**REPORT ON IMPROVING DISASTER RESILIENCE IN THE NORTH EASTERN UNITED STATE**

**ABSTRACT**

Climate change‐related natural disasters, including wildfires and extreme weather events, such as intense storms, floods, and heatwaves, are increasing in frequency and intensity. These events are already profoundly affecting human health in the United States and globally, challenging the ability of communities to prepare, respond, and recover.

This paper addresses two critical gaps in the literature:

 (1) what strategies or interventions have been implemented to build or enhance community resilience against climate change‐related natural disasters

 (2) what metrics were used to measure community resilience as an outcome of those strategies or interventions?

This review provides a succinct list of effective interventions with specific health outcomes. Community or state‐level health officials can use the results to prioritize public health interventions

**INTRODUCTION**

Climate change‐related natural disasters, including wildfires and extreme weather events, such as intense storms, floods, and heatwaves, are increasing in frequency and intensity in the Northeastern United States and globally. These events challenge the ability of communities to prepare, respond, and recover, resulting in impacts to both human health and community resilience

Natural disasters and extreme weather events affect the public’s physical or mental health through injury and other trauma, vector‐ borne diseases, heat‐related illness, and illness resulting from reduced air and water quality. Natural disasters impact the overall functioning of a community by over‐ whelming available healthcare and disaster response resources

Interventions designed to reduce the health impacts of natural disasters may focus on the individual, family, or community to build and enhance community resilience. Here, we define community as a group of individuals who are linked together by shared geographical space, situations, or interests, and collectively engage in action

The Northeastern United States contain some of the largest metropolitan areas, including New York City, and the three most rural states (Maine, Vermont, and West Virginia), where more than 50% of the populations live in rural areas. The Northeast also exceeds all other regions of the contiguous United States in precipitation intensity, and additional precipitation increases are expected as the climate be‐ comes warmer and wetter. As a result, the projected changes in the climate of the Northeast are expected to increase the exposure, susceptibility, and vulnerability of both urban and rural communities to flooding

**METHODS**

We conducted a review of the published literature to answer our questions about community resilience interventions in the Northeastern United States and the metrics used to measure their success.

**Selection Criteria**

 We used a multiple‐step process for this literature review. We began by exploring the peer‐reviewed literature on community resilience interventions and metrics available through Academic Search Complete, Cochrane Library, PubMed, and Web of Science databases. We searched for studies that

1. evaluated interventions designed to increase community resilience and reduce public health impacts of climate change and associated natural disasters
2. employed metrics to measure community resilience, either as a baseline assessment of the community’s resilience and adaptive capacity, or as a result of the intervention.

We limited our search to studies in English conducted in the Northeast‐ ern and Mid‐Atlantic United States. There were no restrictions on the year of publication. Keyword search phrases included:

 (community resilience) AND (evidence‐based interventions OR measures OR metrics OR assessment) AND (severe or extreme weather Sustainability 2021, 13, 11699 9 of 33 OR natural hazards or disasters) AND (community recovery OR adaptation strategies OR hazard mitigation). “Public health impacts” generated too few studies so the term was removed from the search

The search produced 650 publications. Using the selection criteria described previously, we reviewed the title and abstract of each publication. We excluded duplicate articles, conference papers or books, articles about research outside the Northeastern United States, non‐English articles, and publications unrelated to human health and community resilience.Next, we read each article that met the above criteria and analyzed it for information pertaining to the hazard, the intervention, and the metrics used to measure resilience. Each article was analyzed for the following information:

 (1) Type of climate and/or health impact;

 (2) Target population or community and location;

(3) The method used (intervention, tool development or trial, research study);

(4) The formative metrics used to measure community resilience;

 (5) The summative metrics, or health‐related outcomes;

 (6) Data sources;

 (7) If the data was publicly available (local sources or available online);

 (8) Which of the CDC’s seven national standards were met;

 (9) Author(s) and year

**Results**

 The literature review yielded 24 articles that demonstrated a range of interventions and metrics related to community resilience in the Northeast and Mid‐Atlantic states. Three articles described health and community resilience interventions; eight reported on the development and piloting of community resilience tools; and thirteen dis‐ cussed studies of public health and community resilience. The articles explored a variety of climate and health impacts; however, 50% of the articles examined hurricane resilience, specifically to Super storm Sandy. Five articles addressed the impacts of winter and coastal storms, floods, drought, and heatwaves.

 **Data Sources for All Articles Reviewed**

 In the 24 articles we fully reviewed, data used to measure resilience were collected using qualitative and quantitative methods in a variety of formats, and from a range of publicly available national, county, and municipal sources.

The most commonly used data sources were project participants and online U.S. census data. Half of the 24 projects used participant surveys and interviews to gather data on population demographics and community resilience indicators. Eleven studies accessed online U.S. census data sources for demographics and population distribution. Three projects accessed county‐level U.S. census data and shape files for creating maps. Each article described the use of an assessment tool; however, because the focus of this paper is on applied interventions and tools with metrics to measure community resilience, we eliminated 19 research articles from this review because the tools and interventions described were conceptual and were not applied

 **Articles Meeting the Selection Criteria**

 Five articles met all of our selection criteria. Three articles described intervention frameworks and two reported on tools:

 (1) COAST Project mental health intervention;

 (2) Resilience and Coping for the Healthcare Community (RCHC) mental health intervention;

 (3) Ready CDC community resilience intervention;

 (4) COPEWELL rubric social capital and community engagement assessment tool;

 (5) Garden State community resilience tool. All five interventions or tools were implemented and evaluated

**Evidence‐Based Metrics for the Five Selected Articles**

 The formative and summative metrics used to measure community resilience varied with each intervention or tool. Preparedness and recovery interventions focused on formative metrics such as knowledge, coping skills, and mental health, while the resilience tools measured social connectedness and partnerships, pre‐event planning, and community functioning.

 The summative metrics indicated an increase in community resilience and decreases in mental health impacts associated with Super storm Sandy. All three mental health and community resilience interventions were successful in increasing knowledge related to emergency preparedness and risk reduction. Each project met at least four of the CDC’s seven national standards for community resilience, the COAST intervention was the only project that met all seven.

 **Discussion**

 In our review of the initial 205 articles on community resilience interventions and metrics for the Northeast and the Mid‐Atlantic states, we found 5 articles (2.4%) that dis‐ cussed interventions which had been implemented and evaluated. Our key finding, which supported previous research, was that, despite a plethora of articles on theoretical frame‐ works and community resilience tools, few exist that demonstrate an evaluation of the tools or interventions to measure and build community resilience.

 We located only five articles from the Northeast region that demonstrated an evaluation of the tools or interventions that measure and build community resilience.

The five studies used mental health, behavior change, emergency preparedness, and resilience frameworks to engage communities, build capacity, and enhance resilience; however, more evidence‐base studies are needed to aid public health practitioners in choosing frameworks best‐suited to specific community and climate scenarios. There is a specific need for an evaluation of existing frameworks that study the resilience and post‐disaster recovery of communities affected by climate‐related hazards such as hurricanes and flooding

1. **Evidence‐Based Metrics for Community Resilience: Similarities and Differences**

 An intervention must be evaluated to know if it succeeded in enhancing community resilience. Here, we compare the metrics used to measure community resilience in the five selected interventions and tools:

 (1) COAST Project mental health intervention;

 (2) RCHC mental health intervention;

 (3) Ready CDC community resilience intervention;

 (4) Garden State community resilience tool;

 (5) COPEWELL rubric community engagement assessment tool.

The five selected articles used relatively simple, often low‐cost data collection methods, including participant knowledge, pre and post surveys, semi‐structured interviews, and focus groups.

 The metrics reflected aspects of a resilience domain that could be easily measured, such as the stage of house‐hold preparedness, or the number of community organizations engaged in emergency preparedness initiatives

In contrast, some interventions, tools, and research used more complicated, time-consuming, or costly methods to obtain data, making their use less accessible to local health practitioners and emergency planners. For example, data imported into the Resilience to Emergencies and Disasters Index (REDI) tool to assess neighborhood resilience after Super storm Sandy included access to the 311‐call system for New York City, information on the public transportation systems, hurricane evacuation centers, and access to the census of street trees in the city.

During a pilot of the COPEWELL model for hurricane resilience across the United States, county‐level data were obtained on transportation infrastructure, physical distance to coastlines, socio‐economic information, and social organizations. The study on coastal storm vulnerability for U.S. counties along the Atlantic coast required population distribution data, natural habitat information, historical sea level trends, and coastal topology and elevation data to develop a coastal risk index. Despite most of the data’s availability online, acquiring and processing such data may be time‐prohibitive for local planners and public health agencies. In addition, the development of the Recovery Indicators Tool highlighted the reality that not all data may be available for all metrics, increasing the uncertainty of a tool’s effectiveness in measuring or enhancing community resilience.

Data that are not relevant, including climate change projections, or accessible to local planners in a way that reflects their ability to collect, interpret, or use them, are data that may be misused or not used at all. Relying upon participant‐based and publicly avail‐ able U.S. census data may be the most affordable option for smaller communities with limited financial and personnel resources

1. **Strengths and Weaknesses of Community Resilience Interventions and Tools**

 Study authors and participants critiqued interventions and tools in this review. We discuss those critiques here with the intention of informing development of future interventions. Participants who contributed to the development of the Recovery Indicators Tool, which was created to measure disaster recovery, suggested that the tool was flexible enough to be used for a pre‐disaster assessment, as well as an indicator of post‐disaster recovery. We believe the Ready CDC intervention may also be adapted for pre and post‐disaster assessment, as well as individual and community resilience. Ready CDC combined emergency preparedness education with behavior change theory in a model that could easily be adapted for use by adults in a school, workplace, or community setting.

Authors offered suggestions on what to do with the knowledge gained from the implementation or evaluation of the intervention or tool. For example, community resilience assessment tools would be more beneficial to planners and public health officials if they went beyond a current assessment of the community; additional information could include recommendations for actions that are customized to a community’s needs. This feedback was similar to the request made by participants of the COPEWELL rubric who wanted a tool that could be adapted for municipalities with different resource levels

**Intervention and Tool Development and Deployment Costs and Structures**. We reached out to the authors of seven articles in this review who used surveys, focus groups, and participant interviews for data collection and asked about the costs for the interventions, the hours and staffing structure involved, and any funding they received.

 One author reported that the costs for piloting a disaster recovery assessment tool were $23,000 for supervised graduate student stipends over nine months totaling approximately 280 h. Research included a literature review, two case studies, two focus groups, and 21 interviews with experts from academia, and public and private practice. Multiple research papers resulted from the project.

 The development of a disaster preparedness assessment tool for local health departments incurred nearly $250,000 for each of the first two years for research and development and $50,000 during the third year to develop the toolkit. The piloting of the tool took four months and included a survey of 274 disaster preparedness coordinators from local health departments across the country.

 A post‐disaster mental health intervention that involved two school districts in ten locations took two years to complete. Activities addressed trauma and coping skills and included art therapy, workshops, service learning, and therapy. Full‐time staff included a licensed social worker as program manager and a psychology fellow. Part‐time staff included two social workers, a psychologist, a psychiatrist, a nurse practitioner, and two psychology students. The overall program budget was $1.2 million. Financial support was received from America, the CDC and New York social services school grants.

1. **Community Resilience Interventions and Tools for Severe Weather Events**

 We believe that both of the hurricane‐related interventions that focused on mental health resilience could be applied to other severe weather events, such as flooding or extreme winter storms. The COAST model in particular, because of its institution‐based approach, could be adapted for use in nursing homes, prisons, or the workplace. The interventions were tailored to the target populations and could be adapted for smaller com‐ munities, communities with less resources, and communities from different geographic regions.

 Other severe weather events represented in this review included coastal and winter storms, drought, heat waves, and flooding. Although the tools were not implemented and evaluated to demonstrate their ability to measure or enhance community resilience, many of them could be piloted for localized, severe weather events. For instance, the Fault Tree model, which incorporated road systems data, may identify transportation system vulnerabilities for local planners working to improve recovery and resilience during floods, severe wind events, ice storms, or fires that disrupt accessibility to local road systems. While built on food systems resilience, the model could be applied to emergency supplies or other health‐related resource needs and incorporated into a resilience‐building intervention.

Pre‐planning is paramount to community recovery efforts and resilience during and after an event. A community resilience study in New York after Super storm Sandy found that recovery partnerships formed before an event were more sustainable than partner‐ ships formed during or after an event occurred. Zukowski (2014), in an assessment of community resilience for all U.S. counties, found that response and recovery were improved in communities that incorporated pre‐planning, protocols, exercises, and com‐ munity engagement in the form of education, exercises, and community partnerships. The Assessment for Disaster Engagement with Partners Tool (ADEPT) model could be used as a baseline tool for local planners wanting to assess community partnerships before developing a disaster preparedness and recovery network; higher scores on the assessment indicate more active relationships with community and faith‐based organizations

1. **Gaps in the Literature**

 Our review found several gaps in the literature. First and foremost was the lack of interventions, tools, and metrics that were implemented or evaluated in the New England region. This review located interventions that reflected impacts of hurricanes and floods upon relatively large geographic areas. There is a need for research and interventions to build community resilience in smaller communities with localized disasters, especially for communities that do not qualify for FEMA funding, regardless of disaster impact, due to lower recovery costs or geographical area damaged.

 Our search returned no results of interventions designed to address the health impacts associated with climate‐related hazards and that are increasing in New England: extreme flooding; extreme heat; mental health impacts; and vector‐borne diseases such as Lyme disease [3,79]. We found no interventions that addressed the mental health challenges of multiple events, such as a hurricane followed by flooding followed by a heat wave, or a heavy snow or ice event followed by flooding or a power outage.

 For example, many rural communities in Vermont were devastated by the destruction of the transportation and communication systems resulting from the flooding caused by Tropical Storm Irene in 2011; they did not have the resources to adapt and implement a disaster recovery assessment tool for their recovery needs. We view these gaps in the literature as opportunities for targeted research to advance the field of community resilience.

 One additional limitation was that our review located only single‐event studies. There were no peer‐reviewed articles that described studies within the Northeast using the same methodology to compare design, metrics, and outcomes across multiple and/or geographically separated interventions. There were no articles that demonstrated how communities incorporated the resilience‐building strategies into their everyday capacity‐ building efforts. In addition, and most important for a discussion on building and maintaining community resilience, we found no articles that evaluated the effectiveness of an intervention months or years later.

We attribute the lack of evidence‐based literature in part to the way in which data‐ bases and search engines are designed. Our search returned no published studies on com‐ munity resilience in New England; however, we know that studies do exist. We believe the issue is that some tools and metrics are published in journals that appear in specific databases so our searches did not capture all of the relevant articles. For example, despite most of our initial articles appearing in the Web of Science, four of the five articles that met our criteria were found using PubMed.

 **Conclusions**

The purpose of our research was to identify evidence‐based interventions and metrics that were used to build and measure community resilience in the Northeast United States. We were interested in locating studies to serve as models for local public health planners and for communities with modest resources to help a community prepare for, withstand, recover from, and prevent the physical and mental health impacts of a climate change‐related natural disaster. This research identified five peer‐reviewed articles to serve as models for future community resilience initiatives. Local planners and public health professionals who wish to measure community resilience need readily available resources that are cost effective, time efficient, and easy to access, whether they want to implement an intervention, or just establish a baseline assessment for community resilience planning. We propose that much of the data needed for measuring resilience can be generated through the use of semi‐structured interviews, surveys, and focus groups. Additional demographic and socio‐economic data can be gathered from publicly available sources, such as the U.S. census website. Online mapping tools, including the National Environmental Public Health Tracking Program, weather stations, and local emergency preparedness, mitigation, and recovery plans can generate low‐cost data needed for other metrics. We suggest that community partnerships are a critically important resource for additional data as community‐based organizations and other local entities may have access to resources and personnel unavailable to smaller local governments.