# Public Disaster Preparedness Participation and Community Resilience: A Survey

## Abstract

This survey paper investigates the critical role of public disaster preparedness participation in enhancing community resilience. It encompasses diverse themes, such as creative arts-based research methods, effective communication among stakeholders, and spatial-temporal electricity vulnerability, to develop robust preparedness strategies. The paper highlights the significance of public health emergency preparedness, local news coverage, crisis informatics, and the application of deep learning techniques in earthquake engineering. It identifies the inadequacy of current resilience metrics and emphasizes public participation in disaster preparedness. Key themes include empowering citizens through digital technologies, defining public health emergency preparedness, and addressing long-term health effects of disasters. The paper also explores technological advancements in disaster communication, the inadequacy of workplace preparedness protocols, and the role of local knowledge in resilience. The survey concludes by identifying challenges and opportunities in promoting public disaster preparedness participation and building community resilience, suggesting future research directions to foster more resilient societies. This comprehensive analysis aims to contribute to the development of inclusive and adaptive disaster preparedness strategies that leverage local knowledge and community strengths, ultimately fostering resilient societies.

## 1 Introduction

### 1.1 Scope and Objectives

This survey examines the role of public participation in disaster preparedness, emphasizing its significance in enhancing community resilience. The study encompasses themes such as the integration of creative and arts-based research methods, which necessitates methodological reflections on their application [1]. Furthermore, it investigates information management among stakeholders during both natural and human-induced disasters, highlighting effective communication's role in disaster response and recovery [2].

The survey's multifaceted objectives address existing research and practice gaps. A key objective is to assess spatial-temporal electricity vulnerability to enhance resilience against power outages, contributing to robust community preparedness strategies [3]. Additionally, it explores public health emergency preparedness (PHEP), underscoring the need for effective frameworks to navigate health system complexities [4]. The paper also evaluates the value of local news coverage and its evolution, providing a dataset to analyze its relationship with local communities and resilience enhancement [5].

The survey investigates crisis informatics tools that support community assistance during disasters, particularly focusing on older adults' perceptions [6]. It aims to bridge literature gaps regarding Deep Learning techniques in earthquake engineering, addressing challenges posed by seismic uncertainties [7].

Moreover, the paper critiques current community resilience metrics, stressing public participation's importance in disaster preparedness [8]. It analyzes the health and economic impacts of major disas-
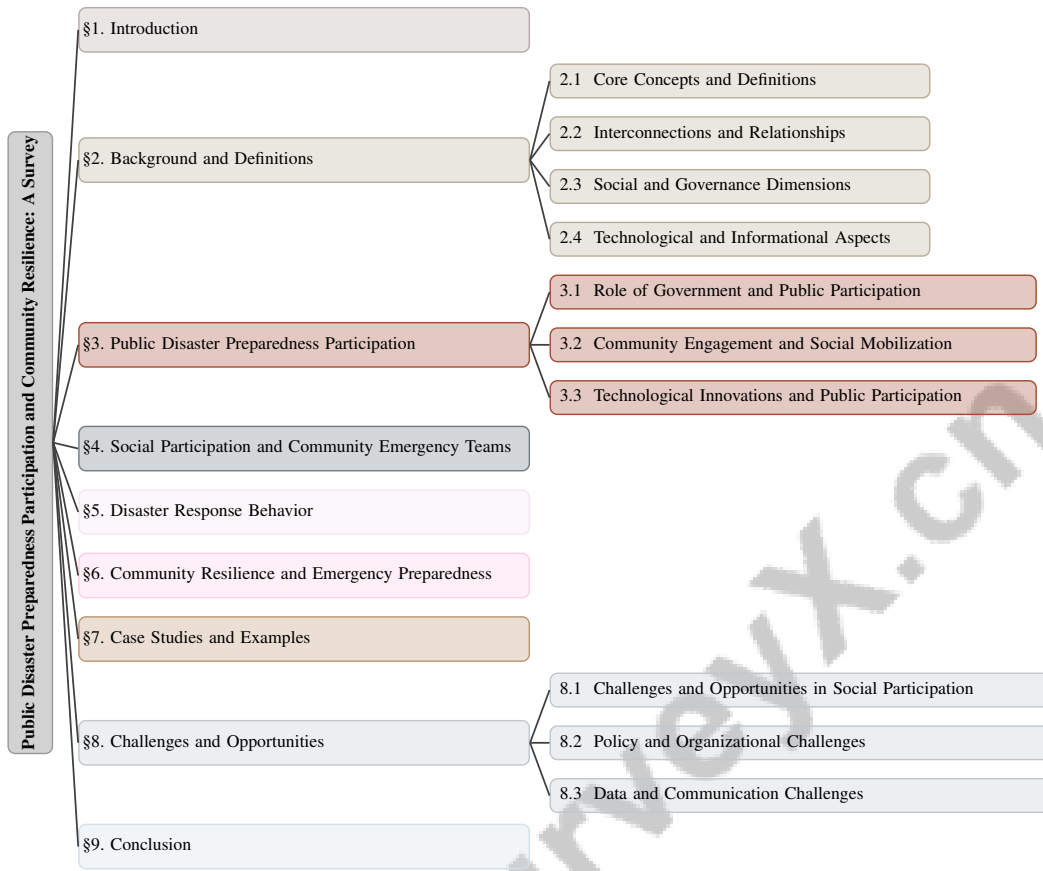
Figure 1: chapter structure

ters, focusing on lessons for future preparedness [9]. Recognizing the high incidence of workplace injuries and fatalities, the survey emphasizes the need for improved emergency preparedness in occupational settings [10]. It also addresses hurricane risks and community resilience in U.S. Gulf Coast counties, filling knowledge gaps regarding public responses to coastal hazards [11].

By addressing these objectives, the paper aims to foster inclusive and adaptive disaster preparedness strategies that leverage local knowledge and community strengths. This approach enhances societal resilience and underscores the significance of community engagement, cross-sector collaborations, and advanced technologies in improving emergency preparedness, particularly in rural and underserved areas. Findings suggest that diverse engagement techniques and strengthened partnerships can enhance communities' capacities to anticipate, respond to, and recover from disasters [12, 13, 14].

## 1.2 Key Themes

This survey identifies critical themes essential for understanding and enhancing community resilience through public disaster preparedness participation. A central theme is empowering citizens through digital technologies, which facilitate participatory design and community engagement, thereby reinforcing community-centric approaches [15]. This empowerment is vital for fostering social participation and participatory democracy, particularly via virtual platforms increasingly relevant in disaster preparedness [16].

The investigation highlights challenges and opportunities in defining preparedness for public health emergencies, emphasizing the need for resilient public health systems capable of addressing diverse hazards [4]. It also examines the long-term health effects of disasters on workers, responders, and residents, underscoring the importance of comprehensive health resilience strategies [9].

Another theme is the inadequacy of existing resilience models, necessitating the incorporation of complexity and interdependencies in assessments to better understand and enhance community

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resilience. This complexity is explored through community power systems' vulnerabilities, integrating occupant demographics, activity patterns, and building characteristics to improve resilience against outages [3].

The role of technology and social media in disaster communication and coordination is examined, highlighting their potential to enhance disaster response and recovery efforts [2]. This includes community-based sampling to prevent healthcare settings from being overwhelmed during pandemics, facilitating self-isolation of suspected cases and thereby enhancing public health resilience [17].

Additionally, the survey addresses the inadequacy of workplace emergency preparedness and response protocols, stressing the need for standardized procedures and training to improve safety and resilience [10]. The exploration of local knowledge, preparedness, community relationships, and communication focuses on enhancing resilience among older adults [6].

Finally, the survey underscores the significance of civil empowerment through digital traces and social structures, crucial for fostering resilient communities. This theme relates to contextual hurricane risks and community resilience indicators, as well as the relationship between community resilience and risk perceptions regarding hurricanes [11]. Collectively, these themes illustrate the multifaceted nature of disaster preparedness and the diverse strategies necessary to cultivate resilient communities.

## 1.3  Structure of the Survey

This survey is systematically organized to comprehensively explore public disaster preparedness participation and its role in enhancing community resilience. The paper is structured into several key sections, each focusing on distinct yet interconnected aspects of the topic.

The survey begins with an **Introduction** that highlights the importance of public participation in disaster preparedness and its impact on community resilience, outlining the scope, objectives, and key themes.

Following the introduction, the **Background and Definitions** section delves into core concepts relevant to the survey, such as public disaster preparedness participation, social participation, and community resilience. It explores the interconnections between these concepts and the social and governance dimensions influencing disaster preparedness, along with the technological and informational aspects critical to disaster response.

The **Public Disaster Preparedness Participation** section examines the role of public involvement in disaster preparedness, highlighting successful initiatives and the government's role in facilitating community engagement. It discusses strategies for social mobilization and the impact of technological innovations on public participation.

In the **Social Participation and Community Emergency Teams** section, the survey investigates the impact of social participation and community emergency teams on disaster preparedness, emphasizing the benefits of social networks in enhancing community resilience.

The **Disaster Response Behavior** section analyzes individual and collective actions during disasters, identifying factors influencing response behavior and challenges in ensuring effective disaster response.

The discussion transitions to **Community Resilience and Emergency Preparedness**, where the concepts of community resilience and emergency preparedness are defined and explored. This section examines strategies for building adaptive capacities and the role of technological and data-driven approaches in improving resilience.

To provide practical insights, the **Case Studies and Examples** section presents real-world examples of successful disaster preparedness and resilience strategies, including lessons learned from major disasters, comparative recovery patterns, and the integration of community resources and infrastructure.

Finally, the **Challenges and Opportunities** section identifies challenges and opportunities in promoting public disaster preparedness participation and building community resilience, addressing issues related to social participation, policy and organizational challenges, and data and communication barriers.

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The survey concludes by synthesizing primary findings and proposing avenues for future research and policy initiatives aimed at enhancing community resilience to both natural and human-made disasters. This includes leveraging social media and crowdsourcing for improved information sharing and stakeholder engagement, as well as emphasizing effective community engagement techniques in disaster preparedness. Additionally, the survey highlights the need for tailored crisis informatics tools catering to vulnerable populations, such as older adults, fostering stronger, more prepared communities in the face of various hazards [14, 6, 18, 19].The following sections are organized as shown in Figure 1.

## 2 Background and Definitions

### 2.1 Core Concepts and Definitions

Public disaster preparedness participation involves diverse strategies to equip individuals and communities for effective disaster risk management and resilience. This concept is crucial for a resilient public health system, where preparedness mitigates disaster impacts [4]. Proactive engagement is vital for robust emergency response protocols and occupational health practices, integrating healthcare worker involvement, disability rights, and public health law for comprehensive preparedness [10].

Social participation entails community members actively engaging in collective activities that fortify social networks and enhance disaster resilience [2]. This participation is pivotal for health service development and evaluation, boosting the community's disaster resilience [20]. Social resilience, a subset of social participation, highlights dynamic social networks and communication channels' role in crisis mitigation, including climate change impacts. However, existing frameworks often rely on static indicators, failing to capture resilience's dynamic nature [21].

Community resilience is a community's capacity to prepare for, absorb, recover from, and adapt to disruptive events [8]. This concept is crucial where demographic and socioeconomic factors affect recovery, such as during power outages from natural disasters [3]. Integrating social dynamics—emotions, cooperation, and risk perception—with technical constraints like power flow is essential for maximizing community resilience [22]. Understanding resilience indicators and interdependencies between social institutions and the built environment is critical for enhancing community resilience [23]. Engaging communities and leveraging socio-spatial networks can improve resilience to public health emergencies, addressing vulnerable populations' specific needs.

Key terms like civil participation, digital traces, and social structures elucidate community engagement's role in disaster preparedness [16]. Community sampling is introduced as a method to test suspected COVID-19 cases outside hospitals, avoiding healthcare facility overload during pandemics [17]. This approach underscores data-driven methodologies' importance in complex disaster scenarios, such as earthquake engineering, where deep learning enhances damage assessment, response prediction, and risk management [7].

### 2.2 Interconnections and Relationships

The interconnections among public disaster preparedness participation, social participation, and community resilience are complex, involving multifaceted relationships across social, institutional, and technological dimensions. These elements collectively enhance community resilience by promoting proactive engagement and coordinated responses. Various community engagement techniques effectively increase preparedness, integrating collaborative planning principles and utilizing disaster citizen science initiatives. Such approaches foster participatory environments where community members actively engage in hazard preparedness, leading to improved communication, behavior change, and a robust capacity to respond to and recover from disasters [24, 18, 14]. Public disaster preparedness participation is inherently linked to social participation, as community involvement is crucial for establishing robust networks that effectively manage disaster risks.

Social capital is foundational to community resilience, where the structural and socio-cultural dimensions of social networks facilitate resource and information sharing during crises [11]. However, the dual nature of online networks can both enhance and undermine social capital, complicating these interconnections. The underutilization of digital traces in empowering civil participation and strengthening social structures further complicates these dynamics [16]. Effective communication

and stakeholder involvement are vital to bridging these gaps, ensuring community resilience efforts are inclusive and comprehensive [2].

Integrating public participation into community resilience frameworks is essential, enhancing the community's disaster response capabilities by considering diverse attributes such as race, income, and housing type, which correlate with the likelihood and duration of power outages [5]. This necessity underscores the importance of equity in resilience planning, where the interplay among community response, dispatcher roles, and emergency medical services forms critical interconnections in survival chains [9]. The absence of comprehensive community resilience models that account for physical and socio-economic components during disaster impacts and recovery phases remains a core challenge [8].

Addressing this gap requires understanding how socio-demographic data and built environment factors influence community responses and recovery processes, thereby enhancing resilience planning [25]. Moreover, the emotional and symbolic aspects of individuals' experiences, often overlooked in existing methods, are crucial for a deeper understanding of community-focused research [1]. The survey highlights the interconnections between older adults' technological experiences and their active participation in safety during crises [6].

Aligning the intentions of researchers and practitioners with community needs poses a significant challenge in digital civics, essential for ensuring that digital tools effectively support community resilience initiatives [15]. Additionally, technological challenges such as network loss, latency, and mobile device limitations can hinder user immersion and interaction, impacting digital solutions' effectiveness in disaster preparedness [26].

Recognizing and leveraging these interconnections enables communities to develop comprehensive and adaptive disaster preparedness strategies that foster resilience and ensure effective responses to future emergencies. Community sampling, for instance, is an effective strategy in healthcare resource management during pandemics, underscoring the importance of data-driven methodologies in addressing complex disaster scenarios [17]. Furthermore, challenges in earthquake engineering, such as the need for large, high-quality labeled datasets and deep learning model interpretability, highlight technology's critical role in enhancing disaster response and preparedness [7].

## 2.3 Social and Governance Dimensions

The social and governance dimensions of disaster preparedness and community resilience are pivotal in shaping effective emergency responses, necessitating collaboration among diverse stakeholders, including government agencies, community organizations, and the public. This collaboration is crucial for developing intelligent infrastructure systems that enhance disaster management capabilities [13]. However, challenges like bureaucratic inefficiencies, exemplified by the Sewol ferry disaster, illustrate the need for governance models prioritizing efficiency and accountability while minimizing hierarchical impediments [27].

Social dynamics, particularly cooperation among individuals, significantly influence community resilience, affecting recovery and adaptation capacities during crises [28]. Disparities in disaster preparedness awareness, especially among lower socioeconomic groups, pose challenges to equitable participation in preparedness activities [29]. The chaotic nature of disaster environments and risks to citizen scientists further complicate the integration of citizen science activities with official emergency response functions [18].

Integrating digital health technologies into disaster preparedness frameworks presents both opportunities and challenges. While these technologies can enhance information sharing and response coordination, issues such as interoperability, data privacy, and timely dissemination of accurate information remain significant hurdles [30]. Moreover, the rapid pace of AI development outstripping safety measures adds uncertainty to its emergency preparedness capabilities [31].

Health systems face specific challenges in addressing rehabilitation needs during emergencies, including under-resourced systems and misconceptions about rehabilitation timing [32]. These challenges emphasize the need for a more integrated approach to healthcare within disaster preparedness frameworks, highlighting the interdependence of health systems and community resilience [12].

Supply chain management and service continuity are critical governance issues, as disruptions can severely impact public health and safety [33]. Understanding spatial spillover effects in recovery

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strategies allows for more targeted recovery efforts [34]. Additionally, standardized data interfaces and reporting practices are essential for improving public health responses during emergencies [35].

Community engagement techniques encounter challenges due to a lack of systematic evaluation methods and difficulties in measuring their impact across various methodologies and contexts [14]. Effective regulation and policy frameworks, alongside technology utilization, are necessary to overcome barriers in evacuation and transportation processes during disasters [36]. Furthermore, structural weaknesses in health systems, community mistrust, and complex social dynamics can hinder compliance with health measures [37].

By addressing these social and governance dimensions, communities can develop more resilient and adaptive disaster preparedness strategies that are inclusive, equitable, and effective in mitigating emergency impacts. This involves recognizing the complex interactions between physical, social, and economic infrastructures and coordinating efforts to address these interactions within resilience research [38].

## 2.4 Technological and Informational Aspects

Integrating technology and information management is pivotal for enhancing disaster preparedness and response. Advanced technological solutions, such as supercomputing-enabled deployable analytics, allow for prestaging analytics as offline files, providing a significant advantage over traditional cloud-based systems that require constant network access [39]. This capability ensures critical data and insights remain available in scenarios where connectivity is compromised, enhancing disaster response resilience.

Organizing current methods into stages of preparedness—including planning, training, and response evaluation—is crucial for effectively integrating healthcare systems and public health departments in disaster scenarios [40]. This structured approach facilitates seamless coordination across sectors, ensuring optimal resource allocation and effective response strategy implementation.

The performance of social network sensors in real-time disaster scenarios is a key focus area, with benchmarks incorporating sentiment analysis to gauge public emotional responses [41]. Real-time social media data analysis provides valuable insights into public sentiment and behavior, enabling emergency responders to tailor communication and intervention strategies accordingly.

GeoGraphVis represents a significant advancement in cyberinfrastructure solutions, leveraging knowledge graph technology and advanced visualization to support disaster response and humanitarian aid [42]. This technology enables intelligent decision-making by providing a comprehensive view of the disaster landscape, facilitating the identification of critical areas requiring immediate attention.

The application of deep learning-based methods for resource allocation and recovery planning in infrastructure networks demonstrates significant potential for optimizing disaster response efforts [43]. By analyzing complex data sets, these methods can predict resource needs and inform strategic planning, ensuring resources are directed where most needed.

Distributed learning techniques, which analyze temporal changes in sensor data, enhance situational awareness for disaster response [44]. This approach allows for continuous environmental monitoring, enabling responders to adapt strategies in real-time to evolving circumstances.

The development of a Smart Citywide Intelligent Emergency Interactive Response System, utilizing AI and machine learning, exemplifies the potential of smart city technologies to enhance emergency preparedness and response [45]. Such systems can automate decision-making processes, streamline communication, and improve overall emergency management efficiency.

Autonomous flying robots, particularly UAV swarms, are highlighted for their role in improving situational awareness during disasters [46]. These technological innovations provide real-time aerial surveillance, offering critical insights into disaster-affected areas and aiding response coordination.

Collectively, these technological and informational advancements underscore the importance of integrating cutting-edge technologies and robust information management systems in disaster preparedness and response. By employing a diverse set of community engagement tools and strategies, including face-to-face interactions and advanced technologies like AI and social media, communities can significantly bolster their resilience against emergencies. These approaches enhance resource allocation and coordination among stakeholders while facilitating timely and effective disaster re-

sponses, ultimately improving preparedness and recovery efforts in the face of natural hazards and public health threats [12, 19, 47, 14].

In recent years, the importance of effective disaster preparedness has gained increasing recognition, particularly in the context of public safety and community resilience. A comprehensive understanding of the factors influencing public participation in disaster preparedness is essential for developing effective strategies. Figure 2 illustrates the hierarchical structure of public disaster preparedness participation, highlighting the role of government initiatives, community engagement, and technological innovations in enhancing resilience and response capabilities. This figure serves to underscore the interconnectedness of these elements and their collective impact on improving preparedness outcomes. By examining these relationships, we can better appreciate the complexities involved in fostering a proactive approach to disaster management.
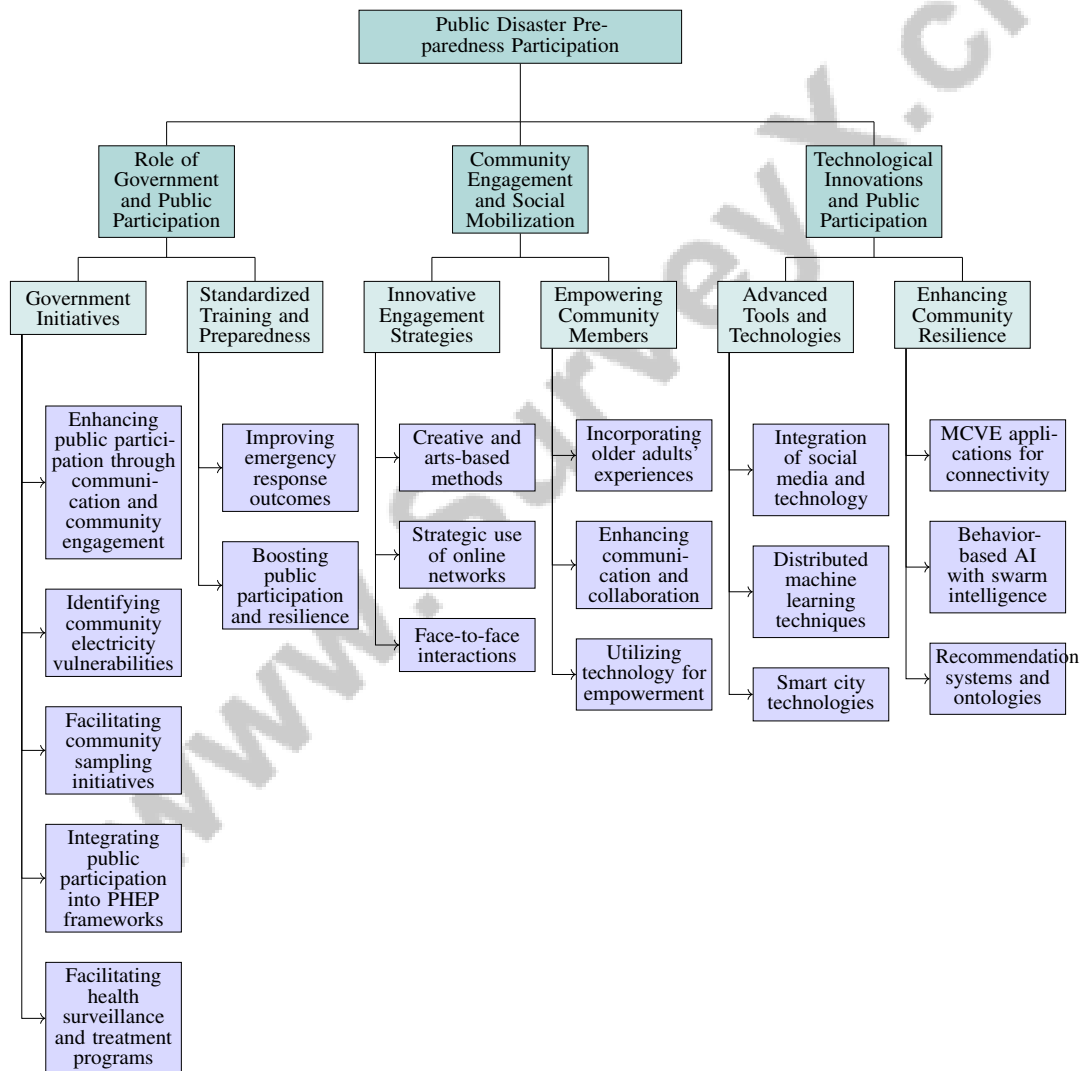


Figure 2: This figure illustrates the hierarchical structure of public disaster preparedness participation, highlighting the role of government initiatives, community engagement, and technological innovations in enhancing resilience and response capabilities.

# 3 Public Disaster Preparedness Participation

## 3.1 Role of Government and Public Participation

Governmental roles in disaster preparedness are pivotal, focusing on enhancing public participation through effective communication, vulnerability assessments, and community engagement strategies. Establishing robust communication networks is essential for timely information dissemination during disasters, thereby boosting public awareness and preparedness [2]. Government-led initiatives, such as identifying community electricity vulnerabilities, ensure readiness for power disruptions during emergencies [3]. Local news outlets, operating within government frameworks, play a crucial role in informing the public about preparedness measures, as evidenced during the COVID-19 pandemic [5]. Entities like NHS Lothian have facilitated community sampling initiatives critical for managing public health emergencies [17].

Governments must integrate public participation into comprehensive frameworks for public health emergency preparedness (PHEP) [4]. The use of digital traces for civil empowerment underscores the importance of government intervention in enabling citizen participation in disaster preparedness activities [16]. The Value-Focused Thinking approach by Suresh et al. aligns community resilience measurement with decision-making processes, emphasizing government involvement in addressing community leaders' priorities during disasters [8]. Additionally, governments are vital in facilitating health surveillance and treatment programs post-disaster [9].

Standardized training and preparedness initiatives across sectors, driven by government efforts, aim to improve emergency response outcomes [10]. Implementing these strategies significantly enhances public participation in disaster preparedness, fostering resilient communities capable of effective response and recovery.

## 3.2 Community Engagement and Social Mobilization

Community engagement and social mobilization are critical for empowering communities to participate actively in emergency planning and response. Creative and arts-based methods provide innovative avenues for engaging community members in participatory research, enriching insights into resilience and preparedness [1]. These approaches are particularly effective with older adults, whose experiences enhance community resilience during emergencies [6].

Online networks, when strategically used, can enhance communication and collaboration among community members, although they may also undermine ties [48]. Interventions that improve communication and perceptions of emergency care are vital for fostering community engagement, especially in healthcare settings [49]. Updating risk models and integrating community engagement into risk management strategies are essential for keeping communities informed and prepared for disasters [50]. Comprehensive emergency response plans enhance collaboration between emergency services and workplaces for coordinated disaster responses [10].

By leveraging the strengths of community members, including vulnerable groups like older adults, and implementing innovative engagement strategies, communities can build robust networks that significantly improve preparedness, resilience, and recovery capabilities. This approach fosters local knowledge and relationships while utilizing technology to empower older adults, ensuring they have the necessary tools for effective crisis response. Diverse community engagement techniques, particularly face-to-face interactions, enhance preparedness and resilience, requiring disaster management agencies to adopt multifaceted strategies engaging all community members [18, 38, 6, 14, 8]. These efforts highlight the importance of tailored communication, local involvement, and strategic use of digital tools in fostering resilient communities.

## 3.3 Technological Innovations and Public Participation

Technological innovations significantly enhance public participation in disaster preparedness by providing advanced tools for communication, decision-making, and resource allocation. The integration of social media and technology is crucial for improving communication channels during disasters, enabling real-time information sharing and community engagement [2]. This was demonstrated by the rapid mobilization of testing resources through community sampling, which proved more effective than traditional hospital sampling in managing public health emergencies [17].

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Distributed machine learning techniques enhance situational awareness by identifying behavioral changes from temporal data, thereby improving disaster response strategies [44]. The '5S' framework categorizes social resilience into five dimensions, emphasizing social capital's role in fostering resilient communities [21]. Technological integration enhances dispatcher-assisted CPR, improving community response in emergencies through advanced communication technologies [51]. Smart city technologies, such as advanced sensors and V2X technology, optimize emergency response actions across urban environments [45].

Innovations in mobile computing and peer-to-peer networking have led to MCVE applications that enhance connectivity and data sharing in disaster scenarios [26]. Additionally, incorporating artistic expression into data collection enriches understanding of community resilience and engagement [1]. Integrating behavior-based AI with swarm intelligence enables UAVs to autonomously adapt to environments and optimize search patterns, enhancing public participation in disaster preparedness [46]. UAVs provide real-time aerial surveillance, offering critical insights into disaster-affected areas and aiding in response coordination.

Technological innovations, including recommendation systems and ontologies, facilitate better understanding and navigation of participatory resources, enabling communities to engage more effectively in disaster preparedness activities [16]. Applying deep learning techniques in earthquake engineering illustrates the potential for vision-based seismic damage assessment and community resilience enhancement [7]. These technological advancements underscore technology's transformative potential in enhancing public participation in disaster preparedness. By utilizing innovative tools and methodologies, communities can significantly bolster resilience, becoming more adept at preparing for, responding to, and recovering from emergencies. Effective community engagement strategies, particularly face-to-face interactions, are crucial for fostering preparedness and social cohesion. Integrating technology, strengthening partnerships, and developing trained personnel are essential for building robust emergency response systems, especially in rural and underserved areas. A multifaceted approach combining these elements will better prepare communities to anticipate and manage the impacts of natural hazards and public health crises [12, 18, 14].

# 4 Social Participation and Community Emergency Teams

## 4.1 Role of Social Participation in Disaster Preparedness

Social participation is crucial for enhancing disaster preparedness and fostering community resilience by engaging diverse community members, including marginalized groups and individuals with disabilities, to ensure inclusive strategies [4]. The dynamic frameworks of social participation emphasize the importance of integrating social and economic factors in resilience-building efforts [38]. Community testing initiatives, such as those during the COVID-19 pandemic, illustrate the effectiveness of social participation in managing public health emergencies, underscoring the role of health surveillance and treatment programs in post-disaster scenarios [17, 9].

Social capital enhances communication and resource sharing, strengthening community responses to disasters [2]. Strategic utilization of digital tools further empowers civil engagement, enabling active community participation in preparedness activities [16]. By increasing awareness of community needs and developing participatory frameworks, social participation significantly boosts citizen engagement and resilience [15].

Understanding risk perception and public behavior is essential for effective disaster management. Tailored strategies that align with community needs foster a culture of preparedness, equipping communities to face future challenges. Leveraging social media, crowdsourcing, and participatory frameworks enhances community capabilities to prepare for, respond to, and recover from disasters. This collaborative approach facilitates vital information sharing among stakeholders, fostering community engagement and leading to enhanced resilience and robust societal structures. Research highlights that effective community engagement techniques, particularly face-to-face interactions, are vital in increasing preparedness and driving community-led initiatives, thereby strengthening societal resilience against future hazards [14, 38, 19].

## 4.2 Formation and Impact of Community Emergency Teams

Community Emergency Teams (CETs) are pivotal in enhancing disaster response capabilities through structured formation and strategic deployment during emergencies. Their establishment involves collaborative processes that incorporate community input, local government support, and best practices from disaster management frameworks. Typically composed of trained volunteers familiar with their community's vulnerabilities and resources, CETs effectively respond to local emergencies [51].

CETs significantly impact disaster response by fostering a culture of preparedness and collective action. They bridge the gap between professional emergency responders and the community, facilitating efficient communication and coordination during crises [10]. By leveraging local knowledge and resources, CETs provide immediate assistance, conduct initial damage assessments, and support evacuation efforts, reducing the burden on formal emergency services and improving response times [2].

CET involvement in disaster preparedness activities, such as community drills and educational workshops, heightens public awareness and encourages proactive participation in resilience-building initiatives. This engagement strengthens community ties and equips residents to handle emergencies, ultimately contributing to the development of more resilient communities [6].

Integrating technology into CET operations amplifies their impact, with digital platforms facilitating real-time communication and coordination among team members and external agencies. This technological enhancement allows CETs to adapt swiftly to changing conditions and optimize response strategies, effectively addressing community needs during disasters [16].

## 4.3 Benefits of Social Networks in Enhancing Resilience

Social networks are vital for bolstering community resilience, serving as platforms for engagement, information dissemination, and resource optimization during disasters. They foster strong community ties and facilitate efficient communication, particularly benefiting vulnerable groups such as older adults during crises [6]. By enhancing information flow and collaboration, social networks enable communities to respond more effectively to emergencies, ensuring that diverse needs are addressed.

The integration of social media into disaster preparedness strategies significantly enhances resilience by enabling real-time communication and rapid dissemination of critical information. These platforms engage citizens in disaster response efforts, fostering a sense of ownership and community involvement essential for effective preparedness and recovery. To maintain public trust and combat misinformation, governments must manage the content and emotional tone of social media communications, ensuring they are timely, relevant, and emotionally resonant, as these factors influence citizen engagement and the public's understanding of government actions during emergencies [2].

Analyzing community characteristics through social networks provides valuable insights into resilience metrics, aiding in predicting community wellbeing outcomes during crises. This comprehensive understanding allows for the development of customized strategies targeting identified vulnerabilities, significantly improving community preparedness, response, and recovery capabilities. Employing a value-focused approach enables these strategies to incorporate measurable attributes across social, economic, and infrastructure domains, ultimately enhancing community resilience against natural and human-caused hazards [12, 38, 8].

# 5 Disaster Response Behavior

## 5.1 Individual and Collective Actions in Disaster Scenarios

Disaster preparedness and response efficacy relies heavily on both individual and collective actions, shaped by emergency responders' knowledge, technological tools, and decision-making frameworks. Advanced technologies, such as supercomputing-enabled analytics, facilitate informed decision-making by providing critical demographic data offline, crucial during internet outages [39]. The use of heterogeneous robots, including UAVs, enhances situational awareness and search and rescue operations, while tools like GeoGraphVis enable rapid decision-making through intuitive data presentation [42]. These capabilities are essential for efficient resource allocation in emergencies.

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Effective communication categorizes emergency messages into stages, ensuring coordinated responses, particularly in public health crises where transitioning to fit-for-purpose responses demands improved digital infrastructure and international collaboration [30]. Understanding population recovery patterns, typically following a negative exponential function, aids in minimizing displacement and enhancing recovery. The Value-Focused Thinking approach supports decision-making in emergency preparedness, bolstering community resilience [8].

These insights underscore the importance of leveraging technology, fostering robust communication, and employing comprehensive frameworks to enhance preparedness and resilience. This multifaceted approach not only facilitates effective disaster responses but also encourages active community engagement, equipping stakeholders to manage risks and recover swiftly. Integrating face-to-face engagement with advanced technologies, such as AI and social media, empowers communities to optimize resource utilization, safeguarding public health and safety [13, 47, 19, 12, 14].

## 5.2 Factors Influencing Response Behavior

Disaster response behavior is influenced by policy frameworks, technological access, psychological responses, and community dynamics. Public perception of risk often leads to discrepancies between awareness and proactive mitigation, highlighting the need for educational initiatives to enhance understanding and participation in preparedness [52]. Urban emergency systems often focus on damage recovery over prevention, necessitating adaptability to improve outcomes [45].

Technological integration, particularly through Social Media and Crowdsourcing Systems (SMCS), offers both opportunities and challenges. While enhancing information dissemination and engagement, challenges in integration and access remain. Research shows face-to-face interactions are more effective than mass media in boosting preparedness, though effectiveness varies by context [13, 14]. A strategic approach combining diverse methods and intelligent infrastructure is essential for enhanced disaster management and resilience.

Policy frameworks significantly impact response behavior. Inadequate policies, training, and support can hinder volunteers' contributions, delaying responses. Bureaucratic inefficiencies prioritize hierarchical accountability over professional urgency, as seen in the Korea Coast Guard's response to the Sewol ferry disaster [27, 53, 2, 54].

The psychological impacts of disasters, such as anxiety and trauma, affect response behavior. Enhancing resilience and addressing psychological challenges require supportive environments and resources, especially in rural and underserved areas. Strategies like strengthening partnerships, workforce development, technology investment, social cohesion, and coordinated emergency plans are vital for building public health resilience [12, 8].

## 5.3 Challenges in Effective Disaster Response

Effective disaster response faces challenges that impede timely action and affect community resilience. Inadequate identification and monitoring of exposed populations create gaps in response efforts, hindering essential services [9]. Timely health assessments post-disaster are crucial for understanding impacts and mobilizing resources.

The complexity of disaster environments requires effective coordination among stakeholders, complicated by the sudden onset and varying severity of disasters. Social media and crowdsourcing enhance resilience and facilitate information sharing, though the chaotic nature often leads to miscommunication and delays. Robust communication frameworks are needed for clear exchanges [2, 19].

Technological limitations pose obstacles to effective response. While innovations improve capabilities, reliance on digital infrastructure can be problematic when connectivity is compromised. Offline analytics and decision-making tools maintain operational efficiency, as demonstrated during the COVID-19 pandemic [39, 55, 42, 56].

Bureaucratic inefficiencies and rigid governance structures hinder rapid decision-making, as seen in the delayed response during the Sewol ferry accident. These constraints prioritize political accountability over professional responsibility, exacerbating challenges [27, 2]. Streamlining governance for flexibility and responsiveness is critical.

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Psychological and social dynamics influence response effectiveness, shaping resilience, risk perception, and information exchange. Understanding these dynamics is essential for improving strategies, as they affect engagement and recovery [19, 52, 57, 2, 58]. Trauma and anxiety can hinder engagement, necessitating supportive interventions to promote resilience.

Addressing challenges in rural and underserved communities requires a comprehensive strategy integrating advanced technologies, governance structures, and health assessments, focusing on partnerships, workforce training, and community engagement to enhance resilience and public health crisis response [12, 35, 59, 30].

# 6 Community Resilience and Emergency Preparedness

## 6.1 Defining Community Resilience and Emergency Preparedness

Community resilience refers to the capacity of communities to withstand, adapt, and recover from various hazards by integrating social, economic, and infrastructural dimensions. This is vital in public health systems, where a complex adaptive systems approach enhances preparedness and response to diverse threats [4]. Effectively managing patient care within community settings is essential to prevent health systems from becoming overwhelmed during emergencies [17].

The integration of participatory data using semantic criteria and recommendation systems bolsters community resilience by facilitating informed decision-making and engagement [16]. The role of older adults in mutual support, aided by crisis informatics tools, underscores the need for inclusive resilience strategies that cater to vulnerable populations [6].

Emergency preparedness is closely linked to community resilience, focusing on developing strategies and frameworks that enhance a community's capacity to respond to and recover from emergencies. This involves creating comprehensive emergency response plans and training to ensure effective outcomes [10]. Establishing robust health programs in response to major disasters is a crucial aspect of community resilience, highlighting the importance of proactive preparedness measures [9].

Deep Learning (DL) methods significantly contribute to community resilience, with Convolutional Neural Networks (CNNs) excelling in vision tasks, Recurrent Neural Networks (RNNs) in sequential data, and Reinforcement Learning (RL) in resilience applications [7]. These technologies support the development of frameworks for assessing community resilience, focusing on outcomes rather than inputs [8].

Economic resilience and community capital shape perceptions of disaster risks, such as hurricanes, with strong institutional frameworks potentially reducing perceived risks [11]. The NELA-Local dataset provides insights into community coverage and information needs, informing resilience strategies by highlighting the role of local news ecosystems in disaster preparedness [5].

## 6.2 Strategies for Building Adaptive Capacities

Enhancing adaptive capacities in communities is crucial for improving resilience and ensuring effective disaster responses. The Sequential Discrete Optimization Approach optimizes recovery actions, providing near-optimal solutions for complex decision-making scenarios, particularly in resource-limited settings [60].

The integration of Probabilistic Multi-Hazard Risk Assessment (PMHRA) is another strategy, accounting for interactions between different hazards and providing a comprehensive framework for risk management and resilience planning [50]. This approach helps communities understand the compounded effects of multiple hazards and devise strategies to address these complexities.

Strong social networks are essential for building adaptive capacities, offering psychological and material support during crises [61]. By fostering robust social connections, communities enhance their collective resilience, ensuring members receive support during emergencies.

Incorporating occupant activity simulations and demographic assessments into resilience planning is effective [3]. Understanding the spatial-temporal dynamics of community activities and demographics allows planners to develop targeted interventions addressing specific vulnerabilities.

Deep learning techniques in earthquake engineering improve adaptive capacities through enhanced data accessibility and model interpretability [7]. Identifying suitable DL techniques for specific challenges can lead to more accurate damage assessments and effective disaster response strategies.

Employing evidence-based strategies enhances adaptive capacities, improving disaster response and fostering long-term resilience and recovery. Factors such as median income, population size, and housing damage rates significantly influence recovery dynamics, indicating that tailored community engagement and preparedness initiatives effectively address vulnerabilities. Engaging communities through diverse techniques, particularly face-to-face interactions, increases preparedness and promotes proactive recovery measures, contributing to a more resilient societal framework in the face of hazards [38, 57, 14].

## 6.3 Technological and Data-Driven Approaches

Technological and data-driven approaches are vital for enhancing community resilience, offering innovative solutions for disaster preparedness and response. Intelligent infrastructure systems, as noted by Dunaway et al., significantly improve disaster management capabilities by integrating advanced technologies to support real-time decision-making and situational awareness [13]. These systems facilitate seamless information flow, enabling swift community responses to emergencies.

The Fuzzy Logic method, integrated into the PEOPLES framework, provides a nuanced assessment of community resilience by capturing the complexity and uncertainty inherent in disaster scenarios [62]. This approach allows for a comprehensive understanding of resilience metrics, informing targeted interventions to enhance preparedness and adaptive capacities.

Social network sensors offer insights into the speed of information dissemination and the emotional impact of disasters on social media users, demonstrating the potential of data-driven approaches to improve community resilience [41]. Analyzing social media data enables communities to better understand public sentiment and behavior, leading to more effective communication and engagement strategies during crises.

GeoGraphVis enhances situational awareness and decision-making in disaster response by integrating and visualizing diverse datasets, supporting informed interventions [42]. This technology helps responders identify critical areas requiring attention, facilitating efficient resource allocation and coordination among emergency services.

Deep learning-based resource allocation methods capture both linear and nonlinear relationships in data, enabling accurate predictions of restoration strategies based on complex interdependencies [43]. This approach optimizes disaster response efforts by informing strategic planning and ensuring resources are directed where most needed.

Collaborative heterogeneous robots allow for real-time data processing and improved situational awareness, enhancing disaster response strategies [44]. These innovations enable responders to adapt swiftly to changing conditions, equipping communities to handle emergencies effectively.

The proposed evacuation management framework integrates real-time data to enhance coordination among emergency services, improving response times and ensuring efficient disaster management [45]. Leveraging smart city technologies streamlines communication and optimizes emergency response across various urban scenarios.

UAV swarms exemplify a data-driven approach to community resilience in disaster response, achieving over 90

These technological and data-driven approaches underscore the transformative potential of advanced technologies in enhancing community resilience. By utilizing diverse community engagement tools, including face-to-face interactions, disaster citizen science initiatives, and social media platforms, communities can significantly improve emergency preparedness, facilitate effective responses during crises, and ultimately build a stronger, more resilient society capable of adapting to and recovering from various hazards [12, 19, 18, 14].

# 7  Case Studies and Examples

## 7.1  Lessons from Major Disasters

Analyzing significant disasters yields insights into preparedness strategies and innovative approaches that enhance community resilience. Case studies such as the Italian earthquake and the Dutch industrial disaster illustrate the practical use of Social Media and Crowdsourcing Systems (SMCS) in disaster scenarios, proving essential for information dissemination and community engagement [19]. The Italian earthquake underscored the need for robust communication infrastructures, with digital platforms facilitating emergency coordination and resource mobilization, thereby strengthening resilience [55, 53, 19]. Similarly, the Netherlands disaster highlighted the integration of technological solutions with traditional practices, where SMCS improved data collection and analysis, enhancing collaboration and resilience [39, 63, 2, 19]. The LINKS Horizon 2020 project exemplifies the potential of these technologies in refining disaster response strategies. These cases emphasize the importance of adaptive preparedness strategies that harness technological innovations to enhance resilience against natural hazards and public health emergencies [13, 12, 18, 38, 14]. By learning from past disasters, communities can refine preparedness plans, integrating SMCS and technological innovations into disaster management practices to foster more resilient societies.

## 7.2  Comparative Analysis of Recovery Patterns

Comparative analysis of recovery patterns offers insights into resilience and effective disaster recovery factors. Recovery trajectories are shaped by socio-economic and infrastructural factors, with social networks and community capital playing pivotal roles in resource sharing and support systems [61]. Economic resilience and community capital significantly impact perceptions of disaster risks and recovery efforts [11]. Communities with robust economic frameworks and institutional support efficiently manage recovery processes. Technologies like GeoGraphVis enhance situational awareness and informed decision-making during recovery [42], while deep learning-based resource allocation methods optimize recovery efforts by predicting restoration strategies [43]. Digital platforms and social media facilitate communication and engagement, enabling real-time information sharing and enhancing coordination during disaster management. By leveraging these platforms, communities engage in collaborative problem-solving and fortify resilience against hazards, leading to efficient disaster recovery [13, 47, 19, 55, 56].

## 7.3  Integration of Community Resources and Infrastructure

Integrating community resources and infrastructure is crucial for effective disaster preparedness, enhancing response capabilities. This involves aligning local resources like health facilities, transportation, and communication networks to function cohesively during disasters, ensuring continuity of care and service delivery [10]. Developing resilient infrastructure, such as fortified hospitals and shelters, is vital for operational continuity during disasters [9]. Advanced technologies, like smart city solutions and intelligent infrastructure systems, enhance disaster management by providing real-time data and facilitating efficient resource allocation [13]. Community engagement fosters collaboration among stakeholders, leveraging local knowledge and expertise to tailor preparedness strategies to specific community needs [6]. Social networks enhance resource and infrastructure integration by facilitating trust-building, participation, and communication, essential for addressing climate change adaptation and disaster resilience. Initiatives like community gardens foster collaboration, improving urban resilience and resource management during crises [16, 19, 55, 64, 48]. Strong social ties and communication channels enhance resilience, ensuring coordinated and efficient disaster response.

# 8  Challenges and Opportunities

## 8.1  Challenges and Opportunities in Social Participation

Enhancing social participation in disaster preparedness involves addressing significant challenges and leveraging opportunities for inclusive community engagement. A critical issue is the disconnect between physical infrastructure resilience metrics and socio-economic systems, leading to inadequate assessments of community resilience [38]. This gap necessitates comprehensive approaches that consider the dynamic interplay between social and physical systems.

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Vaart et al. identified challenges in participant recruitment and retention, essential for fostering social participation in disaster preparedness [1]. These challenges are compounded by individuals' reluctance to engage with social structures, complicating effective communication and resource utilization [16]. The prevalence of hate speech in online networks further erodes social trust, hindering collective engagement [48].

Technological barriers persist, such as insufficient research on integrating mobile peer-to-peer networks with MCVE applications in real-time scenarios [26]. The need for high-quality labeled datasets and issues regarding model interpretability in safety-critical applications complicate the enhancement of disaster preparedness through technological innovations [7].

Staffing and training challenges in PPE protocols affect social participation in community testing efforts, particularly during public health emergencies [17]. Additionally, current methods often overlook the dynamic nature of occupant activities affecting electricity demand, influencing community engagement strategies [3].

Despite these challenges, significant opportunities exist to enhance social participation in disaster preparedness. The Value-Focused Thinking (VFT) approach emphasizes outcomes resonating with community leaders, providing actionable insights for resilience improvement [8]. Addressing gaps in understanding older adults' experiences with technology can enhance their participation in preparedness activities [6]. Moreover, discerning authentic intentions and validating community perspectives are crucial for ensuring sustainable benefits following project engagement [15].

While challenges like the lack of standardized procedures across countries persist, opportunities for developing standardized training programs also arise [10]. A significant challenge remains the absence of statistically rigorous investigations into community-level risk perceptions, especially in aggregating individual perceptions into coherent measures [11].

By leveraging these opportunities and addressing challenges, communities can cultivate more inclusive and effective disaster preparedness strategies. This involves fostering partnerships, utilizing face-to-face communication techniques, and harnessing local knowledge to empower vulnerable populations in responding to and recovering from disasters [12, 65, 14].


## 8.2 Policy and Organizational Challenges

Policy and organizational challenges significantly influence disaster preparedness and resilience, often complicating efforts to enhance community readiness and response capabilities. A primary policy challenge is the endogeneity associated with online networking, complicating the differentiation of its effects on social capital from other influencing factors [48]. This complexity necessitates policies that leverage digital platforms effectively while addressing their limitations.

Another critical policy issue involves the reliability of communication systems during crises, as noted by Moorthy et al., which can impede effective disaster response and coordination efforts [2]. The difficulties in maintaining up-to-date communication channels, such as RSS feeds for local news, hinder the timely dissemination of essential information for public awareness and preparedness [5].

In public health, translating disaster preparedness frameworks into measurable indicators poses a significant policy challenge, affecting public health agencies' ability to promote and implement strategies effectively [4]. Additionally, gaps in data collection and follow-up limit the understanding of long-term health effects post-disaster, constraining the development of informed policy measures [9].

Organizational challenges also arise from the operational limitations of technologies used in disaster response. For instance, the reliance of UAVs on battery life presents a significant hurdle, impacting the continuity and effectiveness of disaster response operations [46]. This limitation necessitates organizational strategies to ensure alternative power sources or enhanced battery technologies to support sustained UAV operations.

The multifaceted nature of hurricane-related risks, extending beyond wind and storm surge to include heavy rainfall, underscores the need for comprehensive policy frameworks addressing these diverse elements [11]. Current studies and policies often fail to capture this complexity, resulting in inadequate risk assessments and preparedness measures.

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Effectively addressing these policy and organizational challenges can significantly enhance disaster preparedness and resilience. This improvement can be achieved through fostering community engagement, strengthening partnerships, investing in technology and infrastructure, and developing coordinated emergency plans. Such strategies enable communities to implement adaptive responses to future emergencies, leading to more efficient management of natural hazards and public health crises [12, 14]. This involves fostering collaborative approaches, standardizing data practices, and integrating technological advancements into existing frameworks to build a more resilient society.

### 8.3  Data and Communication Challenges

Data and communication challenges pose significant barriers in disaster preparedness, impacting the efficiency and effectiveness of emergency responses. A critical challenge is the reliance on pre-computed data, which may not accurately reflect real-time changes in demographics or emergencies, limiting the responsiveness of disaster preparedness strategies [39]. This underscores the need for dynamic data systems capable of adapting to evolving conditions and providing timely insights for decision-makers.

Reliable communication during disaster preparedness is another major challenge, as discussed by Moorthy et al. Unreliable communication systems can severely hinder disaster response efforts, obstructing the dissemination of critical information to affected populations and emergency responders [2]. This issue is further complicated by the intricacies of social networks, which necessitate enhanced semantic navigation enriched with complex networks and natural language processing to facilitate effective communication [16].

Moreover, clear communication regarding safety measures in emergency departments is crucial for maintaining patient trust, as emphasized by Wong et al. [49]. The absence of clear and consistent communication can lead to confusion and mistrust among patients, undermining emergency response effectiveness and potentially exacerbating disaster impacts.

The underrepresentation of socio-cultural dimensions in existing studies further complicates data challenges, leading to incomplete understandings of social capital dynamics within communities during crises [61]. This gap highlights the necessity of incorporating diverse socio-cultural perspectives into disaster preparedness frameworks to ensure comprehensive and inclusive strategies.

Addressing these data and communication challenges requires robust, real-time data systems and reliable, culturally sensitive communication frameworks. By effectively tackling these challenges, communities can significantly improve their disaster preparedness and response capabilities, leading to swifter and more efficient emergency management. This enhancement can be achieved through various strategies, including community engagement, integration of local knowledge, and technology utilization, collectively fostering resilience and ensuring timely, well-coordinated responses [12, 36, 18, 14].

## 9  Conclusion

Public disaster preparedness participation emerges as a cornerstone for bolstering community resilience, underscoring the role of social networks and community emergency teams in enhancing disaster response and resource management. Technological innovations, particularly in intelligent infrastructure, are pivotal in fostering real-time decision-making and situational awareness. The exploration of Fuzzy Logic methods as decision-support tools calls for ongoing refinement to enhance their precision and applicability.

Challenges persist in integrating rehabilitation into health emergency planning to improve long-term outcomes and addressing the psychological effects of emergency drills on vulnerable groups. The complexity of multi-hazard preparedness, such as combining flood and earthquake readiness, requires further investigation for comprehensive risk management. Routine incorporation of disaster preparedness into planning processes is crucial for strengthening community resilience and improving response capabilities.

Future research should focus on establishing ethical frameworks for digital civic engagement and exploring community empowerment through interdisciplinary collaboration. Addressing participant retention and accessibility, alongside enhancing community engagement, remains a priority. Addition-

ally, improving mobile routing protocols and exploring hybrid peer-to-peer and MANET technologies are essential for advancing preparedness strategies. The scalability of community testing and the development of standardized PPE protocols also require attention.

Validating preparedness frameworks in diverse contexts, including Indigenous communities, and effectively measuring resilience are critical research areas. Developing crisis informatics tools tailored to older adults can enhance their engagement and resilience. Further, exploring multimodal datasets, model interpretability, and physics-informed deep learning methods can improve disaster response strategies. Integrating diverse community values into decision-making frameworks could enrich the process.

Research should also aim to integrate mental and physical health services to improve emergency preparedness strategies. Collaboration between emergency services and workplaces, alongside innovative preparedness approaches, is vital. Future studies should examine the dynamic interplay among contextual risks, community resilience, and risk perceptions, incorporating cognitive aspects of resilience and expanding the range of environmental risks considered. Addressing these areas can significantly enhance community resilience, enabling effective disaster response and recovery.

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