crouse Quinn, 2008). Empowering local actors and formalizing existing social support networks could maximize sustainability and accountability.

According to Haldane et al. (2021), robust primary care formed the bedrock of Vietnam's rapid and effective COVID-19 response, attributing its resilience to long-standing investments. Sustained funding, policy commitment and stakeholder buy-in are imperative for rural healthcare systems to build similar adaptive capacities on a routine basis. Besides, a flexible approach involving community input, decentralization of services, coordination across health system components and cultural sensitivity shows promise for bolstering the resilience of under-resourced rural primary care systems. Targeted yet adaptable strategies should aim to remove location barriers and integrate existing social strengths.

3.1.2. Strengthening partnerships and cross-sector collaborations

Most experts concur that multi-disciplinary partnerships are integral to public health emergency preparedness, given its multi-factorial nature (Plough et al., 2013; Rutter et al., 2017). From poultry health to vector control, coordination across human and animal health, NGOs, disaster management, environment, agriculture and other sectors broadens capabilities and ensures a holistic approach (WHO, 2023; Zhang et al., 2021).

At the rural community-level, joint drills, resource-sharing agreements, exchange programs and collaborative situation rooms were proposed to foster familiarity and trust between informal groups, formal institutions and neighboring jurisdictions (Kuziemsky & O'Sullivan, 2015; Stoto et al., 2017). Establishing regular forums for interaction, relationship-building and participatory planning cultivates the communication channels critical during crises (Burkle & Greenough, 2008; Stojmenova & Kocev, 2021). The relationship between emergency communication and community resilience also depends on empowering public participation in decision-making and transparent information-sharing to build understanding and ownership of solutions (Rutter et al., 2017; Silver, 2019). This helps address risks that disproportionately impact the local population and mobilize existing skills and social capital.

However, resource constraints and geographical isolation pose challenges to operationalizing multi-sectoral coordination especially in remote areas (Nelson et al., 2007). Adopting virtual and rotational activities, assigning clear roles and fostering trust between organizations can help overcome such barriers (Gaspar et al., 2021; Wijesinghe et al., 2023). Regional or national forums may also boost rural inclusion and visibility of priorities. Existing networks like faith-based groups, school committees, women's clubs present interfaces for two-way information exchange if engaged respectfully (Plough et al., 2013; Rai et al., 2020). Regular inter-agency simulation exercises could test plans, flag blind spots and retain partnerships central to wellbeing of vulnerable populations during crises (Jones & Faas, 2017; Stojanova & Stankovska, 2017).

3.1.3. Promoting community resilience through social infrastructure

Disasters disproportionately impact marginalized groups lacking resources or social capital (Aldrich & Meyer, 2015; Elliott & Yan, 2013). Developing cohesive communities is critical for building resilience from within. Regular health education, volunteering opportunities for youth and elderly as well as social events fosters this aspect (Blanchard & Rowe, 2007; Glanz et al., 2008). Interventions aim to strengthen trust between heterogeneous groups, trans-generational skills transfer and participation in health governance to achieve culturally-tailored emergency preparedness (Nelson et al., 2007; Ryan et al., 2023). Community radio, local champions, or peer groups help cascade accurate public messaging, address misinformation and mobilize volunteers during crises (Fernandez et al., 2002; Manangan et al., 2014).

Careful trust-building is required due to rural heterogeneity, histories of marginalization and existing prejudices posing barriers (Gaspar et al., 2021; Setbon et al., 2019). Regular support visits, dialogue platforms and representation of diverse voices in planning help foster understanding instead of imposing external models (Abramson et al., 2015; Stojanova & Stankovska, 2017). Flexible social safety nets are another resilience strategy to address post-disaster needs like temporary shelters, food banks or financial assistance coordinated through local groups and relief agencies (Baum et al., 2009; Elliott & Yan, 2013). However, these require political will, funding and community oversight to be sustainable (Runnels et al., 2020; Wijesinghe et al., 2023).

3.1.4. Enhancing emergency risk communication

Effectiveness of rural preparedness plans hinges greatly on two-way communication enabling shared situational awareness and coordinated action between agencies and populations (Burkle & Greenough, 2008; Jones & Faas, 2017). However, achieving this is challenging in remote locales due to inadequate broadband access, language barriers and lack of trust in authorities (Garfin et al., 2020).

Early initiatives focused on conveying top-down alerts through loudspeakers, bulletins or phone trees with limited success (Myers et al., 2006; Wittrock et al., 2019). Newer iterations aim to build on multi-modal locally-driven networks like community radio call-in shows, notice boards, text groups and volunteer communicators to cascade information in transparent and participatory manner (Abramson et al., 2014; Blair et al., 2015).

Successful models tested simple yet regular messaging to high-risk groups, sought feedback and clarified public perceptions through dialogue (Manangan et al., 2014; Palen et al., 2007). For example, WhatsApp groups of farmers or women self-help groups used local languages to share prevention tips, alleviate anxieties and enlist volunteers during Kerala's 2018 Nipah outbreak response (Raghavan et al., 2019; Wijesinghe et al., 2023).

Nevertheless, achieving proximity to diverse communities requires cultural immersion, ongoing trust-building and addressing historical marginalization sensitively. Outsiders should avoid imposing top-down models without community acceptance and ownership (Hosseini et al., 2020; Palttala et al., 2012). In any case, grassroots agencies may act as a bridge if they are recognized in the field. Pre-testing of communication channels, adapting DA messages to suit the local capacity and need for capacity building, and essentially for the identification of intervention social niches. (Rohrmann, 2008; Stojanovska & Tasev, 2020). Intermittent updates and relationship maintenance with the dissemination of information helps in reducing the odds of making vulnerable situations worse (Garfin et al., 2020; Palen et al., 2007).

3.2. Health System Framework and disaster risk management (DRM)

3.2.1. Understanding health system framework

Analysis of the literature published by the WHO (2016) and Thomas et al. (2020) defined health systems frameworks as a concept that involves evaluation of all the necessary components and their relationships within the sphere of health that have to be in harmony to bring the improvement to population's health. Some of these elements are important resources that cannot be over-emphasised as core to the working of any health system such as enough money, quality facilities, the right human resource. The framework also looks at some fundamentals that include service delivery which means the way in which health service is offered to the needy. A third pillar is governance, which refers to the leadership regarding the formulation and administration of policies of the broad health system. Such a broad framework has been used by the WHO (2016) and Thomas et al. (2020) and helps to assess the essential assets and gaps of a country's health system and even in the periods of crises. This, as expounded by Rai et al., ES, enables one understand which domains require focused efforts in order to strengthen up existing disaster risk management capacities. Furthermore, the use of this framework helps in the development of a broad understanding of how all components of any health system will require support and improved coordination for the ability to build resilience to emergencies as explained in the study by Kruk et al. (2015).

 Readiness involves scanning of vulnerabilities with the related constituents and increasing capacities as according to the experiences from ebola and COVID-19 outbreak as presented by Kieny (2014) and Haldane et al. (2021). Moreover, the scheme includes periodic assessment of the health system performance in wide varying stages of a disaster. As stated by UNDRR (2020a) and Stoto et al. (2017) the periodic review assists in the evaluation of the efficiency of the current risk management in continued hazards mitigation, and for the identification of potential important links that should be strengthened for enhancing the levels of disaster preparedness in the long run.

Training of staffs, developing or improving infrastructure, and ensuring quality human assets are some of the factors that enhance the capacity of the health systems. However, limited funding and human resources form a big barrier and set back in the achievement of this objectives towards the implementation of this framework for DRM in many nations as highlighted in the study done by Kruk et al. (2015). Disasters therefore unravel latent weaknesses in health systems since they stretch the current capacity of health systems. Lack of clear structure and poor collaboration as well as the absence of well-defined roles also hamper responses, underlining that such systematic application of this scheme to strengthen nations against great adversities remains relevant even today.

3.2.2. Integration of DRM within health system planning

Abbas (2021) and Rutter et al. (2017) pointed of the strategic positioning of DRMs in that it has to be built into all the elevated processes and into the normal business of the over health system. Thus, while promoting the idea of fitting DRM into the overall architecture of the health systems, both scholars stress the need to augment the preparedness against emergencies.

This requires the integration of risk assessment and risk management strategies as early as at the options and priorities state or at the formulation of health sector policies and programs as informed by broad comprehensive guidelines offered by WHO (2018). Consequently, staff training regimes, resource allocation patterns, infrastructure development initiatives as well as norms of service delivery will need to appropriately factor in potential hazards and accommodate requisite flexibility for swift emergency response actions as recommended by WHO (2018). Establishing emergency operations centers, stockpiles, evacuation plans are tangible ways to integrate DRM suggested by case studies and reports from the BC Ministry of Health (2013) as well as the work of Jones et al. (2021). Regularly testing such prepositions through exercises assists in refining coordination and identifying flawless for amelioration.

Periodic drills as well as reviewing past disasters are vital for continually evaluating and perfecting the integration of DRM within routine health system planning. Experiences from Indonesia showcased in the work of Rai and colleagues (2020) demonstrate the utility of rigorous evaluation. A collaborative strategy cutting across health facilities and linking with other community partners is essential for bolstering incorporated planning at the many administrative levels comprising any health system. The work of Gong et al. (2021) highlights the benefits of multisectoral involvement and coordination, notably how China's "Luohu Model" facilitated Shenzhen's COVID-19 response through integrated health system planning embedded with DRM best practices.

3.2.3. Utilizing health system framework for building resilience

p1. The health system framework provides insightful guidance on targeted actions for developing resilience against emergencies, as noted in various reports and strategic guidelines set by agencies like WHO (2016) and UNDRR (2020a). For instance, strengthening essential service pillars like primary healthcare, public health surveillance systems, logistics, and ensuring access bolsters resistance capabilities according to Burkle and Greenough (2008). Engaging with communities and raising risk awareness among the general public regarding prevention and response measures fosters resilience at the grassroots level as highlighted in the work of Wijesinghe et al. (2023). Table 1 outlines sample strategies across key health system pillars like governance and leadership, financial management, medical resources and more.

Developing flexible tactics such as training medical reserves, prepositioning crucial supplies, and reinforcing critical infrastructure enhances absorptive capacities as evidenced during the COVID-19 pandemic. Standardizing equipment maintenance and developing quality control protocols for essential items as seen in Table 1 also boosts shock absorption. Crafting adaptable management styles and alternative service delivery models aids recovery and evolution, as case studies from China's effective pandemic response presented in Gong et al. (2021) demonstrated. Table 1 provides examples of rehabilitation strategies across multiple health system components.

Table 1 Comprehensive Healthcare System Components for Emergency and Crisis Management

Pillars	Risk Mitigation Strategies	Emergency Readiness	Crisis Management	Rehabilitation Efforts
Governance and Leadership	• Create policy framework for health crisis prevention • Integrate risk reduction into health policies	• Develop crisis preparedness protocols • Create emergency response plans	• Formulate public health emergency plans • Coordinate across sectors	• Set up recovery coordination bodies • Update contingency plans

	• Form public health crisis committees • Establish crisis units in health ministry	• Conduct simulation drills • Design business continuity strategies	• Oversee emergency health operations	• Enhance regulatory oversight • Revise health program guidelines
Financial Management	• Design universal health coverage for crises • Allocate funds for risk reduction	• Budget for emergency preparedness • Establish emergency health funds	• Finance emergency health responses • Implement crisis health coverage	• Mobilize recovery funds • Create sustainable health financing • Improve financial accountability
Medical Resources	• Assess medical supply risks • Map vulnerabilities • Store essential medical items	• List crucial medicines and supplies • Procure emergency kits • Create quality assurance systems • Establish supply chains	• Deploy emergency medical resources • Manage supply chains for essential items	• Enhance supply management Develop quality control measures • Create guidelines for rational use • Standardize equipment maintenance
Information Systems	• Conduct disaster risk assessments • Implement safety surveys	• Create early warning systems • Establish ongoing health surveillance	• Conduct rapid health assessments • Monitor disease outbreaks • Map health service availability	• Assess post-crisis health needs • Strengthen health information systems
Human Resources	• Assess training needs • Train health workers in risk reduction	• Develop emergency staff guidelines • Train rapid response teams • Create roster of emergency experts	• Deploy additional health workers • Protect staff from health risks	• Evaluate impact on workforce • Plan for increased health demands • Enhance staff recruitment and retention
Service Delivery	• Upgrade at-risk health facilities • Review building codes • Conduct public awareness campaigns	• Prepare risk communication strategies • Plan for emergency shelters	• Manage mass casualties • Set up temporary health facilities • Provide essential and specialized care	• Revise basic health packages • Address equity in service access • Implement community-based initiatives

This table outlines key elements of a healthcare system's approach to managing risks, preparing for emergencies, responding to crises, and recovering from disasters across various fundamental components of the health sector.

Periodically evaluating risk reduction initiatives and learning lessons from past crises helps identify additional areas for continuously fortifying resilience against disruption over the long haul. Table 1 outlines evaluation approaches that can be applied. While strategies described in Table 1 provide guidance, scarce evidence on cost-benefit, weak monitoring and bureaucratic barriers continue to impede fully harnessing health systems for resilient disaster preparedness.

3.2.4. Utilizing health system framework for building resilience

Building community resilience is an important aspect of strengthening public health systems and disaster risk management. Community resilience refers to the ability of communities to prepare for, withstand, and rapidly recover from disruptions like public health emergencies or natural disasters (Sherrieb, Norris, & Galea, 2010). A key factor in community resilience is social capital, which includes attributes like strong social networks, high levels of trust and civic engagement (Alonge et al., 2019). Community engagement initiatives can help build social capital and empower communities to play an active role in emergency preparedness, response and recovery (Wijesinghe et al., 2023).

Several studies have examined strategies for building community resilience. A qualitative study in Liberia during the Ebola outbreak found that community resilience was strengthened through social cohesion, effective communication, flexible social structures, reliance on traditional practices, and connection to external support (Alonge et al., 2019). A review of initiatives in Canada identified key community resilience-building strategies like enhancing social connections, supporting self-organization, strengthening community participation and leadership, building partnerships between community and government agencies (Hall et al., 2023).

Community scorecards are a participatory monitoring tool that can be used to improve local governance and build community resilience. In South Africa, action research using community scorecards helped strengthen relationships between local communities and government, built community capacity for collaborative problem-solving, and identified priorities for improving disaster risk reduction and emergency preparedness (Sanchez-Betancourt & Vivier, 2019). The UNDRR developed a disaster resilience scorecard for cities which includes indicators for assessing community resilience and public health system resilience (UNDRR, 2020a; Williams & Sands, 2020).

Stojmenova and Kocev (2021) describe the design of an interactive online platform for communicating flood risk information and building community resilience in North Macedonia.

A community-based participatory model was used to build resilience to emergencies in Los Angeles County (Plough et al., 2013). The promoted activities in the community model involved identification of stakeholders, appreciation of social [dis]advantage, fostering of community capacity, integration of strategies across sectors, and assessment of effects. Likewise, the "One community at a time" program in China that employed grassroots strategies that are participatory risk education, resource mobilization, and community institutional partnerships for disaster risk reduction (Ma et al., 2023). Miller-Karas (2023) came up with a trauma and community resiliency model that aims at enhancing collective resilience at individual, community and societal levels.

3.2.5. Challenges in operationalizing the framework

Despite the fact that the concept of community resilience has received a lot of attention and frameworks to support it are available, there are several problems that arise when the framework is to be implemented in practical scenarios. One of the main concerns is that the identification of comprehensive list of indicators and methods to measure community resilience is relatively limited (Sherrieb et al., 2010). This makes it almost impossible for one to evaluate the initial level of resilience, track progress over time or evaluate the difference between various efforts made in different urban spaces. Community-level factors are also highly complex with interactions between social, economic, environmental and institutional dimensions (Litaker et al., 2006). This complexity presents difficulties in attribution when evaluating resilience-building interventions.

Engaging diverse community stakeholders requires sufficient resources and skilled facilitators (Plough et al., 2013). Hard to reach and more vulnerable groups may not participate if engagement processes are not adequately designed for inclusion. Community mobilization also takes time, and sustained long-term commitment is needed to embed resilience-building approaches locally. Local political and socio-economic priorities may not always align with emergency management goals, necessitating negotiated solutions (Kuziemsky & O'Sullivan, 2015).

Measurement challenges are exacerbated in fragile or post-disaster settings where data collection capacity is limited. Evaluating impact also requires consideration of what resilience means to different communities, as the outcomes prioritized locally may differ from expert or outsider perspectives (Miller-Karas, 2023). Communication and coordination across multi-sector stakeholders is also difficult, as are integrated 'whole of society' planning approaches that span health, disaster management, development and other domains (Rutter et al., 2017).

Community resilience-building competes with other priorities for limited resources, and maintaining long-term funding can be a hurdle. There is also the risk that frameworks shift responsibility excessively onto communities without sufficient enabling conditions or power equalization between stakeholders (Stojmenova & Kocev, 2021). The

intergenerational impacts of trauma and chronic stressors like poverty may pose inherent limits to resilience that frameworks do not always acknowledge (Miller-Karas, 2023).

Addressing these challenges requires flexible, adaptive and participatory approaches to build evidence over time, (Thomas et al., 2020).

3.3. Resilient Health Systems, Communities, and Social Determinants of Health as Basis for Public Health DRM

3.3.1. Linking health systems strengthening and community resilience

Resilient health systems and empowered communities are interdependent pillars for strengthening public health disaster risk management. Health systems play an important role in building community resilience by providing universal access to promotive, preventive, and curative services which help protect health and enable populations to better prepare for, withstand, and rapidly recover from disruptions. Strong primary healthcare that is integrated with social and community-based services allows the health needs of communities to be holistically addressed (Kruk et al., 2015). It is therefore important that health systems are equipped with sufficient resources and well-trained workforce to meet surges in demand during public health emergencies in a way that actively engages communities (Thomas et al., 2020). As shown in Fig 2, systems of health encompass formal health services, as well as social determinants of health, community capitals, and broader systems that influence health.
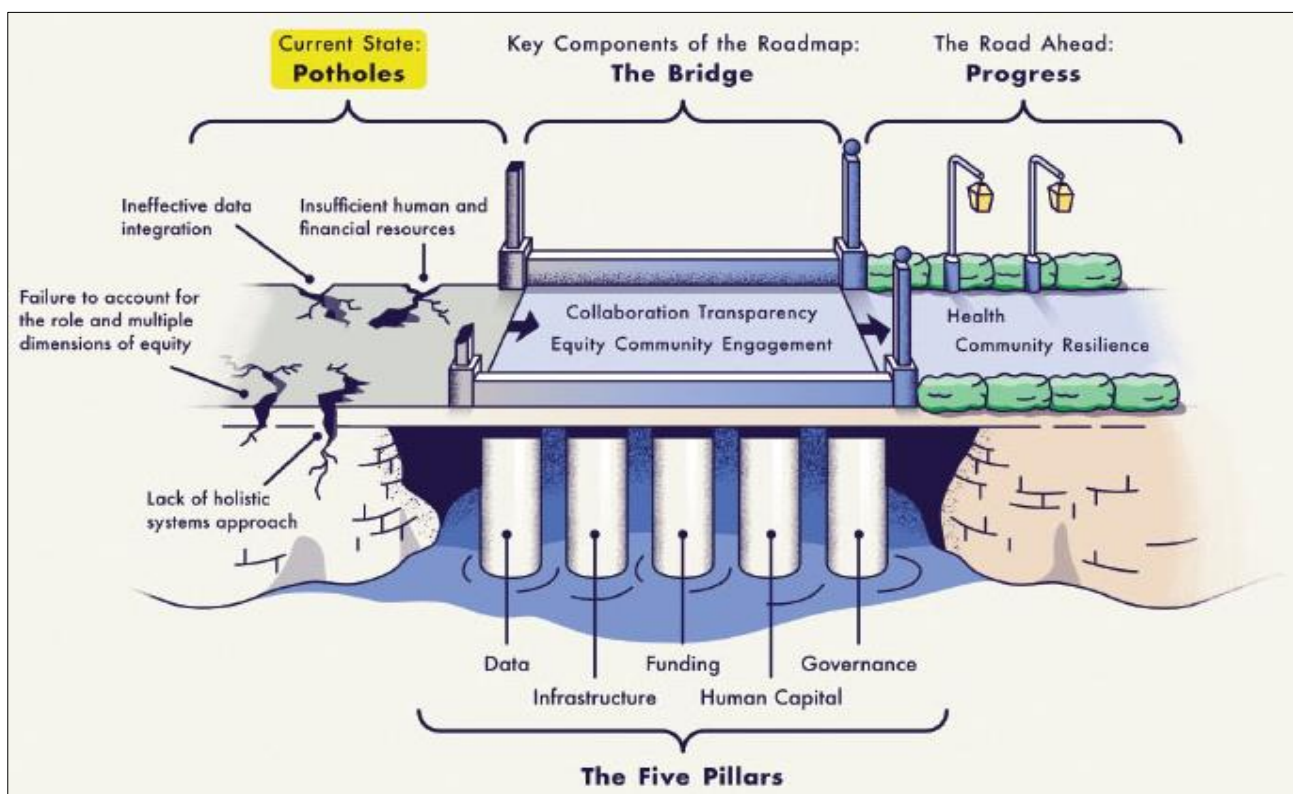
Source: Cohen et al., (2023)

Figure 2 Systems of Health and Community Resilience

Conversely, empowered communities that are socially cohesive and capable of self-organization significantly influence the demand for and accessibility of health services, as well as health behaviors during times of crisis (Alonge et al., 2019). Recognition of this interdependence has led frameworks to emphasize the need for community-centered approaches that assess how health services can be maintained or restored, considering social networks, local knowledge, cultural factors and underlying vulnerabilities affecting community resilience (Hall et al., 2023; Wijesinghe et al., 2023). Strengthening linkages between formal health systems and community structures requires participatory mapping of resources, referral mechanisms, as well as coordination platforms for joint planning, monitoring and response (Sanchez-Betancourt & Vivier, 2019). As shown in Fig 2, community resilience is built upon social support systems, community capitals and governance mechanisms.

3.3.2. Addressing social determinants through multisector action

Social determinants of health relating to factors like income, education, housing, gender and employment have substantial influence on individual and population vulnerability to disease and ability to withstand disruptive events (Sherrieb et al., 2010). During crises, pre-existing social inequalities magnify health impacts as marginalized groups tend to have limited resilience capacities and access to information, services and relief (Roberton et al., 2020). Therefore, building community resilience necessitates addressing underlying social determinants through multisector partnerships that strengthen economic and social safety nets.

. Participatory approaches that engage diverse stakeholders help identify the most pressing social constraints limiting local resilience. For example, in responding to COVID-19 impacts in Sri Lanka, community-led women's groups were supported to not only enhance healthcare access but also generate livelihoods and promote gender equity, thus fortifying community self-reliance (Wijesinghe et al., 2023). Multisector scorecards have also proven useful for jointly monitoring progress in meeting basic needs and reducing disaster risks across health, welfare and other public sectors (Sanchez-Betancourt & Vivier, 2019).

3.3.3. Establishing enabling policy environments

National policy environments set the overarching conditions influencing the capacities of health systems, community groups and social service agencies to strengthen resilience collaboratively. Enabling policies foster universal health coverage, primary care-centered systems, social safety programs, strong regulatory institutions for risk governance, as well as coordinated emergency planning and response (Mills, 2014; Rai et al., 2020). For instance, legislated responsibilities for Indonesia's National Disaster Management Authority helped harmonize roles between national to local disaster stakeholders and health services during major crises (Rai et al., 2020).

Supra-national bodies promote global solidarity through common frameworks, guidelines, research and coordination. The World Health Organization plays a leading role in establishing minimum standards, core competencies and specialist resources to support national efforts. Examples include the Public Health Emergency Framework outlining roles and actions, as well as maintaining reserves for rapid Emergency Medical Teams, Logistics and personnel deployment (WHO, 2016; European Centre for Disease Prevention and Control, 2017). Regional health organizations also facilitate knowledge-exchange between Member States on building resilient capacities proportionate to context-specific hazards (Raguin & Girard, 2018).

3.3.4. Coordinated regional and global collaboration

In the contemporary world defined by increased mobility and interconnected trade, public health emergencies easily traverse national borders requiring supportive regional and global cooperation. Regional networks and agreements are invaluable for timely information-sharing on outbreak detection and control, coordinated procurement of medical supplies, as well as deployment of experts across borders in complex emergencies (Rai et al., 2020). The WHO Regional Offices exemplify such mechanisms for convening countries and development partners to strengthen national capacities through collaborative training initiatives, (Thomas et al., 2020).

At the multilateral level, achieving global health security necessitates institutions fostering policy alignment and collective preparedness. The WHO assumes charge of maintaining global surveillance, issuing travel advisories, leading response in large-scale disasters, facilitating international deliberations and fostering global health solidarity especially for low to middle-income countries (Kieny, 2014; Haldane et al., 2021). Such efforts are becoming increasingly vital with disease spread getting accelerated due to expanding global trade networks and mobility across the world (Raguin & Girard, 2018). Through coordinated action, regional and global partnerships play a key supportive role to national governments.

3.4. Strategies for Advancing Public Health Resilience in Rural and Underserved Communities

### 3.4.1. Understanding Challenges Faced by Rural Communities in Public Health Emergencies

Rural communities face unique challenges during public health emergencies due to their geographical isolation, limited infrastructure, and resource constraints. Nelson et al., (2007) indicated that they experience poor staffing of emergency services; stretched capacity reach of health centers; as well as delayed respond time of specialized health care. There are very few public transport facilities and poor telecommunication network to organise the emergency responses which also aggravates the situation (Burkle & Greenough, 2008). However, poverty especially in the rural areas limits the funding to such a basic facilities indispensable for prepareness activities. According to Costich and Scutchfield

(2004), limited funds are even worse in rural areas, where small and can scattered tax bases render it difficult to create multisector emergency planning groups, not even contingency.

Culturally and socioeconomically differences in risk perception, assigned responsibilities and access to information during crisis also exists in rural areas. Crouse Quinn (2008) underlines the strengthening of local context, priorities, and capacities while working on the units of reformation for the rural areas. In the health system plea, Olu (2017) has laid emphasis on the aspect on how segments of health system in the rural area, for example, service delivery, workforce and information systems may ordain or interact with emergency preparedness. Equally, Plough et al. (2013) emphasize that the analysis of the social determinants of health is critical for enhancing stability in rural zones that are ordinarily wielded because prior disadvantages are kindled when public health crises hit these arbitrary groups.

3.4.2. Examining Strategies for Strengthening Resilience in Underserved Rural Settings

On this account, several measures have been suggested to enhance the preparedness and resilience among rural communities as follows; Chandra, et al. (2013) also recommend that the community based interventions should focus on locally validated what works models and harnessing the community resources. For example, traditional and innovative telehealth has been implemented in various settings in order to continue essential and planned chronic and routine care through video and telephone consults in crisis situations (Haldane et al., 2021). Wijesinghe et al. (2023) share an example of how women's groups across communities in Sri Lanka were empowered with a view to improving health, creating incomes to support households, and advance gender equality, and hence building community resilience during the COVID-19 pandemic. Fig. 3 shows that raising financial resilience is paramount, with focus on improving the amount of assets which can be mobilised before and after disaster, and diversifying risk transfer options.
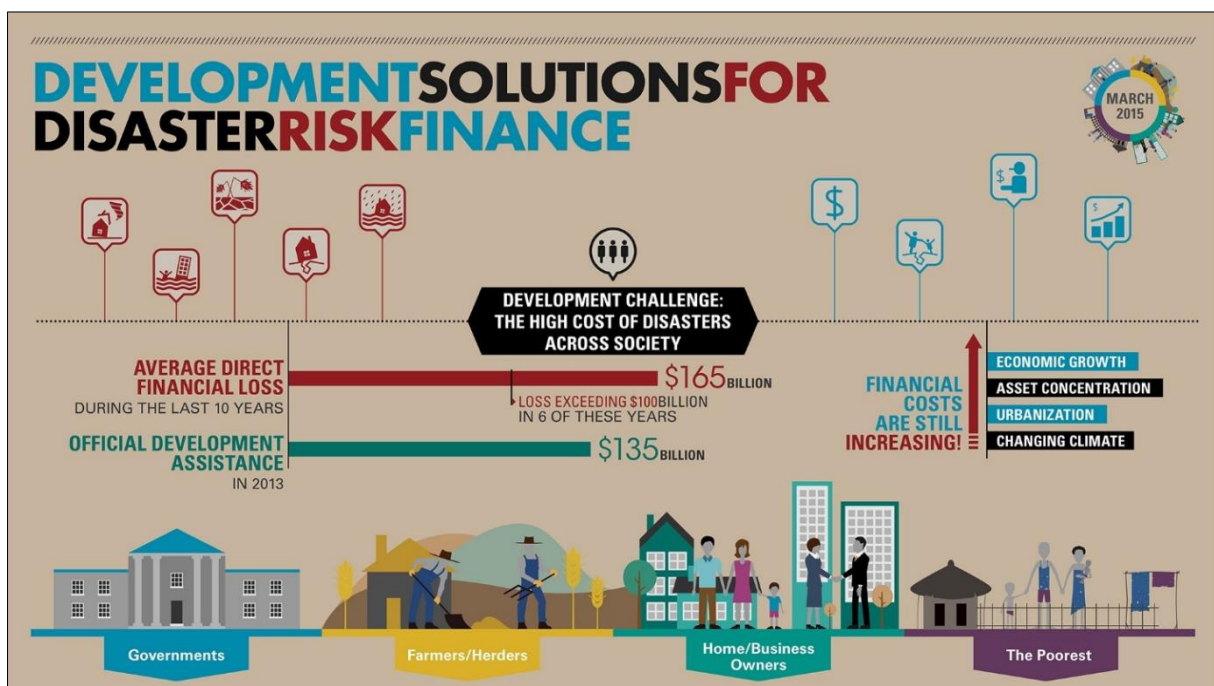
Source: UN Office for Disaster Risk Reduction (UNDRR), (2024)

Figure 3 Strengthen Financial Capacity for Resilience

Intensifying and consolidating the collaborations with different sectors is another strategy pointed out by some of the works. Citing Kuziemsky & O'Sullivan, (2015) recommended for check, the middle managers to have constant forums of interacting and relationship developing with participative planning that is pivotal in crises. According to Stoto et al. (2017), joint drills, resource-sharing agreements, and situational collaboration rooms enhance trust and frequency between and with the groups and institutions whether formal or informal and jurisdictions or regions. In the same regard, Rai et al. (2020) argue that DRM should be a cross-cutting component of Table 1 and embedded into the 'business as usual' in health system planning, from staff training, budget distribution, as well as the infrastructure planning horizon. The above strategies focus on building 'health systems resilience' that is building the capacity of the health systems in rural areas to deliver effective and efficient response to public health threats. According to Fig. 3 above, risk transfer mechanism take on a central role in enhancing the partnerships' financial capacity.

3.4.3. Identifying Evidence on Effective Rural-Focused Interventions for Disaster Risk Reduction

Some past research has documented data regarding the interventions that work best in reducing disaster risks in rural areas. Alonge et al., (2019) explored and discussed community resilience from qualitative research done in Liberia during the Ebola era and identified the five major methodologies by which the communities built resilience including social relation, communication, flexibility of the community, tradition, and outside support. This reinforces one of the critical components in the current community Assets and Social Capital as a framework for community rebuilding. Gong et al., (2021) were able to document the impact of the 'Luohu model' in China, that involves a township hospitals network and a village doctors' scheme to increase COVID-19 testing and case management in rural region. This model proved that through the decentralized community based approach, the strength of the rural health system can be boosted.

There is similarly evidence of success of participatory approaches when it comes to enhancing resilience. Sanchez-Betancourt & Vivier (2019) explain, for example, that the use of the community scorecards in South Africa empowered people and contributed to development of cooperation between communities and the government; it also improved the capacities of communities which engage in problem solving and defined topics related to disaster risk reduction and emergency preparedness. On the same note, there is Ma et al. (2023) who discussed the community-based approach, the "One community at a time," implemented in china; the key strategies in this program included participatory risk education, facilitating local capacity, as well as long-term commitment to building community-institutional relations for enhancing disaster resilience. The current work contributes significance knowledge into the impact of community involvement and ownership in the uptake of disaster risk reduction activities in the rural areas.

4. Conclusion and Directions for Future Study

Therefore, this systematic review has gathered all the information it can acquire on how the topic of interest; rural and underserved community's emergency preparedness and resilience for public health emergencies can be addressed. The studies revealed the fact that these communities encounter manifold problems such as location, absence of infrastructure, and fewer resources, and social issues. But the review process also singles out some strategies and interventions that can be used to buildup resilience in the rural areas.

Some of important perceived implications include the roles of communities, enhancing partnerships and collaboration, linking DRMR with health systems planning and utilization, and enhancing social capital and knowledge. Findings from diverse paradigms suggest that flexible telemedicine technologies, decentered health care delivery systems and health systems participation strategies contribute to the improvement of the coping capacities of rural health systems.

Nevertheless, there are some areas that need further development in the present research and practice. It is imperative that intervention studies have a more rigorous approach towards their trialing to accrete greater stock of empirically tested effective interventions for rural contexts. Subsequent research should aim at constructing contingent indices of measurement for rural health system's and testing them in various contexts. Other works that should be conducted are focused on studying the potential of developing technologies to remove geographical constraints and improve the state of readiness for emergencies in rural areas.

Moreover, future research should investigate how it is possible to achieve long-term viability and expansion of founded efficacious treatments. This entails large scale exploration of the avenues of long term financing as well as political will for the causes of rural health systems. Research should also be done to look at the best ways of linking the indigenous world view and practices of the people to the modern health system in rural areas.

Finally, more effort in understanding the modifiable social determinants of health in determining the resilience of rural communities is required. This includes having a look at how interventions that address social and economical determinants of health status improve the nation's overall Prosperity external disaster preparedness. Health system resilience concepts that will involve public health, social science, and disaster risk reduction perspectives will be important for the development of standard and diverse frameworks for enhancing the wellbeing of the rural populace Health System.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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