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The associations between financial impact of Hurricane María and the 2020 sequence of tremors and psychological distress among young adults in Puerto Rico

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The associations between financial impact of Hurricane María and the 2020 sequence of tremors and psychological distress among young adults in Puerto Rico

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Abstract

The associations between financial impact of Hurricane María and the 2020 sequence of tremors and psychological distress among young adults in Puerto Rico

By Laura Bosque

Background: Puerto Rico has recently experienced some of its worst natural disasters in recent history, with Hurricane María (HM) in 2017 followed by the sequence of tremors (ST) in 2020. Studies have independently documented the negative psychological and financial toll of HM on the island; however, the association between the financial impact of HM and psychological distress has not been examined. Similarly, data are scarce on the financial and psychological toll of the ST 2020 as well as the association between the two. The present study seeks to evaluate the association between the financial impact of HM and the ST 2020, and psychological distress among young adults in Puerto Rico; and will explore the moderating role of social support in these associations.

Methods: This cross-sectional analysis used baseline data from the PR-OUTLOOK study. Participants (n=1,484) were ages 18-29 years, recruited between September 2020 and September 2022. The following psychological outcomes were assessed: symptoms of depression (CESD-10), anxiety (STAI-10), post-traumatic stress disorder (Civilian Abbreviated Scale PTSD checklist), *ataque de nervios*, and perceived stress (PSS-4). All outcomes were dichotomized according to clinical or population-based cutoffs. The financial impact of HM and the ST was assessed through two items with responses dichotomized as no/little (low impact) vs. some/a great deal (high impact). Adjusted prevalence ratios (PR) and their respective 95% confidence intervals (95% CI) were estimated using log binomial regression. The moderating effect of social support was assessed using multiplicative interaction terms with each of the exposures.

Results: Of the sample, 44% reported high financial impact from HM and 10% from the ST 2020. In fully adjusted models, individuals reporting some/high financial impact from HM (vs. none/low) had elevated symptoms of depression (PR=1.15; 95% CI=1.06-1.25), perceived stress (PR=1.14; 95% CI=1.06-1.23), and anxiety (PR=1.41; 95% CI=1.17-1.69). Individuals reporting high financial impact from the ST 2020 (vs. none/low) had higher prevalence of elevated symptoms of depression (PR= 1.41, 95% CI=1.17, 1.69), and perceived stress (PR= 1.10, 95% CI=1.01, 1.19). No moderating effect by social support was found.

Conclusion: Experiencing a moderate/high financial impact from HM and the ST 2020 was associated with higher prevalence of psychological distress among young adults in Puerto Rico. Future studies of the financial impact of natural disasters on psychological distress among young adults are needed to inform potential interventions that build resilience, especially among vulnerable populations.

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LITERATURE REVIEW (BACKGROUND)

Climate Change and Natural Disasters

Mounting evidence suggests that natural disasters will continue to increase in frequency and intensity in the upcoming years due to the effects of climate change[1]. In fact, this increase in natural disasters has been observed since the 1970s[2]. The United Nation's (UN) office for disaster risk reduction reported that, on average, 200 million people per year are affected by natural disasters, with approximately 60,000 deaths per year in the past decade[3]. Although there have been important and impactful advancements in early warning systems[4] and a general economic growth pattern post-disaster[2], the negative financial and emotional repercussions on persons continue to worsen as inequality rises with each event[2]. This inequality surges from uneven impact of natural disasters and unequal access to resources[4]. Marginalized communities are most vulnerable to the mental, emotional, financial, and bodily stress disparities caused by natural disaster exposure[5]. Thus, a thorough understanding of the financial and emotional repercussions of experiencing natural disasters is essential for constructing a comprehensive response.

Financial Impact of Hurricanes

The financial impact of the most historic hurricanes in the United States (US) has been meticulously analyzed throughout the years. One thoroughly studied hurricane is Hurricane Katrina in 2005, which caused property damages that exceeded $100 billion[6]. The US Labor Department reported 220,000 job losses in Louisiana, leaving nearly everyone in New Orleans unemployed and rising unemployment rates by 9 percentage points[7]. A 2006 study published the economic repercussions of Katrina in New Orleans, highlighting the socioeconomic effects at the individual level[7]. The paper explains that labor shortages existed at the same time as high unemployment due to loss of housing that created regional pockets where the workforce could not be homed[7]. Although many studies report on the economic improvement of New Orleans, there is growing evidence that highlights how the urban renewal projects that have improved the

job and housing market in New Orleans have also lead to gentrification. This is due to lack of affordable development in the forefront of planning, thus displacing the most vulnerable populations[8].

Financial Impact of Earthquakes

The literature on the financial impact of earthquakes in the US is far less extensive than the available data on Hurricanes, in part due to the discrepancy in frequency and intensity[9]. The source of financial impact of earthquakes are usually tied to loss of housing or workplace. In the case of the 6.7 magnitude Northridge, California earthquake of 1994, although majority of households damaged or destroyed by the earthquake received federal assistance and temporary housing, more vulnerable populations, such as immigrants, were not helped by these government resources[10].

Psychological Effects of Natural Disasters

Another challenge that sprouts from experiencing natural disasters is the psychological effects that it has on individuals and communities. Adverse psychological effects of natural disasters can vary in severity, but are generally widespread, prolonged, and are linked to experiencing the disaster[11]. In a 1992 study on the psychological impact of experiencing a natural disaster, they found that psychological distress was tightly linked to financial distress[12]. In fact, they concluded that experiencing financial loss was more important than any personal characteristic in predicting psychological distress and that it was an additional risk factor for developing clinically negative psychological symptoms[12]. Risk factors for negative mental health outcomes post-disaster include younger age groups, female sex assigned at birth, or having a previous psychological diagnosis or mental health problems[13].

Psychological Effects of Hurricanes

A systematic literature review on the impact of natural disasters on vulnerable populations conducted in 2018 found that adverse psychological outcomes was exacerbated after natural disasters[5]. They described how extreme weather events can lead to elevated rates of depression, anxiety, post-traumatic stress disorder (PTSD), substance abuse, and suicide[5].

A study on the financial and psychological impact of Hurricane Hugo in South Carolina found that the compounding effects of experiencing a crisis and the loss of resources, possessions, social support, and daily routine, were associated with greater psychological distress[12]. Similarly, a study on low-income mothers who experienced Hurricane Katrina found that one in six participants had post-traumatic stress symptoms 12 years after the hurricane, indicative of possible PTSD[14]. When comparing the levels of psychological distress amongst the women before the hurricane with their distress level after the hurricane, they found that psychological distress among the women was higher post-hurricane compared to pre-disaster period[14]. Although physical health plays a major role in natural disaster morbidity, mental health effects affect a larger number of people and, in many cases, has the potential to last longer[11].

Psychological Effects of Earthquakes

Exposure to earthquakes has also been linked to adverse psychological outcomes. Earthquakes of larger magnitudes and greater physical deterioration are studied to a greater extent than earthquakes of lesser magnitudes. One extensively studied earthquake is the 8.0 magnitude earthquake that struck Loreto, Peru in 2007[15]. In a cross-sectional study among 298 adults who experienced this earthquake, it was found that 25% of the study sample had PTSD 5 months after the natural disaster[15]. They also found associations between having PTSD and being female, and having low levels of family and friend support[15]. A more recent and less studied earthquake event in Peru is the 6.1 magnitude earthquake that struck Piura in 2021[16]. A preliminary analysis performed on 177 individuals who experienced the event found that presence of depressive symptoms was associated with housing damage[16].

Puerto Rico: Vulnerability to Natural Disasters

The extensive literature on the financial and mental health effects of natural disasters creates a worrisome picture for vulnerable countries and regions frequently affected by hurricanes and earthquakes. One understudied yet highly vulnerable region is Puerto Rico.

Due to Puerto Rico's location in the Caribbean basin, it is frequently affected by harsh weather [17] and earthquakes[18]. The island is extremely vulnerable to these events due to the amount of housing built in regions prone to flooding and ground slides[19]. There is an estimated 389,000 people who live in flood-prone areas and more than 75,000 housing units that don't comply with the safety standard of construction[19]. Additionally, Puerto Rico has experienced some of the worst natural disasters in recent history, with Hurricane María in 2017[17] and the sequence of tremors in 2020[18]. Hurricane María was a category 4 hurricane that decimated the power grid, caused extreme structural damage, and disrupted infrastructures across the island[20]. The toll was not equally distributed however, with more vulnerable populations experiencing greater and longer duration of hardships[20]. The sequence of tremors of 2020 had its epicenter in the Southern region of the island[21]. The most powerful earthquake was of 6.4-magnitude and it was followed by powerful shock waves across the island for months[21]. These events coincided with political unrest due to scandals of corruption in the midst of natural disaster recovery[22] on top of a historically long financial crisis that is reflected in the island's high poverty rate (amongst the highest in the US) [23]. This is particularly important and relevant since socially vulnerable people, such as those with low-income status and limited access to resources, are at higher risk of adverse mental health outcomes after natural disasters[24].

The cyclical nature of natural disasters in Puerto Rico (as demonstrated by hurricane María quickly followed with the sequence of tremors) contributes to existing trauma and increases the risk of adverse psychological outcomes[25]. Before these events, more than 15% of residents of Puerto Rico were experiencing a psychological pathology[26]; including *ataque de nervios*, a cultural response to acute stressful experiences[27]. Studies documenting risk of adverse psychological outcomes on the island after these events found elevated symptoms of depression, anxiety, and PTSD in sample populations[28,20,25].

Puerto Rico: The Financial and Psychological Toll of Natural Disasters

Financial Toll of Hurricane María

It is important to discuss the impact of these recent natural disasters at the individual and societal level in Puerto Rico, since both affect the ability to overcome disparities caused by these events. One pilot study conducted after Hurricane María characterized the population of Punta Santiago, a low-income town in the Southeast corner of the island where hurricane María made landfall[20]. Participants reported losing employment, experiencing a decrease in productivity, and depending on aid for basic necessities[20]. These individual-level changes are coupled with the greater changes caused by María. Hurricane María propelled Puerto Rico into an economic crisis by damaging houses, infrastructure, roads, and depleting social capital from public spaces and tourism[19]. Damages caused by the hurricane summed up to an estimated $133 billion in damages, with an estimated 472,000 housing units damaged and 70,000 housing units completely destroyed[19]. The hurricane also caused an island-wide power outage that took months to restore. Rural and underserved regions of Puerto Rico were the hardest hit, where power restoration took the longest[29]. Loss of power led to delayed school and university start and completion of the school year, as well as a general decline in productivity[30, 20].

Financial Toll of Sequence of Tremors

The New York times reported that 8,300 houses were damaged after the initial earthquake of January 7, with about 2,500 homes deemed to be uninhabitable[21]. Although more than 30,000 individuals applied for financial help, only 8,500 applicants had received assistance as of March 2020[21]. One report estimated the damage costs to sum up to $110 million[31]. It is essential to pair this financial disaster with the pending $18 billion in federal funding from the damages of Hurricane María that had not been received at the time of the tremors[31], and the subsequent COVID-19 pandemic. The long-term financial effects of the sequence of tremors have not been reported up to this date.

Psychological Toll of Hurricane María

One cross-sectional study conducted in Punta Santiago, within the region where Hurricane María made landfall in Puerto Rico, found that 66.2% of respondents had clinically significant symptom elevations for major depression, generalized anxiety, or PTSD just 6 months after the storm[20]. A secondary data analysis on the findings of a temporary healthcare unit (THCU) that accommodated patients of low-socioeconomic status highly affected by the destruction of hurricane María in Puerto Rico found that 52% of all the patients treated at the THCU met the criteria for a psychological disorder[24]. Most frequently reported symptoms among this population were feelings of hopelessness (50%), anhedonia (67%), loss of appetite (67%), and concentration problems (42%)[24].

Psychological Toll of Sequence of Tremors

An opinion piece regarding the mental health effects of experiencing the 2020 sequence of tremors in Puerto Rico establishes how the cyclical nature of natural disasters adds on to existing trauma, and the persistence of earthquakes/aftershocks for weeks to months after the initial occurrence create an atmosphere of constant anxiety, fear, and unease[25]. This behavioral pattern was observed after residents in the Southwest corner of the island experienced 44 aftershocks within 8 days of the initial earthquake[32]. Many of the aftershocks occurred at night, increasing the level of anxiety amongst residents and interrupting sleep as individuals were restless and preferred to sleep outside away from the possible collapse of their homes[32]. Dr. Chokroverty highlights how an event similar to this one had not taken place in the island in over 100 years, adding on to the graveness of the traumatic experience[25].

The previously discussed studies have documented the psychological toll and financial toll the passage of Hurricane María caused on individuals on the island. However, these studies are limited to certain regions of the island or have small sample sizes, in addition to lacking a thorough evaluation on how the financial impact of the hurricane relates to psychological distress. Similarly, there is a significant lack of studies on the psychological and financial toll of the sequence of tremors as well as how the financial impact of the tremors relates to psychological distress. Additionally, there is a lack of literature researching what modifiable factors may moderate the financial impact of these natural disasters on psychological distress

post-natural disaster in Puerto Rico. Given the previously discussed vulnerability of the population and the lack of resources due to the financial and political crisis being experienced on the island, it is essential to investigate accessible and cost-efficient ways to address these barriers to health and well-being.

Social Support

One potential factor that may moderate the association between financial impact from natural disasters on psychological distress is social support. Social support is defined as the perception of being cared for and loved, as well as being a member of a network of communication[33]. Different studies have hypothesized and found that social support helps reduce maladaptive responses to stressful life situations[34]. Social support has even been studied in more extreme scenarios of psychological distress, such as natural disasters. For example, one study on the psychological distress among survivors of Hurricane Katrina assessed pre/post-disaster perceived social support[35]. They found that having social support pre-disaster was associated with a decrease in the negative psychological effects of the Hurricane[35]. Based on these findings, they highlighted the importance of bolstering post-disaster social support networks[35]. In fact, social support has been studied as an integral part of post-disaster resiliency. In a study of post-earthquake community response in a small town in Italy, they found an emergence of aftershock economies, societies, communication, and engagement[36]. This phenomenon refers to the rebuilding that occurred as a society through sharing pain, sorrow, and rediscovering joy through widespread support among survivors in the community[36].

Social support may be a promising tool to curve health outcomes, especially in Latin American settings where cultural values are centered on community and family. A small scale study observed this post-disaster behavioral pattern in Puerto Rico, where two communities got together to care for each other after Hurricane María[37]. Existing literature discusses the power social support can have in interventions to improve health outcomes in Puerto Rico, including in settings of disasters[38]. However, no study has investigated this relationship at a greater scale, nor has it directly evaluated its potential moderating role in response to the adverse outcomes of psychological distress associated with financial distress from

natural disasters. Given the aforementioned research gaps, the present study sought to measure excess psychological distress symptoms when exposed to high financial impact from Hurricane María and the 2020 sequence of tremors, as well as the potential moderating effect of social support.

INTRODUCTION

Mounting evidence suggests that natural disasters will continue to increase in frequency and intensity in the upcoming years due to climate change [39]. Puerto Rico (a US territory primarily comprised of Latine persons) is frequently affected by harsh weather and earthquakes. The island has experienced some of the worst natural disasters in recent history, with Hurricane María in 2017 and the sequence of tremors in 2020 [40]. Hurricane María, a category 4 storm, caused over 2,900 excess deaths[41]. The destruction caused by the hurricane to homes, island-wide infrastructure, and roads summed up to $133 billion in damages[19]. The 2020 sequence of tremors started in December 28, 2019, followed by sequential aftershocks, the largest of these was a magnitude 6.4 earthquake on January 7, 2020[18]. The major earthquake damaged 8,300 houses with an estimated total damage cost up to $110 million[31]. These exposures have occurred during a historical 15-year-long financial crisis that is reflected in the island's high poverty rate (amongst the highest in the US) [23].

Natural disasters are associated with a wide range of adverse outcomes that can impact every aspect of a person's or a community's livelihood, including in the financial and economic sphere. For example, the 2005 Hurricane Katrina caused property damage that exceeded $100 billion [6] and further impacted the people's place of relocation, employment, wage, and total income [6]. Similarly, the damages of the 6.7 magnitude Northridge, California earthquake of 1994 totaled to over $20 billion and impacted living arrangements and employment[42]. Other studies have documented that direct disaster victims, (i.e., people whose home was damaged or destroyed) experienced increased financial hardships compared to those who were not directly affected by the disaster, [43] and that the populations who were the most affected by the disaster and least resilient were more likely to be young, in poor health, of low socioeconomic status, and had limited social support[43]. Although the structural and financial impact of both Hurricane María and the 2020 sequence of tremors in Puerto Rico has already been documented at the ecological level, evaluation of the financial impact of these events at the individual level is scarce. Only one study evaluated this after Hurricane María, where job loss, decreased productivity, and dependence on aid for

basic needs were reported after the hurricane among a small sample of 74 residents of Punta Santiago (location where Hurricane María made landfall)[20]. Studies in larger sample sizes, with representation of persons residing across the island (given the magnitude of Hurricane María) and evaluating the financial impact of the 2020 sequence of tremors are needed to deeply understand the potential effects of these events.

The impact of natural disasters on psychological distress has been well studied[5], with studies linking both hurricanes and earthquakes to elevated rates of depression, anxiety, post-traumatic stress disorder (PTSD), substance abuse, and suicide[5,14,16,44]. A few studies have documented the psychological toll of Hurricane María and the 2020 sequence of tremors on persons living in Puerto Rico. The study conducted in Punta Santiago found that 66% of respondents had elevated symptoms of depression, generalized anxiety, or PTSD 6 months after the storm [20]. A report on a temporary healthcare unit serving patients of low-socioeconomic status highly affected by the destruction of hurricane María in Puerto Rico found that 52% met the criteria for a mental health disorder[45]. However, the impact of the 2020 sequence of tremors on psychological distress nor the relationships between the financial impact of Hurricane María and the 2020 sequence of tremors on psychological distress have been evaluated. The cyclical nature of natural disasters adds on to existing trauma, and the persistence of earthquakes/aftershocks for weeks to months after the initial occurrence might have created an atmosphere of constant distress[25]. In light of this cyclical trend, there is a need for a sustainable approach to mitigate psychological distress.

Some studies have identified the importance of social support to moderate psychological distress following natural disasters. Among survivors of Hurricane Katrina, a study assessed pre/post-disaster perceived social support [35] and found that having social support pre-disaster decreased the negative psychological effects of the Hurricane [35]. This highlights the importance of bolstering post-disaster social support networks [35]. Social support is a powerful tool to curve health outcomes, especially in Latin American settings where cultural values are centered on family. There is evidence on the power social support can have in interventions to improve health outcomes in Puerto Rico, including in settings of

disasters [38]. However, there are no studies evaluating the moderating role of social support on financial and psychological distress post-natural disaster on the island. Thus, given this knowledge gap, the lack of studies on the financial impact of Hurricane María and the 2020 sequence of tremors on psychological distress, the vulnerability of the Puerto Rico population to natural disasters, this study sought to examine the association between the financial impact of Hurricane María and the 2020 sequence of tremors, and psychological distress among young adults in Puerto Rico; and explored the moderating role of social support in these associations.

METHODS

Study Sample

Data for this cross-sectional secondary analysis came from the Puerto Rico Young Adults' Stress, Contextual, Behavioral & Cardiometabolic Risk (PR-OUTLOOK) study. PR-OUTLOOK is an ongoing cohort study of young adults residing in Puerto Rico. Eligible participants were between the ages of 18 and 29; self-identified as Puerto Rican, were born in Puerto Rico, or at least had one Puerto Rican-born parent; were not in active military duty; and did not have a history of cognitive, physical, or psychiatric conditions that could interfere with study completion. Participants were recruited through social media, media outlets, email blasts in academic institutions, and in community events starting in September 2020. Participants completed a baseline online survey and in-person clinical assessment. PR-OUTLOOK is a joint research project among the University of Massachusetts (MA) Chan Medical School (Worcester, MA), University of Massachusetts Lowell (Lowell, MA), the University of Puerto Rico Medical Sciences (San Juan, Puerto Rico) and Mayaguez Campus (Mayaguez, Puerto Rico), the Fundación de Investigación (FDI) Clinical Research (San Juan, Puerto Rico), and the Harvard T.H. Chan School of Public Health (Boston, MA). Data for the current analysis came from the following questionnaires: socio-demographic characteristics, mental health outcomes, health behaviors, self-reported diagnosis of chronic disease, social-support, and financial impact.

A total of 1,505 individuals were enrolled in PR-OUTLOOK and had completed the baseline survey at the time of analysis. Of these individuals, we excluded those who had missing data on exposure (n=3), covariates (n=15), or outcomes (n=3). Thus, a total of 1,484 participants were included in this analysis.

Variables and Measures

Financial impact from Hurricane María and the 2020 sequences of tremors. This was assessed using two individual items. Participants were asked "How much was your financial situation affected after Hurricane María?" and "How much was your financial situation affected after the tremors/earthquakes?". There were 4 response options: not impacted, little impact, some impact, impacted a lot. These were dichotomized for analysis into low ('no/little impact' responses) and high ('some/a lot' responses).

Symptoms of depression. These were assessed with the widely used Center for Epidemiological Studies Depression (CESD) 10-item scale[46]. This scale asks about the frequency of depressed mood, feelings of guilt and worthlessness, helplessness and hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance in the previous week. Responses are based on a 4-point scale ranging from "rarely or none of the time" to "most or all the time". A depression score is calculated by adding responses to all items (score range: 0-30). Higher scores suggest greater depression symptoms. For this analysis, depression was dichotomized using a cut-off of 10 or greater to identify persons with elevated depression symptoms as defined in previous studies[47].

Symptoms of anxiety. These were assessed using the Spielberger Trait Anxiety 10-item scale[48]. This scale asks about the tendency to feel apprehension, worry, nervousness, and tension in the previous week. Response options range from "almost never" to "almost always". An anxiety score is calculated by adding responses to all items (score range: 0-30). For this analysis, anxiety was dichotomized using the top quartile as the cut-off score to identify individuals with elevated anxiety symptoms, given the lack of validated cutoffs for this scale.

Symptoms of post-traumatic stress disorder (PTSD). These were assessed using the PTSD Civilian Abbreviated Scale[49]. Two specific items were used that measure disturbing memories of an adverse event and feelings of distress due to these memories in the previous month. Response options to both items were on a 5-point scale and ranged from 'not at all' to 'extremely'. A score was calculated by summing up both items. PTSD was dichotomized as in prior studies by using a cut-off of 4 points or greater to identify persons with elevated symptoms of PTSD[49].

Ataque de nervios. These experiences were assessed using one single item previously used in the National Latino and Asian American Survey[50]. The question asked "Have you ever had an *ataque de nervios* in which you felt you had no control?", to which participants responded yes or no.

Perceived stress. This was assessed using the widely used Perceived Stress Scale (PSS-4), a 4-item questionnaire that assesses stress levels in young adults and adults[51]. A total score is calculated by summing responses to all items. Higher scores indicate higher levels of perceived stress. For this analysis, perceived stress was dichotomized using a score of 6 or greater, a cutoff that has been used in previous studies[52,53].

Social support. This was measured with the Midlife in the United States (MIDUS) study scale[54]. This scale consists of 17 items, subdivided into three categories: partner support (i.e., "How much does your partner care about you?"), family support (i.e., "How well do your family members understand how you feel about different things?"), and friend support (i.e., "How much could you count on your friends if you had a serious problem?"). Response options for all items were on a 4-point scale ("not at all" – "a lot"). The score for each subscale was calculated by adding up the items and dividing them by the total number of items within the subscale. A general score was then computed by averaging the three subscales (if the participant did not have a partner, the general score consisted of the family and friends' subscale). Social support was further categorized using population-based cutoffs (quartiles) and evaluated as a categorical variable.

Covariates. Covariates considered for this analysis were selected according to the literature and included age, sex, education, childhood material deprivation, marital status, work status, physical activity, income, perceived sleep quality, chronic disease, and vaping[14,15,41]. Age, sex, highest level of education, and income were self-reported at the time of study assessment. Perceived sleep quality was assessed with one item that asked "In general, in the last 4 weeks, your typical nighttime sleep was" with response options: extremely uneasy, uneasy, medium quality, extremely profound, or profound. Material deprivation during childhood was assessed with one item that asked, "When you were a child, did your family have difficulties paying for basic needs (i.e., food, housing, healthcare and public services)?". Responses were yes/no. Marital status was dichotomized into married or living with their partner vs. single, widowed, divorced, and separated. Physical activity (PA) was assessed with the Women's Health Initiative Physical Activity Questionnaire[55]. Usual number of days in the week and duration in minutes of light, moderate, and vigorous physical activity were calculated and categorized according to the CDC recommendation of 150 min of PA per week[55,56]. Vaping was reported as never vaping, former vaping, or current vaping. Work status was self-reported by answering the question "What is your current work situation?" with possible responses being: not working, stay at home, working. Lastly, a chronic disease variable was created by adding up all the reported chronic diseases and categorizing it by having 0, 1, 2 or more reported chronic diseases. Chronic diseases included in the data collection were elevated blood pressure, diabetes, elevated cholesterol, angina, history of heart attack, arrhythmia, and peripheral artery diseases.

Statistical Analysis

Differences in sample characteristics across source (Hurricane María or 2020 sequence of tremors) and level (high vs low) of financial impact were examined using chi-square tests for categorical variables and T-tests for continuous variables. Unadjusted and adjusted logistic regression models with robust error variance were used to estimate prevalence ratios (PR) and their respective 95% confidence intervals (CI) across each level of financial impact for each mental health outcome using low financial impact as the reference. The potential moderating effect of social support was evaluated using multiplicative interaction

terms with each of the exposures. Likelihood ratio test were used to determine significance of the interaction term. Statistical analysis was conducted using SAS 9.4. Significance was set at $p<0.05$.

RESULTS

Sociodemographic and behavioral characteristics of the total sample and by financial impact of each natural disaster are shown in Table 1. The overall sample had a mean age of 22.5±3 years, 63.9% were female, 11.5% were married or living with partner, and half of the total sample reported that they were not working. Nearly one-third of the total sample reported less than high school education, having experienced childhood material deprivation, and an annual household income between $20,000 and $49,999. A large proportion of the sample (44%) reported high financial impact from Hurricane María, whereas this was 10% for the 2020 sequence of tremors. There were significant differences in sample characteristics by level of financial impact caused by Hurricane María and the 2020 sequence of tremors; with those experiencing higher financial impact by either of these natural disasters reporting lower annual income, greater childhood deprivation, and to be currently working (Table 1). There was also a statistically significant difference in education levels, with fewer reports of postgraduate education among those experiencing high financial impact by Hurricane María. In addition, people with high financial impact from the 2020 sequence of tremors reported a greater number of chronic diseases than those with low financial impact (Table 1).

A large proportion of the sample experienced psychological distress (Figure 1). Overall, 60% had elevated depression symptoms, 65% elevated perceived stress, 77% elevated symptoms of PTSD, 54% reported experiences of *ataque de nervios*, and 24% had elevated anxiety symptoms. Bivariate analysis showed that the proportion of people who experienced elevated symptoms of all outcomes (elevated symptoms of PTSD, depression, anxiety, *ataque de nervios*, and perceived stress) was higher amongst those that experienced high financial stress than those who did not experience high financial stress from either exposure (Hurricane María or the 2020 sequence of tremors).

In the unadjusted regression models (table 2, model 1), having experienced high financial impact from Hurricane María was associated with a higher prevalence of elevated depression symptoms (PR= 1.25, 95% CI=1.15, 1.36), elevated perceived stress (PR= 1.21, 95% CI=1.13, 1.31), elevated PTSD symptoms (PR= 1.13, 95% CI=1.07, 1.20), experiences of *ataque de nervios* (PR= 1.13, 95% CI=1.03, 1.24), and elevated anxiety symptoms (PR= 1.59, 95% CI=1.32, 1.91) when compared to those that experienced low financial impact from Hurricane María. The relationship between high financial impact from Hurricane María and these psychological distress outcomes continued to be significant after adjusting for age, sex, education, childhood material deprivation, chronic disease, marital status, vaping, physical activity, and sleep quality, with the exception of *ataque de nervios* where the relationship was no longer significant (table 2, models 2-3). There was no significant interaction between social support and financial impact from Hurricane María for any of the outcomes evaluated. After including social support in regression models (table 2, model 4), high financial impact from Hurricane María remained significantly associated with higher prevalence of elevated depression symptoms (PR= 1.15, 95% CI=1.06, 1.25), elevated perceived stress (PR= 1.14, 95% CI=1.06, 1.23), and experiences of anxiety symptoms (PR= 1.41, 95% CI=1.17, 1.69); it no longer remained significant for PTSD symptoms.

Unadjusted models (table 2, model 1) for the relationship between having experienced high financial impact from the 2020 sequence of tremors and poor mental health outcomes show that high financial impact was associated with a higher prevalence of elevated symptoms of depression (PR= 1.30, 95% CI=1.17, 1.44) and of perceived stress (PR= 1.20, 95% CI=1.09, 1.33), when compared to those that experienced low financial impact from the 2020 sequence of tremors. The relationship between high financial impact from the 2020 sequence of tremors and these outcomes of psychological distress continued to be significant after adjusting for age, sex, education, childhood material deprivation, chronic disease, and marital status (table 2, model 2). Nevertheless, after adjusting for vaping, physical activity, and sleep quality, only higher prevalence of elevated depression symptoms remained significant (PR=1.12, 95% CI= 1.03, 1.21) (table 2, model 3). Similar to the moderation analysis conducted for

financial impact from Hurricane María, no significant interaction with social support was found in the relationship between financial impact from the 2020 sequence of tremors and outcomes of psychological distress. Therefore, model 4 was further adjusted for social support. After this adjustment, high financial impact sequence of tremors continued to be significantly associated with higher prevalence of elevated symptoms of depression (PR= 1.41, 95% CI=1.17, 1.69), and of perceived stress (PR= 1.10, 95% CI=1.01, 1.19) (table 2, model 4).

DISCUSSION

To our knowledge, this is the first study that evaluates the association between financial distress experienced from natural disasters among young adults in Puerto Rico, specifically Hurricane María and the 2020 sequence of tremors in Puerto Rico, and symptoms of psychological distress. This study also examined the moderating role of social support in this relationship. Overall, our results showed that findings differed by exposure and outcome evaluated. Among those who experienced high financial distress due to Hurricane María, there was a higher prevalence of elevated symptoms of depression, perceived stress, and anxiety. Similarly, those who experienced high financial distress due to the 2020 sequence of tremors had a higher prevalence of elevated symptoms of depression and perceived stress.

There was a higher prevalence of persons with elevated symptoms of depression and perceived stress among those who experienced high financial distress from either natural disaster. This aligns with previous studies that identified elevated symptoms of depression as the most frequently reported outcome in the immediate and delayed aftermath of Hurricane Maria [24,20]. Studies on earthquakes that affected other countries also found an increased reports of depression among the population affected [57,58]. Furthermore, other studies also found perceived stress to be significantly associated with experiencing natural disasters[59]. However, our study goes a step further and makes a unique contribution to the body of work on natural disasters and psychological distress by focusing on and highlighting the financial impact of such events as a potentially important predictor of depression symptoms, but longitudinal studies are needed to continue monitoring these associations.

A higher prevalence of elevated symptoms of anxiety was found in those with high financial distress caused by Hurricane María. This aligns with other studies that found elevated levels of anxiety symptoms in the immediate and long-term aftermath of Hurricane María[20,24] as well as studies on different hurricanes that identified financial losses and property damage as significant predictors of distress[44]. Contrarily, we found no elevated symptoms of anxiety among those who experienced financial distress from the 2020 sequence of tremors. One study on a major earthquake in northern Peru found that anxiety symptoms were associated with physical injury; while depression was associated with housing damage[16]. Given that reports on the toll of the tremors on affected communities in Puerto Rico highlighted housing damage rather than injuries,[21] this may help understand the lack of association with elevated symptoms of anxiety. More detailed data on how financial distress is experienced is needed to better understand the relationship between financial distress and elevated symptoms of anxiety.

Experiencing any of the exposures was not associated with a higher prevalence of experiences of *ataque de nervios*. The lack of association between either exposure event and this specific outcome can potentially be attributed to *ataque de nervios* being an acute experience. Studies have shown that people who report having experiences of *ataque de nervios* describe similar symptoms and meet diagnostic criteria for panic attacks/disorders[50,60]. Similar to panic attacks, the experienced effects of *ataque de nervios* could potentially be short-lasting, and thus not captured in the timeframe of data collection[61]. Furthermore, there are no studies on the relationship between experiencing financial distress and *ataque de nervios*; thus, this potential relationship is unknown and understudied. Further research is necessary to better understand *ataque de nervios* in the context of financial distress experienced from natural disasters.

This study did not find a significant association between financial distress from either natural disaster and elevated symptoms of PTSD. Although contrary to what we had hypothesized, one other study may help understand and support our results. This study documented that, among adults in Puerto Rico who experienced Hurricane María, there was no association between hurricane-related adverse exposures related to property loss and loss of services and elevated symptoms of PTSD[41]. This study only found an

association between greater personal losses and such outcome. Although the exposure of financial distress in this current analysis only asks for general financial distress suffered by either event, it may align more with loss of material resources than personal loss. Further research is necessary to deeply understand the relationship between the financial impact of natural disasters and PTSD symptomology in populations vulnerable to natural disasters.

Our findings also showed that there was no moderating effect of social support in the relationship between the exposures of interest and any of the outcomes. Our initial hypothesis was that social support would buffer the association between financial impact from natural disasters and psychological distress, particularly given the relevance of social connections and the Puerto Rican and Hispanic culture[38]. There are several plausible explanations for this lack of findings. Firstly, the timing of data collection for the social support measure (current) may not reflect social support at the time of Hurricane María and the 2020 sequence of earthquakes. Secondly, as other studies have documented, there is a decline in perceived social support in the months after a natural disaster[62], which may be of particular importance given Puerto Rico's vulnerability to atmospheric and environmental events[41]. Furthermore, Puerto Rico was affected by subsequent extreme weather events and hurricanes after the sequence of tremors in 2020[63]. Although these later events were not assessed in PR-OUTLOOK, they could potentially play a role in the lack of moderation from social support. Lastly, based on Puerto Rico's ongoing financial crisis and alarmingly high poverty rates, it is possible that social support does not mitigate the effects of financial distress on psychological outcomes in disaster settings and that policy changes to increase access to financial and mental health resources are needed. One study on financial development to alleviate negative impact on personal and domestic finance in Pacific small islands concluded that governments should expand financial instruments for disaster risk management, increase financial inclusion by facilitating physical access to financial tools and disseminating financial literacy knowledge, as well as strengthening their national disaster resilience plan[64].

Limitations/Strengths/Future Directions

Our study findings need to be taken with certain limitations in mind. Firstly, due to the cross-sectional nature of this study, causality cannot be inferred. In addition, the study relied on self-report measures of psychological distress outcomes, which may be affected by responder bias. Generalizability of findings is restricted to Puerto Rico given the unique context of the island. Further, findings are also restricted to young adults, and thus future studies should evaluate this relationship in populations of different age ranges. Additionally, because the 2020 sequence of tremors primarily affected the southern region of the island[18], this analytical sample may not capture people who were directly affected or had a close social circle that lived in that region and were affected by the tremors. Lastly, because financial impact was determined by a single item, it may not capture information regarding the duration of financial impact and how it was experienced (loss of goods, loss of housing, or loss of employment).

Despite these limitations, there are multiple strengths to this study. Firstly, it is amongst the first to examine this relationship between financial impact and psychological distress from the recent natural disasters in Puerto Rico using the largest cohort of young adults on the island. It also uses validated questionnaires to assess symptoms of psychological distress and social support [34,46,48–50,53]. Another study strength is the focus on young adults in Puerto Rico, a population that has been disproportionately exposed to uncontrollable adversities and stressors[65], but has remained understudied in research. Lastly, the significant relationship discovered between experiencing financial distress and certain psychological outcomes highlights the need to design and implement financial natural disaster relief efforts and access to mental health resources in future emergencies.

Future studies should continue to explore other facets of financial impact to further understand how certain financial strains and stresses relate to outcomes of psychological distress. Longitudinal studies are needed to monitor psychological distress following natural disasters in this vulnerable group. These studies and others may lead to policies that ensure prompt allocation and access to mental health services and financial assistance in the aftermath of natural disasters.

Public Health Implication

The finding of an association between experiencing financial distress from Hurricane Maria 2017 and the sequence of tremors in 2020 in Puerto Rico, and experiencing psychological distress has important public health implications. These results highlight the potential long-term impacts of natural disasters on individuals' mental health and well-being. They also underscore the need for targeted mental health interventions and support for individuals in the aftermath of natural disasters. Specifically, the findings suggest that future efforts for financial support and assistance with financial stress management as targets and interventions aimed at reducing psychological distress may be particularly important for individuals who have experienced a natural disaster. Adequate preparation and response measures can help to reduce the impact of natural disasters on individuals' health and well-being.

Generally, social support is considered a key factor that can play a protective role in mitigating the negative effects of disasters on mental health. However, these findings suggest that social support may not be as effective in buffering the impact of financial strain on psychological distress as previously hypothesized. This underscores the need for a more nuanced understanding of the role of social support in disaster recovery, including the need for tailored interventions that take into account the specific needs of different populations in a comprehensive and integrated approach to disaster management.

Overall, the finding of an association between financial strain from Hurricane Maria 2017 and psychological distress during the sequence of tremors in 2020 in Puerto Rico emphasizes the need for a comprehensive and coordinated public health approach to disaster management, which includes both financial and mental health resources.

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TABLES

Table 1. Characteristics of PR-OUTLOOK participants in the total sample and by level of financial impact (n=1,484)

Variable	**Total sample** n=1,484 (%)	**Low Financial Impact Hurricane Maria** n=829 (55.9%)	**High Financial Impact Hurricane Maria** n= 655 (44.1%)	P value*	**Low Financial Impact Sequence of Tremors** n= 1343 (90.5%)	**High Financial Impact Sequence of Tremors** n= 141 (9.5%)	P value*
Age, mean (SD)	22.5 (3.0)	22.5(3.0)	22.6 (3.1)	0.522	22.5 (3.0)	22.70 (3.4)	0.482
Female	948 (63.9)	530 (63.9)	418 (63.8)	0.96	854 (63.6)	94 (66.7)	0.469
Annual income				<0.001*			<0.001*
<$20,000	406 (27.4)	175 (21.1)	231 (35.3)		346 (25.8)	60 (42.6)	
$20,000-$49,999	442 (29.8)	235 (28.4)	207 (31.6)		400 (29.8)	42 (29.8)	
>$50,000	397 (26.8)	282 (34.0)	115 (17.6)		373 (27.8)	24 (17.0)	
Missing	239 (16.1)	137 (16.5)	102 (15.6)		224 (16.7)	15 (10.6)	
Education				0.015*			0.355
≤High school	476 (32.1)	273 (32.9)	204 (31.2)		436 (32.5)	40 (28.4)	
Some college	327 (22.0)	168 (20.2)	159 (24.3)		289 (21.5)	38 (27.0)	
College graduate	531 (35.8)	290 (34.9)	242 (37.0)		479 (35.7)	52 (36.9)	
Any Postgraduate education	150 (10.1)	100 (12.0)	50 (7.6)		139 (10.4)	11 (7.8)	
Childhood material deprivation	487 (32.8)	208 (25.1)	279 (42.6)	<0.001*	423 (31.5)	64 (45.4)	0.001*
Married or living with partner	171 (11.5)	87 (10.5)	84 (12.8)	0.163	152 (11.3)	19 (13.5)	0.445
Work Status				0.002*			0.001*
Not working	745 (50.2)	447 (53.9)	298 (45.5)		686 (51.1)	59 (41.8)	

Stay at home	15 (1.0)	5 (0.6)	10 (1.5)		10 (0.7)	5 (3.6)	
Working	724 (48.8)	377 (45.5)	347 (53.0)		647 (48.2)	77 (54.6)	
Meets physical activity recommendation	937 (63.1)	526 (63.5)	411 (62.8)	0.781	844 (62.8)	93 (66.0)	0.466
Vaping				0.190			0.577
Never	883 (59.5)	502 (60.6)	381 (58.2)		795 (59.2)	88 (62.4)	
Former	222 (15.0)	130 (15.7)	92 (14.1)		205 (15.3)	17 (12.1)	
Current	379 (25.5)	197 (23.8)	182 (27.8)		343 (25.5)	36 (25.5)	
Perceived sleep quality				0.278			0.137
Extremely uneasy/uneasy	129 (8.7)	64 (7.7)	65 (9.9)		111 (8.3)	18 (12.8)	
Medium quality	900 (60.7)	513 (61.9)	387 (59.1)		814 (60.6)	86 (61.0)	
Extremely profound/profound	455 (30.6)	252 (30.4)	203 (31.0)		418 (31.1)	37 (26.2)	
Chronic Disease				0.153			0.041*
0 Chronic Diseases self-reported	994 (67.1)	566 (68.3)	428 (65.5)		911 (67.9)	83 (58.9)	
1 Chronic Disease self-reported	351 (23.7)	197 (23.8)	154 (23.6)		313 (23.3)	38 (27.0)	
2+ Chronic Diseases self-reported	137 (9.2)	66 (8.0)	71 (10.9)		117 (8.7)	20 (14.2)	

Table 2. Prevalence ratios of psychological distress variables by financial impact of natural disasters among PR-OUTLOOK participants.

	Depression symptoms PR (95% CI)	**Perceived stress** PR (95% CI)	**PTSD** PR (95% CI)	**Ataque de nervios** PR (95% CI)	**Anxiety** PR (95% CI)
Model 1					
Low Financial Impact Hurricane Maria	1.00	1.00	1.00	1.00	1.00
High Financial Impact Hurricane Maria	1.25 (1.15, 1.36)	1.21 (1.13, 1.31)	1.13 (1.07, 1.20)	1.13 (1.03, 1.24)	1.59 (1.32, 1.91)
Low Financial Impact Sequence of Tremors	1.00	1.00	1.00	1.00	1.00
High Financial Impact Sequence of Tremors	1.30 (1.17, 1.44)	1.20 (1.09, 1.33)	1.08 (0.99, 1.17)	1.14 (0.99, 1.31)	1.23 (0.93, 1.63)
Model 2					
Low Financial Impact Hurricane Maria	1.00	1.00	1.00	1.00	1.00
High Financial Impact Hurricane Maria	1.20 (1.10, 1.30)	1.16 (1.08, 1.25)	1.09 (1.03, 1.15)	1.08 (0.99, 1.19)	1.47 (1.22, 1.77)
Low Financial Impact Sequence of Tremors	1.00	1.00	1.00	1.00	1.00
High Financial Impact Sequence of Tremors	1.20 (1.09, 1.33)	1.13 (1.03, 1.24)	1.02 (0.95, 1.10)	1.06 (0.93, 1.21)	1.10 (0.83, 1.44)
Model 3					
Low Financial Impact Hurricane Maria	1.00	1.00	1.00	1.00	1.00
High Financial Impact Hurricane Maria	1.17 (1.10, 1.27)	1.11 (1.04, 1.18)	1.06 (1.01, 1.11)	1.07 (0.98, 1.16)	1.46 (1.21, 1.76)
Low Financial Impact Sequence of Tremors	1.00	1.00	1.00	1.00	1.00
High Financial Impact Sequence of Tremors	1.12 (1.03, 1.21)	1.07 (1.00, 1.15)	1.03 (0.96, 1.10)	1.03 (0.92, 1.17)	1.13 (0.86, 1.49)
Model 4					

Low Financial Impact Hurricane Maria	1.00	1.00	1.00	1.00	1.00
High Financial Impact Hurricane Maria	1.15 (1.06, 1.25)	1.14 (1.06, 1.23)	1.05 (1.00, 1.11)	1.08 (0.99, 1.19)	1.41 (1.17, 1.69)
Low Financial Impact Sequence of Tremors	1.00	1.00	1.00	1.00	1.00
High Financial Impact Sequence of Tremors	1.41 (1.17, 1.69)	1.10 (1.01, 1.19)	1.03 (0.96, 1.10)	1.06 (0.93, 1.21)	1.06 (0.93, 1.39)

Model 1: Unadjusted

Model 2: Adjusted for age, sex, education, childhood material deprivation, chronic disease, and marital status.

Model 3: Adjusted for model 2 factors, vaping, physical activity, and sleep quality.

Model 4: Adjusted for model 3 factors and social support.

FIGURES

Figure 1. Psychological distress measures among PR-OUTLOOK participants by financial impact. (n=1,484)

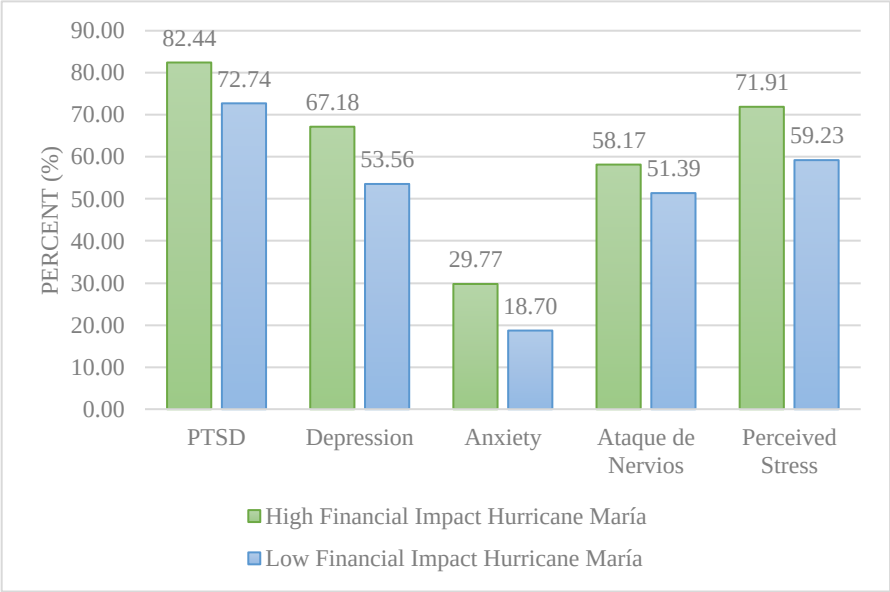

Figure 1.a. Psychological distress among PR-Outlook participants who experienced high and low financial impact from Hurricane María

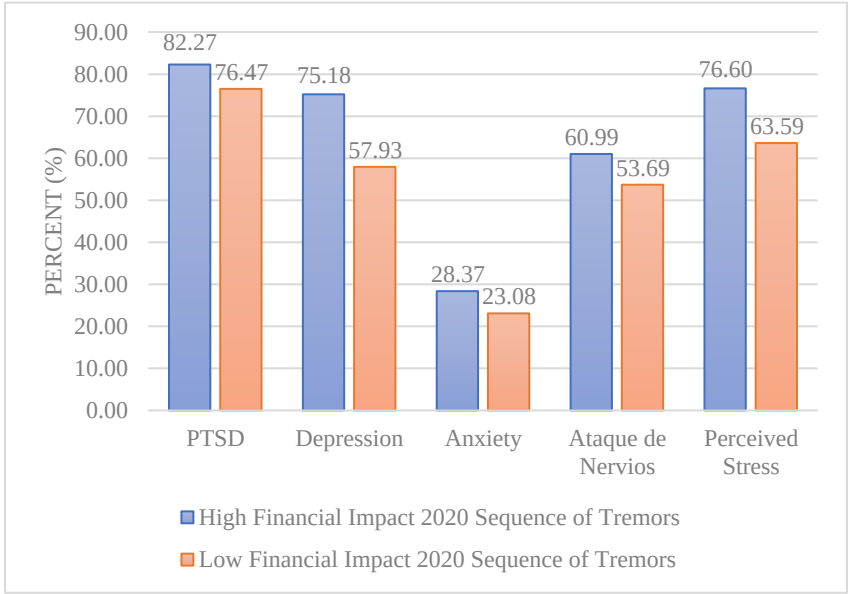

Figure 1.b. Psychological distress among PR-Outlook participants who experienced high and low financial impact from the Sequence of Tremors of 2020