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Social Capital, Community Health Resilience, and Compounding Hazards in Corcovada, Puerto Rico

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Executive Summary

Overview

Compounding climate (e.g., extreme storm events) and non-climatic (e.g., COVID-19 pandemic) hazards pose significant risks to the security of food, energy, and water systems (FEW systems), and consequently, community public health in the U.S. Territories. This research explores the relationships between social capital, community health resilience, and compounding hazards in the community of Corcovada, which is located in the municipality of Añasco, Puerto Rico.

Research Questions

We asked three research questions: (1) what is the role of social capital in building community health resilience?; (2) how do co-occurring hazards affect this relationship?; and (3) what do community leaders perceive as challenges to their FEW security and health resilience under these compounding hazard contexts?

Research Design

These research questions, amongst others, were explored using a community-based participatory research approach (CBPR) with 16 community leaders, identified using a purposive sampling design. CBPR explicitly honors and centers local community members as experts of their own public health histories, conditions, and contexts. Under the CBPR research approach, three data collection methods were employed: group and collective discussion on core themes of compounding hazards, FEW resources, social capital (i.e., actors' abilities to benefit from group membership), and public health; community mapping of local FEW resources; and the development

and validation of a co-created FEW assessment intended to share and preserve local knowledge about community assets, needs, and risks, effectively involve younger generations in decision-making, and pursue funding opportunities for local resource management.

Findings

Our preliminary findings stress key interlinkages between compounding hazards, social capital, and community health resilience (i.e., ability for a community to withstand, adapt, and recover from public health risks). First, social capital is strongly associated with leaders' understanding of community health resilience. Second, social capital and collective action is strengthened by multiple entities at different scales, which support community preparedness, response, and recovery to climatic and non-climatic hazards. Third, and significantly, community leaders are concerned about the impact of the COVID-19 pandemic on the physical (i.e., ability to gather), and emotive and affective (e.g., unity) dimensions of bonding social capital—a major source of community health resilience and recovery in the wake of climate disasters. Fourth, local relations, outmigration, and intergenerational knowledge transfer are salient challenges for community health resilience under compounding hazard contexts.

Public Health Implications

Our research approach and early findings carry public health implications. The research process clarified the value of CBPR in identifying context-specific community-level risks posed not only to critical FEW infrastructures, but to social capital and collective action—a hallmark of community health resilience. Therefore, we recommend CBPR as a form of expert elicitation critical for disaster mitigation, preparedness, and response. More substantively, public health practitioners should develop programs that support and enhance evidenced characteristics of bonding social capital, such as familiarity, trust, and civic participation, for responding to the immediate health risks associated with compounding hazards and FEW insecurities. Moreover, government programs that train community leaders to support public health objectives, including through creating spaces (e.g., workshops, capacity-building, grant-writing) for leaders to expand bridging social capital to respond to compounding stressors, are needed. Our results highlight community self-organization as crucial for advancing public health functions of evaluation and security. For instance, leaders leverage their collective knowledge and social capital to advance public health objectives, including the successful administration of a solar-powered communal water aqueduct, reforestation efforts after hurricanes Irma and Maria, the repurposing of abandoned buildings as community gathering centers and a future health clinic, and the implementation of online mental health workshops during the COVID-19 pandemic. Therefore, we recommend policy makers and public health experts foster social capital for community health resilience. Finally, the COVID-19 pandemic presents complex challenges for community social capital. We recommend public health experts and policy makers identify and address the relationships between social capital and climatic- and non-climatic hazards to advance community health objectives. Siloed public health strategies that aim to reduce the direct and indirect health risks associated with either climate change or disease outbreaks may in fact undermine the ability for social capital to contribute to community health resilience in the wake of diverse and compounding hazards.

Introduction

Human-induced climate change increases the severity of climate and weather events, and crucially, increases the chances of extreme events occurring simultaneously (Intergovernmental Panel on Climate Change, 2021, p. 10¹)—a phenomenon known as compounding climate hazards (Thomas et al., 2020²; Zscheischler et al., 2018³). Additionally, emerging research provides evidence of how the uneven impacts of the COVID-19 pandemic, including the effects of risk-mitigation measures, intersect with extreme climate events to further concentrate physical and emotional health risks within populations (García et al., 2021⁴; Phillips et al., 2020⁵; Sultana, 2021⁶;

Wilhelmi et al., 2021⁷). Today, however, conventional impact assessments often quantify risk based on the projected impacts of single hazard contexts, and therefore, underestimate the public health impacts associated with compounding events (Zscheischler et al., 2018). Thus, identifying, understanding, and building adaptive capacity for compounding climatic- and non-climatic hazards is imperative for safeguarding community public health.

Importantly, emerging public health risks do not emerge from biophysical impacts alone. Such a perspective has the potential to otherwise displace the place-based, socio-economic, and political systems that transition biophysical hazards into public health disasters (Blaikie et al., 1994⁸). In the case of Puerto Rico, our focus, best-case estimates for excess mortality after the temporally compounding^{Endnote 1} hurricanes Irma and Maria ranged between 822 (Rivera & Rolke, 2018⁹) and 4,645 (Kishore et al., 2018¹⁰). Adjusting for population displacement, Santos-Burgoa et al., (2018¹¹) estimated 2,975 excess deaths, and further found mortality was disproportionately higher for residents in municipalities with the lowest levels of socio-economic development.^{Endnote 2} The extreme precipitation levels of Hurricane Maria—the largest rainfall event in Puerto Rico since 1956—was estimated at nearly 5 times more likely to occur because of climate change (Keellings & Hernández Ayala, 2019¹²). But behind the increasing, human-generated force of these storms are historical and on-going processes of colonialism, and regimes of neoliberalism and austerity, which fueled Puerto Rico's debt crisis and failed to properly fund life-saving critical food, energy, and water (FEW) and health infrastructures, ultimately precipitating the devastation of these extreme events (Bonilla, 2020¹³; García-López, 2018; Hammer, 2018¹⁴; Moulton & Machado, 2019¹⁵; Ramos et al., 2022¹⁶; Rivera, 2020¹⁷).

Anti-racist and decolonization movements seeking to transform the underlying social and political relations responsible for transitioning hazards into disasters are central to climate and environmental justice efforts (e.g., García-López, 2018¹⁸; Moulton & Machado, 2019; Popke & Rhiney, 2019¹⁹). At the same time, long histories of collective action and autonomous self-organization (autogestión) shape community resilience and regeneration (García-López et al., 2017²⁰; Roque et al., 2021²¹)—and serve to enact new visions of sovereignty and care (Bonilla, 2020). Both approaches shift the dominant focus away from purely technical solutions to an environmental crisis, and center social and political relations as essential in building community resilience (Aldrich & Meyer, 2017²²). Given the increased likelihood of compounding hazards with cascading implications for FEW resource systems, we investigate whether and under what circumstances bonding, bridging, and linking social capital and relations, described below, contribute to the mitigation, and even enhancement of community assets, health, and capabilities for public health.

Literature Review

FEW are interdependent resources essential for public health. Their availability, safety, and affordability represent only a handful of the indicators used to understand their interrelationships and consequences for human wellbeing. Food and water insecurities are interrelated, and can interact to compound one another (e.g., Brewis et al., 2020²³; Workman, Stoler et al., 2021²⁴; Workman, Brewis et al., 2021²⁵). Food security is defined as a state “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (Food and Agriculture Organization, 2003²⁶, official concepts of food security section, para. 6.). Food insecurity is associated with adverse health outcomes, such as malnutrition, depression, and anxiety (Gundersen & Ziliak, 2015²⁷). While food security is vital for sustaining a healthy life, only a fraction of disaster-related research focuses on food insecurity (Smith et al., 2018²⁸).

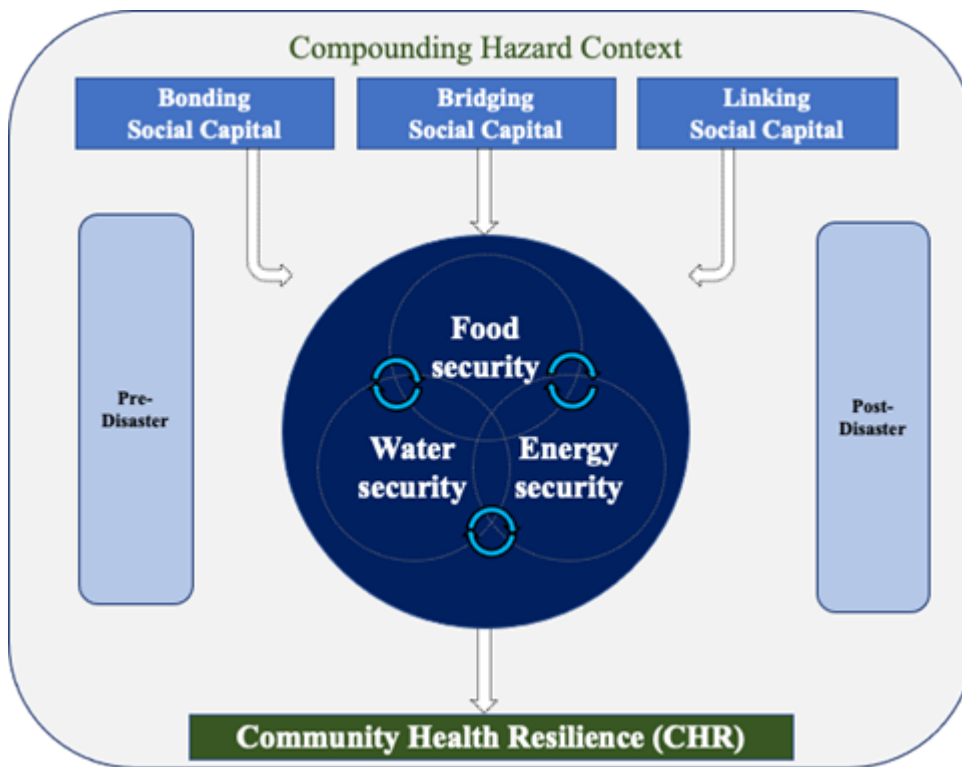
Water security, affecting food security (Brewis et al., 2020), can be defined as accessible, safe, and affordable water for drinking, domestic, and livelihood purposes such that unacceptable water-related risks are mitigated, context-specific needs are met, and self-defined aspirations are reachable (Cook & Bakker, 2012²⁹; Grey & Sadoff, 2007³⁰; Jepson et al., 2017³¹; Shah, 2021³²). As hazards interact with water infrastructures, pipes can break, water quality can be affected, and households can experience lengthy water shutoffs (Roque et al., 2021). Thus,

household and community health and wellbeing may be threatened by a forced reliance on untreated water sources, which could lead to exposures to waterborne pathogens, infectious diseases, and chronic stress. Research exploring water insecurity in the wake of disasters and its implications for human health remains understudied.

Energy security has several different framings, including availability, pricing, infrastructure, and coupled social-ecological needs (Ang et al., 2015³³; Azzuni & Breyer, 2018³⁴). We follow Hernández (2016³⁵) by defining energy security as a “multi-dimensional construct that describes the interplay between physical conditions of housing, household energy expenditures and energy-related coping strategies” (p. 1). Energy security has implications for health because it is essential for household activities (e.g., cooking, boiling water, food preservation). As an example, study participants (Respondents 4 and 16) identified the significance of energy security for the continued function of life-saving health equipment, and for the storage of nutritious and perishable foods (Respondent 5). Another participant discussed the emotional stress from feeling unprepared for the relentless heat and the darkness that came from not having electricity (Respondent 9). Further, energy insecurity affects access to clean and safe water, including in Puerto Rico after hurricanes Irma and Maria, where the catastrophic impacts to the electrical grid left some households without water access for months (Preston et al., 2020³⁶). Understanding the potential direct and indirect impacts and community responses to FEW insecurity in compounding disaster contexts remain understudied. Our research addresses these gaps using Corcovada as a case study.

Described earlier, the concept of social capital has gained considerable interest in public health and community resilience literatures for its potential to enhance health outcomes (e.g., Allen, 2006³⁷; Moore et al., 2004³⁸)—or what is known as community health resilience, the “ability of a community to use its assets to strengthen public health and healthcare systems and to improve [its] physical, behavioral, and social health to withstand, adapt to, and recover from adversity” (U.S. Department of Health and Human Services, 2015, para. 1³⁹). Although definitions vary, social capital can be defined as “the ability of actors to secure benefits by virtue of [their] membership in social networks and other social structures” (Portes, 1998, p. 6⁴⁰). Bonding, bridging, and linking or vertical capital are three types of social capital that community resilience and recovery depend on (Aldrich & Meyer, 2017; Ferlander, 2007⁴¹; Jovita et al., 2019⁴²; Putnam, 1993⁴³; Szreter & Woolcock, 2004⁴⁴). Bonding social capital refers to relationships between those who share socio-cultural backgrounds (Nakagawa & Shaw, 2004⁴⁵). Bridging social capital indicates relationships and networks with diverse communities (Nakagawa & Shaw, 2004). Linking or vertical social capital refers to relationships with institutions of power at multiple scales (e.g., government, for-profit entities) (Nakagawa & Shaw, 2004). In the disaster scholarship, bonding capital is found to catalyze resource and information sharing, bridging ties enable resources from nearby communities, and linking relations provide communities with improvements in social and physical infrastructures (e.g., Aldrich, 2012⁴⁶; Nakagawa & Shaw, 2004; Roque et al., 2020⁴⁷). Given the increased probability of compounding hazards, it is important to investigate how bonding, bridging, and linking social capital may provide mechanisms for assessing, preserving, and even enhancing community assets, health, and capabilities for public health. This includes studying the types of groups and networks that communities like Corcovada—our study site—have access to, as well as the norms of cooperation, collective action, social cohesion, and reciprocity that support community health resilience. Specifically, identifying and strengthening forms of social capital to respond to the diversity of compounding hazards could inform and support community health resilience. Figure 1 illustrates the relationships between social capital, FEW security, and community health resilience.

Figure 1. The Interrelationships Among Social Capital, Community Health Resilience, and Food, Energy, and Water Security



Research Design

Research Questions

In this report, we provide preliminary analyses for three major research questions:

1. What is the role of social capital in building community health resilience?
2. How do co-occurring hazard contexts affect this relationship?
3. What do community leaders perceive to be the challenges to their FEW security and community health resilience under compounding hazard contexts?

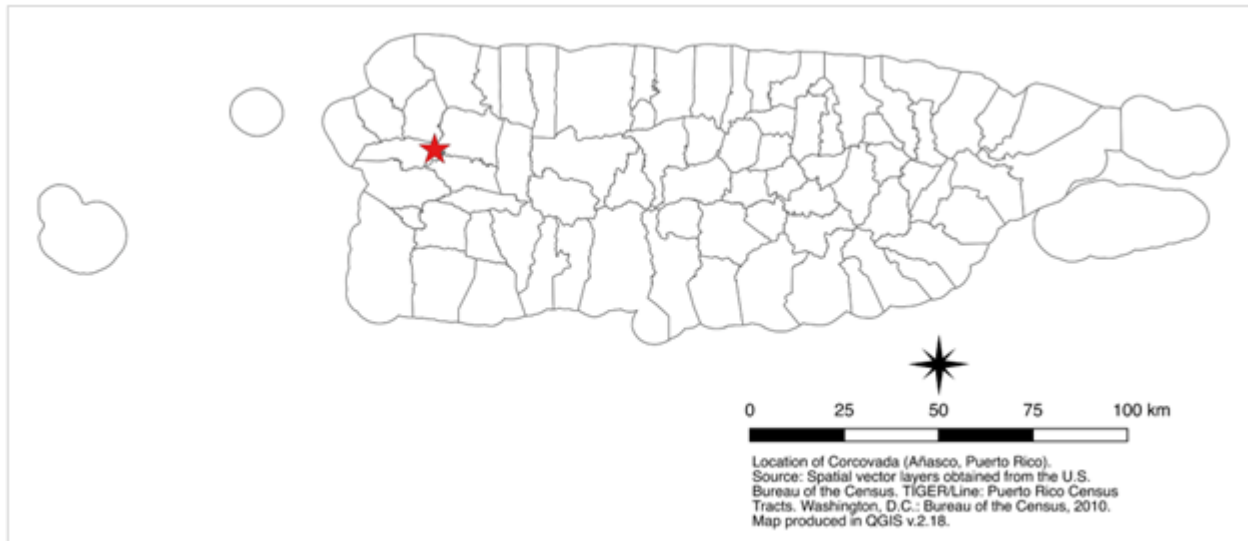
Community-Based Participatory Research

Our research understands that policy and decision makers can learn about the underlying causes associated with public health risks, and develop targeted strategies to meet local needs, when working directly with residents who are impacted by inadequate public health policies. One mechanism to accomplish this is a community-based participatory research (CBPR) design. CBPR seeks to “increase knowledge and understanding of a given phenomenon and integrate the knowledge gained with interventions and policy and social change to improve the health and quality of life of community members” (Israel et al., 2005, p. 5⁴⁸). CBPR explicitly honors local community members as experts of their own public health histories, challenges, and conditions. Our larger project drew from multiple data collection tools informed by a CBPR research design. These included: (a) focus group discussions through a two-day community workshop; (b) community mapping exercises focused on FEW resources in relation to community health; and (c) content validity and data quality evaluation of a co-created FEW and community health assessment.

Study Site

Our research focuses on the experiences of Corcovada, a barrio (which in Puerto Rico refers to a smaller legal division within a municipality) located in the mountains of the western municipality of Añasco, Puerto Rico (Figure 2). This remote and rural community was organized over 50 years ago, and today has approximately 600 residents. In the 1960s, with support of a Presbyterian Church U.S. mission, Corcovada's leaders built an access road and a communal aqueduct for drinking water because of their exclusion from the Puerto Rico Aqueduct and Sewer Authority (PRASA) water supply and distribution network (Asencio et al., 2018). With the creation of the communal aqueduct, Corcovada founded a community-based non-profit organization in 1990, the Comité Communal de Corcovada Inc., an organization which would manage the aqueduct and other community necessities. Today, Corcovada has two “non-PRASA”^{Endnote 3} systems and a free tap available for nearby communities facing water insecurities.

Figure 2. The Community of Corcovada, Añasco Municipality, Puerto Rico



Note. The red star on the map depicts the location of Corcovada. The map was produced by the authors using QGIS v.2.18 (Open Source Geospatial Foundation, n.d.⁴⁹).

The study site was selected for four reasons. First, our team has a long-standing research partnership with the community on themes related to social capital, energy and water insecurity, and community resilience. Second, co-principal investigator Quintana is a community member of Corcovada. Third, between 2017 and 2021, climatic and non-climatic hazards impacting Corcovada included landslides, earthquakes, flooding, and the COVID-19 pandemic. Similar to other remote communities in southern and central Puerto Rico, these hazards coupled with weak critical infrastructure resulted in regular power outages, challenges in accessing nearby resources, and water shortages. Fourth, remote communities in Puerto Rico were disproportionately impacted by hurricanes Irma and Maria. By focusing on remote community experiences, we aim to co-develop applied and theoretical research products that can be used in other rural communities in Puerto Rico.

In light of the aforementioned research needs and contexts associated with compounding climatic and non-climatic hazards, we explored the role of social capital in promoting community health resilience in Corcovada. This was accomplished by using CBPR with 16 community leaders, who participated in a multi-day workshop. The limited time-period for data collection and analyses under the **Special Call for Proposals: Strengthening Community Resilience in the U.S. Territories** resulted in overlapping phases between the data analyses and reporting. Therefore, our report relies on memoing and reflections from workshop facilitators, and emerging themes from the analysis of workshop discussions. Results from the other CBPR methodologies used in the workshop, including participatory mapping of local FEW systems and the co-creation of the FEW assessment, are described in the Data Collection section. These additional elements will enable a spatially-explicit understanding of FEW resources as well as shared knowledge of what FEW security entails—crucial in supporting funding

opportunities for future capacity-building activities in Corcovada. The results from these diverse methodologies will be analyzed in later refereed and non-refereed publications and will complement the results presented in this report.

Participant Selection

We held two community-based workshops on February 13 (Workshop 1) and February 20, 2022 (Workshop 2) with community leaders in Corcovada. We used a purposive sampling strategy—a non-probability sampling framework where leaders were invited based on certain characteristics. Specifically, we invited leaders from diverse socio-economic backgrounds that had formal and informal leadership roles in Corcovada (e.g., community board, committees, local business owners), and that possessed a depth of knowledge about the community. In Workshop 1, 15 community leaders attended, and in Workshop 2, the same 15 attended with the addition of one more leader. A diverse representation of age and gender was present in both workshops, with participant age ranging between 25 and 81 ($\bar{x}$ = 52.5 years). Almost two thirds of (n = 10) of the participants self-identified as men and 37.5% (n = 6) self-identified as women. While participants were diverse, we recognize out-migration patterns over the last decade result in Corcovada having a predominantly elderly demographic.

Data Collection

Workshops were conducted in-person, with handwashing stations available and KN-95 masks provided to all participants. We implemented physical distancing as another risk-reduction measure for participants. Workshop 1 consisted of developing a deep contextual understanding of the everyday lived experiences in Corcovada, as well as the FEW infrastructures and vulnerabilities that exist and impinge on community public health. As depicted in Table 1, the research team organized several interactive activities, including large- and small-group discussion and a participatory mapping exercise. Workshop 1 began with a memory exercise for participants to reflect on their life in Puerto Rico over the last decade. This memory exercise involved the use of a timeline upon which critical events and risks in Puerto Rico over the last decade were listed. These events included concerns associated with food (e.g., farming challenges, food access during the COVID-19 pandemic), energy (e.g., unaffordability, power outages), water (water shortages, water costs, droughts), and public health risks (e.g., Zika outbreak). This was followed by a discussion on FEW (in)securities in Corcovada, how these insecurities have affected the community in the past and present, and how they could be exacerbated by multiple compounding hazards in the future. With this context in mind, participants were organized into four small break out groups to discuss the concept of resilience. The workshop closed with a community mapping exercise to identify and understand FEW resources, insecurities, and coupled health challenges. For this exercise, we used three maps—one of Corcovada, one of Añasco, and one of Puerto Rico. We divided the leaders into five subgroups and used a set of questions around social and physical infrastructures for energy, water, and health security for participants to identify these resources across the three maps.



Community leaders meet with investigators at a community-based workshop in Corcovada, Puerto Rico in February 2022. Image credit: Research Team photo, 2022.

Table 1. Workshop 1 Schedule

Time	Workshop Activity
------	-------------------

1:00 pm – 1:30 pm	<i>Participants briefed about:</i> • Project reintroduction • Promoting an inclusive space • The role of community-based participatory research • Overview of expectation and activities
1:30 pm – 2:00 pm	<i>Participants engaged in:</i> • “Memory exercise”: Life in Puerto Rico in last 10 years
2:00pm– 2:30pm	<i>Participants engaged in:</i> • Describing and sharing food, energy, and water security challenges in Corcovada.
2:40pm– 3:10pm	<i>Participants engaged in:</i> • Describing the concept of resilience, including in the context of community health, and experiences with compounding disasters.
3:50pm – 4:50pm	<i>Participants engaged in:</i> • Participatory mapping exercise (continued in Workshop 2)
4:50pm – 5:00pm	Concluding remarks

As depicted in Table 2, Workshop 2 began by continuing the participatory mapping exercise. The concept of social capital, its critical sources, and functions in the community were elaborated, including within the context of compounding climatic and non-climatic hazards. This exercise was followed by an in-depth discussion over what constitutes community health, and identifying how the community leaders support essential public health services, assessments, and policy development. Finally, and not discussed in significant detail within our report, we entered Workshop 2 with a preliminary outline of what FEW security meant, and the kinds of criteria it might denote for community members in Corcovada. We based our preliminary outline on our collective understanding of existing assessment tools, including the Australian Red Cross Community Assessment and Engagement Tool (2013⁵⁰), the American Red Cross Community Resilience Assessment Tool (2014⁵¹), the U.S. Agency for International Development Water Security Assessment (n.d.⁵²), and the U.S. Department of Agriculture Community Food Security Assessment Toolkit (2002⁵³). The outline was also informed by our knowledge of FEW insecurities in Corcovada from prior research and experience (e.g., Roque et al., 2020). In addition to identifying FEW challenges and needs, the assessment hoped to define particular strategies to increase the resilience of, and between, interconnected FEW resources using sources of social capital, while also acknowledging limitations to act. After presenting the ideas from our existing research, we spent two hours in small subgroups co-creating the assessment protocol with community leaders. Each subgroup developed a set of normative (“should”) statements about FEW security in Corcovada, and participated in a content validation process. This assessment will be refined and provided back to the community in the form of a toolkit to support disaster risk-reduction and emergency management, as well as for leaders to use in future applications for government funding that support community capacity-building.

Table 2. Workshop 2 Schedule

Time	Workshop Activity
1:00 pm – 1:15 pm	• Welcome and recap of community agreements • Introduction of activities and expectations

1:15 pm – 1:45 pm	• Participatory mapping exercise
1:45 pm – 2:30 pm	• Participants describe their positionality in the community and how it relates to the way members relate to each other • Participants engaged in an exploration of personal social capital for community food, energy, and water (FEW) and health insecurities building from the positionality exercise
2:45pm– 3:30pm	• Participants engaged in a discussion of the essential services of public health and how they as community leaders are public health promoters within the community
3:45 pm – 5:40 pm	• Participants engaged in small group discussions to co-create a food, energy, and water (FEW) assessment with three key pillars: community census, key information interviews and household level survey • Feedback and validation
5:40 pm – 5:50 pm	• Discussion and conclusion

All workshop activities and discussions were conducted in Spanish. As described more below, we used digital recorders and fieldnote memos to capture participant statements. Quotations from the workshops were translated into English by the authors. Please see the Appendix for original Spanish quotation text.

Data Analysis

The activities in each workshop were audio-recorded. We used NVivo Transcription, a powerful automation software that transcribes, verbatim, audio-recordings from 28 languages with a reported 90% accuracy in quality (QSR International, 2020⁵⁴). A bilingual (Puerto Rican) Research Assistant assisted in correcting errors from the automated NVivo Transcription service. For this report we rely on data transcriptions from several workshop activities, discussed earlier, as well as on memoing (Birks et al., 2008⁵⁵) from workshop facilitators. The findings we report emerge from a preliminary thematic analysis of the interview data, which was guided by the three research questions defined earlier (Ryan & Bernard, 2003⁵⁶).

Ethical Considerations, Positionality, and Reciprocity

This research was approved under an amendment to co-principal investigator Tormos-Aponte's existing Institutional Review Board (IRB) Protocol, entitled "Environmental Inequity and Disasters Research" (#698), at the University of Maryland, Baltimore County. The original Protocol encompassed projects investigating the social and political factors that affect disaster relief response, with a focus on Puerto Rico. The Protocol was amended to reflect the activities outlined in our funded proposal. The amendment was approved on January 1, 2022, prior to participant recruitment. All co-principal investigators and graduate student research assistants received their Collaborative Institutional Training Initiative certification. All participating community leaders were remunerated for their time and contributions during the workshops. As a part of our research, we have committed to substantively engaging with the knowledge that emerges from the community of Corcovada. This involved fostering an inclusive workshop environment to navigate and respond to the potentially uneven experiences of participation. Discussed earlier, we incorporated small-group discussions, as well as time to hear from each

participant's experiences and perspective, to ensure inclusive participatory dialogue. Community leaders will have access to all workshop data once transcribed. Last, we will work with respondents to ascertain how they would like to be credited for their knowledge contributions in future refereed and non-refereed publications.

Preliminary Findings

As described above, we asked three research questions: (1) what is the role of social capital in building community health resilience?; (2) how do co-occurring hazards affect this relationship?; and (3) what do community leaders perceive to be key challenges to their FEW security and community health resilience under compounding hazard contexts? We elaborate findings for each research question below.

Role of Social Capital in Building Community Health Resilience

In Workshop 1, participants were organized into four small break-out groups to discuss the concept of resilience in the context of compounding hazards. In elaborating perceptions of resilience, participants implicitly associated social capital with its meaning by describing the roles of bonding, bridging, and linking capital individually, and collectively.

First, bonding social capital—or, ties between residents of Corcovada based on similarity, shared experiences, and mutual objectives—was indicated as underlying community engagement, and especially critical for achieving shared public health goals ranging from water quality monitoring to post-disaster organizing. Likewise, bonding capital enables, and is reinforced by, “check-ins” with community members, which have been critical for reducing feelings of isolation and disconnection during the COVID-19 pandemic. Second, linking social capital—or, relationships with institutions holding power—facilitates community health resilience. For instance, community leaders collaborated with local government and the Puerto Rico Health Department to use Corcovada’s assisted living center as a space to administer COVID-19 vaccinations to residents. Similarly, the leadership has used their connections, including with Maximo Solar (for-profit organization), to install solar panels that create a more resilient energy system, and to power a refrigerator for safe storage of medications, like insulin. These linking ties serve water resilience through the installation of solar panels that power the community aqueduct.

Third, and as a collective, bonding, bridging, and linking social capital, have enabled community preparation and adaptation to climatic and non-climatic hazards. For example, participants discussed diverse forms of support in the context of responding to different climatic and non-climatic stressors. These included resources and support within Corcovada, across communities, and with communities and stakeholders with power. In the aftermath of the compounding hurricanes Irma and Maria in 2017, bonding ties facilitated access to and use of resources, such as machinery, to clear roads for community use. Regarding the Puerto Rican earthquakes in 2019-2020, leaders identified and participated in emergency management procedures, including the usage of their repurposed community school as a center for shelter and planning. Moreover, linking capital has been invaluable for the leadership to receive resources, such as training, media coverage, donations, food, water tanks, home-building materials, and fuel for electric generators, in the wake of compounding hazards. These sources of social capital collectively support community health resilience in single and compounding hazard contexts.

The Corcovada community water system (CWS), which is central to food provision, hygiene, and public health in the barrio, is an example of the community’s long history of community organizing and collective action and the ways that social capital contributes to the resilience of community institutions. In the mid-1960s, Corcovada constructed their own CWS and a 23,000-gallon storage facility after being reliant on importing water from other communities (Kinnunen, 2019⁵⁷). Communal self-organization, combined with linking sources of social capital, enabled the CWS to benefit from granting bodies to construct a second aqueduct, a chlorination disinfection system, and an alternative solar energy system (Asencio-Yace et al., 2018⁵⁸; Kinnunen, 2019; Roque et al., 2020; see Figures 5A-C). The impacts of hurricane Maria, and that of hurricane Irma only weeks prior, resulted in physical damage (e.g., destroyed homes and community spaces; and lack of electricity for over four months) in

Corcovada, as well as disruptions in medical and food supplies (Roque et al., 2020). Impressively, the Corcovada CWS managed to provide water only one day after hurricane Maria, through relying on a diesel generator system (Asencio-Yace, 2020⁵⁹). Across Puerto Rico, Ruiz-Aviles et al. (2021⁶⁰) have documented the resilience of similar aqueducts to the compounding disasters of hurricanes Irma and Maria. Community autonomy in the forms of flexible and rapid organization, and linking capital with multiple organizations and agents, facilitated preparation, recovery, and redundancy (Ruiz-Aviles et al., 2021).



The water storage tank for the Community Water System in Corcovada, Puerto Rico. Image Credit: Research Team photo, 2020.



Solar panels installed for the Community Water System in Corcovada, Puerto Rico. Image credit: Research Team photo, 2020.

While financial and technical forms of capital are key arguments for enhancing resilience of the water sector in general in Puerto Rico (Preston et al., 2020), Ruiz-Aviles et al., (2021) found diverse and multi-scalar forms of social capital served water system resilience in systems otherwise caricatured as highly vulnerable. Indeed, in Corcovada the role of strong and weak social capital networks at multiple scales enabled the continued functionality of the system (e.g., Asencio-Yace, 2020; Roque et al., 2020). Roque et al. (2020) found high levels of bonding social capital (i.e., connections between similar people) demonstrated by participation from community leaders, adults, and youth in increasing access outside of the community, and in rebuilding the community immediately. Regarding bridging social capital (i.e., connections with dissimilar groups), Roque et al., (2020) found the local church played a key role in acquiring and donating resources for the community, such as water purifiers, and used their space as a food collection center. The church donated for a backup electricity system for the CWS (Roque et al., 2020). Concerning linking social capital, formal relationships with federal and local agencies and organizations (e.g., Federal Emergency Management Agency, municipality, non-profits) as well as from donations from mainland U.S. citizens, was instrumental in helping run the CWS (Roque et al., 2020).

How Co-Occurring Hazards Affect Social Capital and Community Health Resilience

Participants elaborated how compounding climatic and non-climatic hazards affected the relationship between social capital and community health resilience. Namely, we find compounding hazards affect social capital by reducing physical connectedness, and by disrupting intergenerational knowledge transfer through exacerbating outmigration.

First, in Workshop 1, participants discussed the concept of resilience under different hazards, and specifically, under the premise of what enables resilience in one disaster context, such as an extreme hurricane, versus another, such as an earthquake. Here, leaders mentioned that physical connectedness affected their interactions because of health concerns and overall safety. This was demonstrated in one memorable quotation:

In the four groups, well uh there's really three categories where you can see this, in hurricanes, earthquakes, and droughts there's community unity. In hurricanes, we see cooperation during evacuations and preparation. In earthquakes, we see fear and improvisation because each of us can have a family evacuation plan but at the time of the earthquake, what's going to happen? And then you forget about everything in the plan. When it comes to droughts, we wrote about the restrictions that occur within the community. For example, let's suppose I usually give you 25 dollars but now I will give you 20 dollars. Why am I giving you 20 dollars? Because I have to limit myself, no? When it comes to the pandemic, we see distancing, personal protection, and limitations. Why did we include limitations? Because maybe in the three other categories we can unite, work hand by hand to protect human lives but here in the pandemic, unfortunately, well we have these limitations because even though we want to help, we can't do it like we've done it in the other three categories.

This is a key insight because it reflects how the COVID-19 pandemic actively affects the physical dimensions of self-organization, which was previously elaborated by participants as crucial in responding to climatic hazards (see Role of Social Capital in Building Community Health Resilience section). Second, intergenerational knowledge transfer and outmigration in the wake of compounding hazards has affected social capital. Corcovada is a predominantly elderly community because of their remote location and lack of opportunities for the youth beyond agriculture and small business creation. At the same time, the impacts of hurricanes Irma and Maria, and the pandemic, have further reduced the opportunities for the youth to stay in Corcovada. Regarding outmigration, leaders discussed concerns about the transfer of knowledge, including as it relates to the management of community health resources, namely the CWS.



Pumping station for the Corcovada Community Water System.

Image credit: Research Team photo, 2022.

Key Challenges to Food, Energy, and Water Security and Community Health Resilience

Our third, and final, research question asked: what do community leaders perceive to be salient challenges to their FEW security and community health resilience under compounding hazard contexts? Related to our discussion above, participants' indicated how handling compounding hazards will be more difficult due to

disasters like the COVID-19 pandemic. The preparation, response, and recovery for hurricanes, droughts, and earthquakes vary but all share one quality: people are able to unite by being in close proximity to each other. Participants implicitly described the importance of adaptation in the context of responding to the challenges posed to conventional modes of self-organization, such as bonding capital. For instance, if there are future pandemics like COVID-19, community groups will have to be more careful when organizing. They might use the Internet more for group meetings and other activities that can be done remotely. For in-person work, they will have to wear masks, practice social distancing, and get tested often. While these practices can physically adapt communities to a “new normal,” most groups were further concerned about unity during the COVID-19 pandemic. During COVID-19, people practice mask-wearing and social distancing, which reduces or even prevents quality in-person activities that help foster unity.

In one exchange, participants described how hurricane Maria fostered unity, but how COVID-19 had impacted relationships. Participant 2 said, “family relationships were ended by [COVID-19].” Participant 11 added, “[Maria] united the family, COVID separated it.” (See appendix for a full excerpt of the exchange in the original Spanish and an English translation.) It is clear that if epidemics or pandemics occur in the future, unity will be challenging, and will challenge responses to compounding hazards.

Regarding their FEW security, the leaders spoke on the larger challenges of the government to provide reliable electricity access, particularly in the wake of hazards such as hurricanes and earthquakes. Leaders also addressed the challenges local farmers have with permits and the bureaucratic processes that limit their ability to produce their own food. Concerning water security, now powered with solar panels and a battery system, leaders felt more prepared for extreme hurricane events; however, their Principal Water Systems Manager identified challenges related to drought (water quantity), and concerns of water quality and non-compliance with the Puerto Rico Department of Health and the Environmental Protection Agency. Overall, while leaders and residents respond to these challenges to the extent possible—and have a long history of doing so—there was a distinction made that compounding climatic and non-climatic events with direct and indirect implications to FEW and health represent additional layers of complexity and uncertainty for community mobilizing and organizing.

Conclusions

This Report investigated how bonding, bridging, and linking social capital provide mechanisms for assessing, preserving, and enhancing community assets, health, and capabilities for public health in Corcovada—a community that has, and will continue to experience interacting climatic- and non-climatic hazards. We provide four significant, yet preliminary, findings:

1. Social capital is strongly associated with the community’s understanding of health resilience;
2. Bonding, bridging, and linking social capital, which enable Corcovada residents to self-organize in the wake of disasters, is supported by multiple entities at different spatial and temporal scales;
3. The COVID-19 pandemic challenges the physical and affective dimensions of community self-organization—a key source of health resilience in the wake of climate disasters; and
4. Numerous challenges, persistent and newly emerging, and concerning state-citizen relations, out-migration, and intergenerational knowledge transfer affect community self-organization to compounding hazards.

Public Health Implications

These preliminary findings have implications for public health policy and strategy. First, community organizing in Corcovada advances core public health functions of evaluation and security. Community leaders have leveraged collective knowledge, the range of abilities within the community, and social capital to address public health concerns and support community health resilience. Leveraging multiple sources of knowledge and relations have supported various projects, including: the successful administration of a solar-powered communal aqueduct, implementation of risk mitigation strategies for mosquito breeding sites, reforestation efforts after hurricanes

Irma and Maria, identification and management of stray animals, the repurposing of abandoned buildings as community gathering centers and a future health clinic, the implementation of online mental health workshops during the pandemic, and resource mobilization for the rapid vaccination of community members against COVID-19. Thus, social capital and collective action, while emergent from specific histories of state government neglect, are key determinants of community health resilience—i.e., the ability for Corcovada to mitigate, adapt to, and recover from the health risks associated with socio-environmental hazards.

Second, the COVID-19 pandemic has had physical and non-material impacts on bonding social capital—a key source of resilience for reducing and responding to the impacts of natural hazards. In particular, the pandemic increased physical isolation, which affected the ties and relationships that had been effectively mobilized in the wake of hurricane Maria. This finding demonstrates how climate change resilience cannot be viewed in isolation from the ongoing COVID-19 pandemic. Public health policies should adopt a comprehensive view that does not treat pandemic and climate responses as distinct and separate objectives. Further, addressing compounding hazards entails recognizing how hazards interact, and adopting policies and practices to address the outcomes of these interactions. In this context, one disaster can negatively impact the measures developed to mitigate a different disaster.

Third, CBPR has demonstrated its added-value of identifying specific community-level risks posed to critical FEW infrastructure and function in the wake of compounding hazards. The knowledge shared by community leaders, described herein, identifies important social risks and effective approaches to problem-solving that would not be possible through top-down and conventional “expert-driven” knowledge and project implementation. We recommend CBPR as a form of expert elicitation critical in disaster mitigation, preparedness, response, and recovery, and as key to effective resilience project design, adoption, implementation, and evaluation for issues of FEW security. Even while the workshop interviews were the primary source of data for this report, we described each CBPR methodological approach (i.e., community-based mapping; FEW assessment co-creation) for public health experts and practitioners to provide examples of how CBPR could be mobilized as a form of expert elicitation.

Limitations and Future Research Directions

The primary limitation on the findings reported here was the overlapping phases of analysis and reporting. As such, future research will explore each of these findings in significantly greater depth. Further, we will continue to co-develop and refine the FEW assessment with the community, which was not described in this report. Being able to co-create and deploy the FEW assessment will provide community members with the information they need to increase their own knowledge about community needs and assets; effectively involve younger generations in community decision-making; improve coordination and collaboration with community members; establish community decision-making based in data; reinforce links between governmental and non-government entities; identify community priorities; pursue funding opportunities; and manage priorities, needs and assets over time.

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Endnote 1: Zscheischler et al. (2020⁶¹) create a typology of compounding hazards, including compounding temporal events, defined as events succeeding one another and affecting a given place. ↩

Endnote 2: Other research documents psychological and emotional stress (Orengo-Aguayo et al., 2019⁶²), power outages (Kishore et al., 2018), and food insecurity (Rodríguez-Cruz et al., 2022⁶³). ↩

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