POSTTRAUMATIC GROWTH IN THE CLIMATE CHANGE CONTEXT: PROTECTIVE FACTORS AMONG UNIVERSITY STUDENTS DURING HURRICANE MARIA

CRECIMIENTO POSTRAUMÁTICO ANTE EL CAMBIO CLIMÁTICO: FACTORES PROTECTORES EN UNIVERSITARIOS DURANTE EL HURACÁN MARÍA

Recibido: 10 de febrero de 2025 | Aceptado: 1 de diciembre de 2025
DOI: https://doi.org/10.55611/reps.3603.02

Valerie M. **González Velázquez** [1], Aida L. **Jiménez Torres** [1], Lisa **Fortuna** [2],
Michelle V. **Porche** [2], Jesús J. **Marrero-Centeno** [1]

[1.] Universidad de Puerto Rico, Recinto de Río Piedras, San Juan, Puerto Rico
[2.] University of California, Riverside, California, United States of America

ABSTRACT

Climate change threats have prompted research documenting their negative psychological impacts, such as posttraumatic stress, on the population. However, some individuals do not develop clinical symptoms after a disaster. Posttraumatic growth (PTG) helps explain this phenomenon by highlighting positive transformations that facilitate coping during potentially traumatic situations. Other protective factors, such as self-efficacy and spirituality, can also promote well-being, strengthening individuals facing adversity. Our study identified factors related to PTG and explored whether spirituality moderated the relationship between self-efficacy and PTG. We employed a quantitative, cross-sectional correlational design to assess the relationship between self-efficacy, spiritual well-being, sociocultural factors, and PTG. Our sample consisted of 158 university students in Puerto Rico, surveyed one year after Hurricane Maria. We found that self-efficacy and spiritual well-being were positively and significantly correlated with PTG but spiritual well-being did not statistically moderate the relationship between self-efficacy and PTG. Hierarchical multiple linear regression analyses indicated that self-efficacy, elevated adverse perceptions of Hurricane Maria's impact, and spiritual well-being significantly contributed to PTG in our sample. Our findings highlighted the importance of promoting factors that support PTG in student populations and emphasized protective factors to consider when developing practices for student psychological well-being.

KEYWORDS: posttraumatic growth, self-efficacy, spirituality, university students, climate change.

RESUMEN

Las amenazas del cambio climático han generado investigaciones enfocadas en documentar sus impactos psicológicos negativos, pero hay personas que no desarrollan síntomas clínicos tras un desastre. El crecimiento postraumático (CPT) ayuda a explicar este fenómeno y resalta transformaciones positivas que facilitan el afrontamiento. Otros factores, como la autoeficacia (AE) y la espiritualidad (ES), también promueven sentimientos de fortalecimiento ante la adversidad. Nuestro estudio propuso identificar factores relacionados al CPT y explorar si ES moderaba la relación entre AE y CPT. Utilizamos un diseño correlacional transversal para evaluar la relación entre AE, ES, los factores socioculturales y CPT. La muestra consistió en 158 personas estudiantes universitarias en Puerto Rico, un año después del huracán María. Nuestros resultados resaltaron que AE y ES se correlacionaron positiva y significativamente con CPT, pero ES no moderó estadísticamente la relación entre AE y CPT. Los análisis de regresión lineal múltiple jerárquica indicaron que AE, las percepciones elevadas del impacto del huracán María y ES contribuyeron al CPT en la muestra. Destacamos la importancia de promover factores que fomenten CPT en las poblaciones estudiantiles y enfatizamos los factores protectores a considerar al desarrollar prácticas para el bienestar psicológico de esta población.

PALABRAS CLAVE: crecimiento postraumático, autoeficacia, espiritualidad, población universitaria estudiantil, cambio climático.

Correspondencia de este artículo debe ser dirigida a Valerie M. González Velázquez. E-mail: valerie.gonzalez6@upr.edu

Climate change presents a profound threat to communities worldwide. The 2024 Lancet Countdown report highlights how the rising frequency of climate-related disasters endangers both present and future generations (Romanello et al., 2024). Increasing global temperatures intensify hurricanes, floods and droughts, producing severe and often irreversible ecological and social losses (Intergovernmental Panel on Climate Change [IPCC], 2023). The World Health Organization (WHO, 2023) estimates that 3.6 billion people reside in regions highly vulnerable to such disasters, where mortality rates are up to fifteen times higher than in less exposed areas (IPCC, 2023). Communities in the Caribbean are disproportionally affected, facing interwined social, cultural, and historical challenges that limit their capacity to prepare for and recover from these crises (Cianconi et al., 2020; Fortuna et al., 2024 Hagen et al., 2022). These circumstances underscore the urgency of addressing climate vulnerability through culturally grounded approaches.

Growing research documents the psychosocial consequences of climate-related disasters. Physical health outcomes include increased rates of infectious, respiratory, and cardiovascular diseases (Rocque et al., 2021), while mental health outcomes such as depression, anxiety, and posttraumatic stress, have become mayor concerns (Nie et al., 2024). Studies worldwide report elevated psychological distress following hurricanes, floods, wildfires, and earthquakes (Bradwell & Lee, 2019; Hudson, 2018; Vafeiadou et al., 2023), particularly among groups facing socioeconomic instability and limited access to care (Caruso, 2017).

In Puerto Rico, a U.S. territory recurrently impacted by hurricanes and earthquakes, research following Hurricane María (which struck the island in 2017) has documented adverse psychological and academic outcomes, including posttraumatic stress symptoms (Orengo-Aguayo et al., 2019; Vázquez Torres, 2021). Although most studies have not explicitly assessed climate change worry, they provide valuable insight into the mental health burden of climate-related disasters. Recent evidence among Puerto Rican university students showed that 59.3% reported moderate to severe depressive symptoms and 36.2% reported moderate to extremely severe stress levels following multiple disasters (Jiménez et al., 2024). Jiménez et al. (2024) noted that these disasters included Hurricane María, the 2020 earthquakes, and the COVID-19 pandemic, all of which affected students living within an already fragile socioeconomic and political context in Puerto Rico. These findings align with evidence that, although acute distress is common after trauma, most individuals do not develop enduring disorders (Tedeschi & Calhoun, 1996). Instead, they recover and depend on protective factors that buffer the effects of disaster exposure (Charlson et al., 2021; Crane et al., 2022).

The concept of posttraumatic growth (PTG) provides a valuable framework for understanding positive psychological adaptation after adversity. PTG refers to transformative personal development across five domains: appreciation for life, improved relationships, personal strength, new possibilities, and spiritual growth (Tedeschi & Calhoun, 1996). Studies indicate that PTG is associated with cognitive reappraisal, meaning-making, and other adaptive coping processes (Henson et al., 2020). In disaster contexts, PTG varies according to sociodemographic factors, social support, psychological distress, and time since the event (Amiri et al., 2021; Arias & García, 2019; Jiménez et al., 2024).

Among the predictors of PTG, self-efficacy and spirituality have drawn growing attention. Self-efficacy, the belief in one's ability to manage challenges, is linked to lower posttraumatic stress and greater PTG (Di Corrado et al., 2022; Robles-Bello et al., 2022; Xu et al., 2023). Likewise, spirituality offers a key psychological and communal resource that fosters hope, meaning, and collective recovery (Davis et al., 2019; de Brito Sena et

al., 2021). Studies from diverse disaster contexts, including Hurricane Katrina and the 2016 Alberta Wildfires, demonstrate that faith-based practices nurture spiritual meaning and facilitate resilience and growth (Alawiyah et al., 2011; Lalani et al, 2021). Systematic reviews confirm that spiritual meaning can buffer the psychological impact of disaster and promote PTG (Aten et al., 2019; Haynes et al., 2017). In Hispanic and Puerto Rican contexts, spirituality and family cohesion are core sociocultural resources that sustain well-being and resilience (Sampson et al., 2024; Valdivieso-Mora et al., 2016). Family networks often serve as sources of emotional, financial, and spiritual support, reflecting collectivist values that foster solidarity and belonging. These culturally grounded factors may enhance coping and facilitate PTG by promoting meaning, connection, and mutual care during prolonged recovery.

Despite growing evidence, few studies have simultaneously examined self-efficacy and spirituality as predictors of PTG in Caribbean or Latin American populations affected by climate-related disasters. Limited findings from other contexts suggest that spirituality may strengthen the link between self-efficacy and adaptive outcomes (Israel-Cohen et al., 2016; Sehra & Mishra, 2022). To our knowledge, no published studies have explored this interaction among Puerto Rican university students exposed to multiple disasters.

Guided by the posttraumatic growth framework, this study aimed to identify factors associated with PTG and to examine whether spirituality moderates the relationship between self-efficacy and PTG among university students in Puerto Rico who experienced Hurricane Maria and subsequent adversities. We hypothesized that higher levels of self-efficacy, spirituality, and family support would be positively associated with PTG among university students, and that spirituality would moderate the relationship between self-efficacy and PTG. Moreover, we expected that spirituality, self-efficacy, family support, and perceived impact of the hurricane on mental health would significantly predict PTG, even after controlling for demographic and psychological variables.

METHOD

In this quantitative study, we employed a cross-sectional, correlational design to examine the associations among self-efficacy, spirituality, sociocultural factors, and posttraumatic growth (PTG) among university students.

Participants

The sample consisted of 158 students from the University of Puerto Rico, Río Piedras Campus (UPR-RP), 77% of whom identified as female, 21% as male, and 2% as transgender or other identities. Participants' ages ranged from 18 to 60 years (M = 23.34, SD = 5.37). Most students (92.2%) were between 18 and 29 years, and 7.8% were 30 years or older. The vast majority identified as Puerto Rican (97%), with a small proportion identified as Dominican (1%), or other nationalities (2%). Most participants were undergraduate students (74.7%), resided in urban areas (71.5%), and identified as single (84.2%). Accounting for missing values, we found that approximately half (53.2%) of the participating students were employed, 39.2% were unemployed, and 7.0% did not respond. Despite missing values, this item reflected participant's employment status at the time of response. In terms of socioeconomic status, 48.7% described themselves as middle-class, 41.1% reported belonging to lower-middle socioeconomic groups, 7.6% stated belonging to upper-middle class socioeconomic groups, 0.7% described themselves as upper class, and the remaining 1.9% did not respond.

Procedure

This study was approved by the Institutional Review Board of the University of Puerto Rico, Rio Piedras Campus (IRB-UPRRP#2324-182) and is based on a secondary analysis of data collected in the 2019 study "Overcoming Uncertainty: University Students' Academic

Experience Perspectives Related to Hurricane María" (IRB-UPRRP#1920-004). Participants completed an online questionnaire via Google Forms, which required approximately 15 minutes to complete. Recruitment occurred through institutional email invitations and flyers posted on campus containing study information and a survey link. Eligibility criteria included being 18 years of age or older, fluent in Spanish, and enrolled part-time or full-time at UPR-RP during the aftermath of Hurricane Maria (2017). Participants provided electronic informed consent prior to beginning the survey. The researchers who conducted the original study did not offer monetary or academic incentives. Data collection took place between August and December 2019.

The questionnaire consisted primarily of numerical items, minimizing the need for data transformation and ensuring the accuracy of the dataset. The researchers who conducted the original study collected quantitative variables using numerical response formats (e.g., Likert-type scales, single-value entries), eliminating the need to convert string-based responses into numeric codes. Prior to conducting the analyses, we performed standard data-screening procedures, including detection of duplicate entries, and response inconsistencies. We did not detect automated responses.

Participants could skip any survey item, including sociodemographic questions, as the platform did not require forced responses. The two open-ended sociodemographic questions, municipality of residence and municipality of origin, were the only items recorded in text format. Importantly, we did not collect or used personally identifiable information (e.g., names, email addresses, phone numbers, IP addresses) in this secondary analysis.

Measures

We assessed sociodemographic, psychological, and sociocultural variables. We conceptualized sociocultural factors, spirituality, family well-being, and perceived impact of Hurricane María as culturally embedded variables reflecting connectedness, interdependence, and subjective appraisal of adversity. The following instruments were used to measure the study variables:

Sociodemographic Survey

The sociodemographic questionnaire gathered demographic and contextual information, including age, gender, marital status, residential zone (urban/rural), level of education, employment status, and socioeconomic status.

Perceived Impact of Hurricane María

We drew this variable from the sociodemographic questionnaire and conceptualized it as a sociocultural contextual factor, reflecting participants' subjective appraisal of the disaster's psychological impact within their social and cultural environment. We assessed it using a single global item: "How would you describe Hurricane Maria's impact on your mental health?". Responses were recorded on a 5-point Likert-scale ranging from 0 (*no impact*) to 4 (*severe impact*). Single-item measures have been supported for concrete constructs and in post-disaster research where brevity is essential (Fisher et al., 2016: Hoeppner et al., 2011). In this sample, 18.1% reported little to no impact, 29.7% moderate impact, and 52.2% high to severe impact. To provide evidence of construct validity, a t-test indicated that participants reporting moderate/high perceived impact showed significantly higher levels of PTG than those reporting no/little impact, $t(147) = -2.80$, $p = .003$, $d = -.46$, supporting the item's validity as a meaningful indicator of perceived psychological impact.

Posttraumatic Growth Inventory (PTGI)

The PTGI is a 21-item self-report measure assessing positive psychological change following a major life crisis (Tedeschi & Calhoun, 1996). Items are rated on a 6-point Likert-scale from 0 (*no change*) to 5 (*very great degree of change*). This study used the Spanish version adapted by Weiss and Berger

(2006), which has shown high internal consistency (α = .94 -.95) across Latin American populations (Arias, 2017; Quezada-Berumen & González-Ramírez, 2020). In this study, internal consistency was excellent (α =.95). The mean score was 54.78 (*SD* = 23.88), and the median score was 55.00, suggesting moderate levels of PTG. Although lower than the means reported in the original and Latin American validation samples, the scores were comparable to those observed in Arkin and colleagues' (2022) post-Hurricane Katrina sample, suggesting temporal decline in PTG.

General Self-Efficacy Scale (GSES)

The GSES (Schwarzer & Jerusalem, 1995; Spanish by Baessler & Schwarzer, 1996) assesses perceived ability to manage life's challenges. It includes 10 items rated on a 4-point Likert-scale from 1 (*never*) to 4 (*always*). The instrument has shown strong psychometric properties in Latin populations (Brenlla et al., 2010; Bueno-Pacheco et al., 2018). In this sample, the reliability was high (α = .91), with a mean score of 30.05 (*SD* = 5.99) and a median score of 31.00 consistent with prior university samples (e.g., Brenlla et al., 2010, *M* = 30.8; Bueno-Pacheco et al., 2018, *M* = 29.4).

Spiritual Well-being Subscale (SWB)

The SWB (Rojas Pérez, 2019) assesses spiritual well-being and engagemet in practices that foster meaning, hope, and connectedness. It includes 21 items rated on a 5-point Likert-scale from 1 (*completely disagree*) to 5 (*completely agree*). Example items include: "My faith provides me with comfort and guidance in difficult times"; "I regularly engage in prayer or meditation." Internal consistency in the original validation was excellent (α = .98); reliability in this study was similarly high (α = .99). The mean score was 66.12 (*SD* = 33.95) and the median was 68.00, slightly lower than Rojas Pérez's (2019) findings (*M* = 88.81, *SD* = 22.24), and reflected moderate spiritual well-being among students.

Familial Well-being Subscale (FWB)

The FWB (Rojas Pérez, 2019) measures perceptions of family functioning, cohesion, and mutual support through 19 items rated on the same 5-point Likert-scale. Example items include: "I feel at peace knowing that my family is protected"; "My family is my reason for moving forward"; "If my family is okay, I am too." This subscale reflects culturally embedded values of interdependence and family-centeredness, central to Latinx communities. In this study, reliability was excellent (α = .94). The mean score was 76.83 (*SD* = 13.38) and the median 78.00 , slightly higher than values reported by Rojas Pérez (2019; *M* = 58.7, *SD* = 6.89), suggesting high perceived family well-being and continued cultural salience among participants.

Data Analyses

We performed all analyses using IBM SPSS Satistics version 31.0.0.0. We calculated descriptive statistics for all variables, including posttraumatic growth (PTG), self-efficacy, family well-being, and spiritual well-being. Prior to inferential testing, we assessed the distribution of continuous variables using the Shapiro-Wilk test. Because several variables deviated from normality, we used Spearman's rank-order correlations to examine associations among self-efficacy, spiritual well-being, family well-being, and PTG. To test whether spiritual well-being moderated the relationship between self-efficacy and PTG, we conducted a hierarchical multiple linear regression. First, we conducted the hierarchical regression analyses reported in Table 2 using a three-model approach. Model 1 included the demographic predictors of age, gender, and Hurricane María impact, all of which we dummy-coded. In Model 2, we added self-efficacy to examine its incremental predictive value beyond demographic factors. Model 3 incorporated all variables from Models 1 and 2, along with the additional predictors of spiritual well-being and family well-being, to evaluate their combined contribution to posttraumatic growth.

In addition to these analyses, we conducted a separate moderation analysis to explore whether spiritual well-being moderated the association between self-efficacy and posttraumatic growth. For this analysis, the first step included self-efficacy and spiritual well-being, entered simultaneously as predictors. In the second step, we entered the interaction term between mean-centered self-efficacy and mean-centered spiritual well-being to test for the presence of a moderation effect.

Prior to regression analysis, we evaluated assumptions of multicollinearity, independence of errors, normality, linearity, and homoscedasticity. Multicollinearity diagnostics indicated no violation, with tolerance values exceeding .30 (lowest = .87), and variance inflation factors (VIFs) below 1.15. The Durbin-Watson statistic (*DW* = 1.91) confirmed independence of residuals. Our visual inspection of residual plots supported assumptions of linearity and homoscedasticity, and residuals appeared approximately normally distributed.

We managed missing values analytically based on the requirements of each statistical test and guided by recommendations from methodological literature. We did not conduct imputations. For descriptive statistics, we used available-case information. For bivariate correlations (Table 1), we applied pairwise deletion, which resulted in an analytic sample of 150 cases for correlations involving variables with missing data. For multiple regression analyses predicting PTG, we used listwise deletion to ensure consistent sample sizes across predictors, yielding 141 cases. These reductions reflect missing values, "prefer not to answer" responses, and cases excluded during data-screening due to extreme outliers that violated statistical assumptions.

RESULTS

Prior to conducting correlational analysis, we assessed the distribution of all continous variables using the Sahpiro-Wilk test. Results indicated that PTG was normally distributed (p = .082), whereas spirtitual well-being, family well-being, and self-efficacy were not (p < .001). Consequently, Spearman's rank-order correlations were used to examine relationships among variables. As shown in Table 1, PTG correlated positively with self-efficacy (r_s = .265, p = .001, 95% CI [.104, .412]), spiritual well-being (r_s = .243, p = .003, 95% CI [.081, .391]), and family well-being (r_s = .323, p < .001, 95% CI [.167, .463]). Family well-being also correlated positively with spiritual well-being (r_s = .293, p < .001, 95% CI [.138, .433]) and self-efficacy (r_s = .225, p = .005, 95% CI [.066, .372]).

TABLE 1.
Correlation Matrix Among Non-Demographic Variables Included in Model 3.

Variable	1	2	3	4
1. Posttraumatic Growth	—			
2. Self-Efficacy	.265**	—		
3. Spiritual Well-Being	.243*	-.038	—	
4. Family Well-Being	.323***	.225**	.293***	—

Note. N = 150. All coefficients are Spearman's r_s.
Two-tailed correlation test. Estimation is based on Fisher's r-to-z transformation.
*p < .05; **p < .01; ***p < .001.

A moderation analysis tested whether spiritual well-being moderated the relationship between self-efficacy and PTG. However, the interaction term was not statistically significant (β = .004, p = .959). In Table 2, we summarize the results of the hierarchical multiple regression predicting PTG. In Model 1, age, gender, and the perceived impact of Hurricane María on mental health (coded 1 = high/severe, 0 = none/mild/moderate; gender coded 1 = female, 0 = male). We entered age as a continuous variable based on theoretical

and statistical considerations (Royston et al., 2006). We retained these predictors as the most theoretically relevant sociodemographic variables associated with PTG and accounted for 4.1% of the variance in PTG (R^2 = .041, p = .034). Adding self-efficacy in Model 2 significantly increased the explained variance (ΔR^2 = .083, p <.001). In Model 3, the inclusion of spiritual well-being and family well-being further improved the model (ΔR^2 = .090, p < .001).

The final Model explained 19.9% of the variance in PTG (R^2 = .199, p < .001). Self-efficacy (β = .285, p < .001), spiritual well-being (β = .224, p = .007), and higher perceived impact of hurricane Maria (β =.230, p =.004) emerged as significant independent predictors. These findings suggest that contextual or sociocultural factors contributed to PTG beyond the effects of demographic variables and self-efficacy. However, family well-being (β = .154, p = .065) did not emerge as a statistical significant independent predictor.

TABLE 2.
Hierarchical Multiple Regression Predicting Posttraumatic Growth.

Predictor	*B*	*SE (B)*	95% CI for *B*	β	*t*	*p*
Model 1						
Age (years) †	0.05	0.09	[–0.11, 0.22]	.052	0.63	.532
Gender (1 = female, 0 = male)	1.73	1.13	[–0.51, 3.96]	.128	1.53	.129
Hurricane María impact (1 = high/severe, 0 = none–moderate)	2.50	0.95	[0.62, 4.37]	.221	2.64	.009**
Model R^2 = .041, p = .034						
Model 2						
Age	0.02	0.08	[–0.14, 0.18]	.020	0.25	.807
Gender	1.53	1.09	[–0.62, 3.67]	.113	1.41	.161
Hurricane María impact	2.56	0.91	[0.79, 4.39]	.229	2.85	.005**
Self-Efficacy	0.27	0.08	[0.22, 0.62]	.290	3.63	< .001***
ΔR^2 = .083, p < .001						
Model 3						
Age	-0.04	0.08	[–0.20, 0.12]	-.038	-0.49	.627
Gender	1.54	1.07	[–0.57, 3.64]	.114	1.44	.152
Hurricane María impact	2.60	0.89	[0.85, 4.36]	.230	2.94	.004**
Self-Efficacy	0.26	0.07	[0.12, 0.41]	.285	3.67	< .001***
Spiritual Well-Being	0.04	0.01	[0.01, 0.06]	.224	2.75	.007**
Family Well-Being	0.07	0.04	[-0.00, 0.13]	.154	1.86	.065
ΔR^2 = .090, p < .001; Final R^2 = .199, p < .001						

Note. N = 141. Age entered as a continuous predictor.
*p < .05; **p < .01; ***p < .001.
† Although age was slightly skewed, diagnostic plots indicated that its inclusion as a continuous variable did not violate regression assumptions.

DISCUSSION

Climate-related disasters have disproportionate effects on vulnerable populations, especially in the Caribbean, where colonial histories, economic dependency, and geographic exposure heighten risk (Cianconi et al., 2020; Lizarralde et al., 2021; Shultz et al., 2019). Yet, limited research has examined protective psychological and social factors that foster recovery (Charlson et al., 2021). In Puerto Rico, the interplay of historical, structural, and socioeconomic inequalities contiinue to exacerbate vulnerability (Eroglu et al., 2020). Understanding how individuals adapted and found meaning after Hurricane Maria offers valuable insight into coping processes that foster PTG.

Our findings highlight the relevance of PTG as a framework for understanding recovery in Puerto Rico. Participants reported moderate

PTG levels, comparable to findings among university students exposed to major hurricanes or earthquakes (Arkin et al., 2022; Osofsky et al., 2022). Although Jiménez et al. (2024) examined PTG among Puerto Rican students exposed to multiple disasters, only part of their sample directly experienced more than one event. Thus, the PTG levels in our study likely reflect growth processes specific to the aftermath of Hurricane María, rather than cumulative adaptation across multiple crises. These levels also correspond to findings that PTG may moderate over time, as immediate recovery gives way to long-term adaptation (Arias & García, 2019; Arkin et al., 2022).

Consistent with prior research, self-efficacy was a strong predictor of PTG (Jiménez et al., 2024; Xu et al., 2023). The belief in one's capacity to overcome challenges facilitates adaptive coping, meaning-making, and agency after adversity (Di Corrado et al., 2022; Robles-Bello et al., 2022), reinforcing its central role in recovery even after controlling for sociodemographic factors and perceived impact.

Spiritual well-being also emerged as a significant contributor to PTG, consistent with evidence that faith and meaning-making restore hope and coherence after disasters (García et al., 2017; Sampson et al., 2024). However, spirituality did not moderate the relationship between self-efficacy and PTG, possibly reflecting the multidimensional nature of spirituality. Moreover, in the aftermath of Hurricane María, some individuals may have experienced spiritual disruption or a reevaluation of faith (Aten et al., 2019), shifting spirituality's role from buffering distress to facilitating the reconstruction of meaning and fostering collective solidarity.

Perceived psychological impact of Hurricane María predicted higher PTG, aligning with studies showing that subjective appraisal of disaster severity can catalyze adaptation and growth (Jung & Han, 2023). Similar patterns have been observed in survivors of earthquakes and hurricanes, where perceived threat and disruption were linked to cognitive restructuring and personal growth (Rhodes & Tran, 2012). These results suggest that in contexts of widespread adversity, individuals' perception of impact may serve as a psychological catalyst for resilience and transformation.

Conversely, family well-being did not predict PTG, suggesting that familism, thought culturally salient, functions as a normative resilience factor rather than a unique predictor (Valdivieso-Mora et al., 2016). Collective stressors may have constrained familes' ability to foster individual growth, with connectedness reflected through spirituality or emotional well-being.

Sociodemographic Predictors

Neither age nor gender predicted PTG. This finding aligns with studies suggesting that in populations facing prolonged collective recovery, demographic differences may become less pronounced (García et al., 2014). While older individuals may exhibit higher PTG in other contexts due to greater life experience (Amiri et al., 2021; Di Corrado et al., 2022), among university students in post-Maria Puerto Rico, shared contextual stressors may have overshadowed such differences. Future research should explore how age and developmental stage interact with time since the event to shape growth trajectories.

Cultural and Structural Context of Recovery

Our results suggest that self-efficacy and sociocultural strengths operate within a broader structural context. In colonial and disaster-prone settings, self-efficacy may extend beyond personal agency to include collective empowerment and critical consciousness (Sawyer & Gampa, 2022). For Puerto Rican students, this could translate into community engagement, advocacy, or academic inquiry addressing inequities illuminated by Huricane Maria (Benach et al.,

2019). While this study did not measure "awareness of social injustice," our findings highlight the need for future studies to examine how critical awareness and collective meaning-making mediate the link between self-efficacy and PTG. These insights underscore the importance of post-disaster interventions that combine individual and collective strategies, programs that cultivate self-efficacy alongside community building, cultural resilience, and advocacy may foster sustainable psychological and social recovery (Hernández-Ballester et al., 2023).

Cross-Cultural and Caribbean Implications

This study contributes to the limited body of PTG research in the Caribbean by identifying spirituality and family well-being as key culturally grounded pathways to resilience. These results align with evidence from other Hispanic and Caribbean contexts emphasizing collectivism, spirituality, and intergenerational resilience as drivers of adaptation (Arias & García, 2019; Fortuna et al., 2024). Recognizing Puerto Rico's long-standing structural inequities and exposure to recurrent disasters highlights the need for culturally responsive interventions that integrate faith-based practices, family systems, and community solidarity as mechanisms of recovery and transformation (González Nieves, 2023).

Limitations and Recommendations

This study has several limitations. First, we used a general measure of self-efficacy (GSES) rather than a trauma-specific scale. Future studies should include the Posttraumatic Self-Efficacy (PTSE) scale, which better captures perceived ability to manage trauma-related challenges (Luszczynska et al., 2009). Second, the perceived impact of hurricane on mental health was assessed using a single item; future research should replicate these findings with multi-item validated measures of disaster impact and psychological distress. Third, the sample consisted entirely of students from a public university, which limits the generalizability of findings to students from private institutions or other socioeconomic backgrounds. Fourth, because additional sociodemographic covariates were not included, it remains unclear whether the observed effects would persist after adjusting for those factors. Fifth, data were collected approximately 1.5 years after Hurricane María, which may have influenced participants' recall and perceptions compared to those reported in the immediate aftermath of a disaster. Finally, all self-report measures reflected participants' current perceptions at the time of data collection, which may not precisely represent their levels of self-efficacy, spirituality, or family well-being during the months following the hurricane. Although PTG inherently involves retrospective meaning-making, this temporal gap limits causal interpretation. Future studies should adopt longitudinal designs assessing these constructs at multiple time points to clarify how PTG and its predictors evolve throughout the recovery process.

Conclusion

From acute weather crises to global climate instability, climate-related disasters continue to challenge both individual and collective well-being. As their frequency and intensity rise, identifying factors that foster resilience and PTG becomes increasingly critical (Corvalan et al., 2022). This study highlights the contributions of self-efficacy, spiritual well-being, and perceived impact of the hurricane on mental health as key contributors to PTG among Puerto Rican university students, a population navigating developmental transitions amid enduring colonial and environmental adversity. Understanding how these sociocultural strengths support growth and recovery can inform interventions that promote not only individual coping but also collective resilience, cultural continuity, and empowerment. Beyond Puerto Rico, these insights hold broader relevance for communities worldwide confronting the intertwined challenges of climate change, structural inequity, and

psychological trauma, emphasizing the need for culturally grounded, community centered approaches to healing and adaptation.

Research Ethical Standards

Funding: No funding was reported for the completion of this study.

Conflict of Interest: The authors confirm that this manuscript is original, has not been previously published, and is not under consideration by another journal. All authors contributed significantly to the work, approved the final version of the manuscript, and declare no competing interests.

Institutional Review Board Approval: This study was approved by the Ethics Committee/Institutional Review Board of the University of Puerto Rico, Río Piedras Campus (protocol number 2324-182).

Informed Consent: We conducted study procedures conducted in accordance with the approved Institutional Review Board protocol, which included ethical provisions for informed participation.

REFERENCES

Alawiyah, T., Bell, H., Pyles, L., & Runnels, R. C. (2011). Spirituality and faith-based interventions: Pathways to disaster resilience for African American Hurricane Katrina survivors. *Journal of Religion & Spirituality in Social Work: Social Thought, 30*(3), 294- 319. https://doi.org/10.1080/15426432.2011.587388

Amiri, H., Nakhaee, N., Nagyova, I., Timkova, V., Okhovati, M., Nekoei-Moghadam, M., & Zahedi, R. (2021). Posttraumatic growth after earthquake: A systematic review and meta-analysis. *International Journal of Social Psychiatry, 67*(7), 867–877. https://doi.org/10.1177/0020764021995856

Arias, P. R. (2017). Propiedades psicométricas del Inventario de Crecimiento Postraumático en población ecuatoriana [Psychometric properties of the Posttraumatic Growth Inventory in Ecuadorian populations]. *Revista Evaluar, 17*(2), 67–80. https://doi.org/10.35670/1667-4545.v17.n2.18722

Arias, P. R., & García, F. E. (2019). Crecimiento postraumático en sobrevivientes de los terremotos en Ecuador y Chile. [Posttraumatic growth in survivors of earthquakes in Ecuador and Chile]. *Ajayu Órgano de Difusión Científica Del Departamento de Psicología UCBSP, 17*(2), 317–331. http://www.scielo.org.bo/scielo.php?script=sci_arttext&pid=S2077-21612019000200005&lng=es&tlng=es

Arkin, M., Lowe, S. R., Poon, C. Y. S., & Rhodes, J. E. (2022). Associations between religious coping and long-term mental gealth in survivors of Hurricane Katrina. *Psychology of Religion and Spirituality, 16*(1), 63–71. https://doi.org/10.1037/rel0000483

Aten, J. D., Smith, W. R., Davis, E. B., Van Tongeren, D. R., Hook, J. N., Davis, D. E., Shannonhouse, L., DeBlaere, C., Ranter, J., O'Grady, K., & Hill, P. C. (2019). The psychological study of religion and spirituality in a disaster context: A systematic review. *Psychological Trauma: Theory, Research, Practice and Policy, 11*(6), 597–613. https://doi.org/10.1037/tra0000431

Baessler, J., & Schwarzer, R. (1996). Evaluación de la autoeficacia: Adaptación española de la Escala de Autoeficacia General [Assessment of self-efficacy: Spanish adaptation of the General Self-Efficacy Scale]. *Ansiedad y Estrés, 2*(1), 1–8. https://dialnet.unirioja.es/servlet/articulo?codigo=186652

Benach, J., Díaz, M. R., Muñoz, N. J., Martínez-Herrera, E., & Pericàs, J. M. (2019). What the Puerto Rican hurricanes make visible: Chronicle of a public health disaster foretold. *Social*

Science and Medicine, 238, 112367. https://doi.org/10.1016/j.socscimed.2019.112367

Bradwell, M. W., & Lee, J. (2019). Environmental disaster and mental health: Coping and depression among survivors of multiple disasters. *Best Practices in Mental Health: An International Journal, 15*(2), 61–73.

Brenlla, M. E., Aranguren, M., Rossaro, M. F., & Vázquez, N. (2010). Adaptación para Buenos Aires de la Escala de Autoeficacia General [General Self-Efficacy Scale adaptation for Buenos Aires]. *Interdisciplinaria Revista de Psicología y Ciencias Afines, 27*(1), 77–94.

Bueno-Pacheco, A., Lima-Castro, S., Peña-Contreras, E., Cedillo-Quizhpe, C., & Aguilar-Sizer, M. (2018). Adaptación al español de la Escala de Autoeficacia Feneral para su uso en el contexto ecuatoriano [Spanish adaptation of the General Self-Efficacy Scale for use in the Ecuadorian context]. *Revista Iberoamericana de Diagnóstico y Evaluación – e Avaliação Psicológica, 48*(3), 5–17. https://doi.org/10.21865/ridep48.3.01

Caruso, G. D. (2017). The legacy of natural disasters: The intergenerational impact of 100 years of disasters in Latin America. *Journal of Development Economics, 127*, 209–233. https://doi.org/10.1016/j.jdeveco.2017.03.007

Charlson, F., Ali, S., Benmarhnia, T., Pearl, M., Massazza, A., Augustinavicius, J., & Scott, J. G. (2021). Climate change and mental health: A scoping review. *International Journal of Environmental Research and Public Health, 18*(9), 4486. https://doi.org/10.3390/ijerph18094486

Cianconi, P., Betrò, S., & Janiri, L. (2020). The impact of climate change on mental health: A systematic descriptive review. *Frontiers in Psychiatry, 11*, 74. https://doi.org/10.3389/fpsyt.2020.00074

Corvalan, C., Gray, B., Villalobos Prats, E., Sena, A., Hanna, F., & Campbell-Lendrum, D. (2022). Mental health and the global climate crisis. *Epidemiology and Psychiatric Sciences, 31*, e86. https://doi.org/10.1017/S2045796022000361

Crane, K., Li, L., Subramanian, P., Rovit, E., & Liu, J. (2022). Climate change and mental health: A review of empirical evidence, mechanisms and implications. *Atmosphere, 13*(12), 1–23. https://doi.org/10.3390/atmos13122096

Davis, E. B., Kimball, C. N., Aten, J. D., Andrews, B., Van Tongeren, D. R., Hook, J. N., Davis, D. E., Granqvist, P., & Park, C. L. (2019). Religious meaning making and attachment in a disaster context: A longitudinal qualitative study of flood survivors. *Journal of Positive Psychology, 14*(5), 659–671. https://doi.org/10.1080/17439760.2018.1519592

de Brito Sena, M. A., Damiano, R. F., Lucchetti, G., & Peres, M. F. P. (2021). Defining spirituality in healthcare: A systematic review and conceptual framework. *Frontiers in Psychology, 12*, 756080. https://doi.org/10.3389/fpsyg.2021.756080

Di Corrado, D., Muzii, B., Magnano, P., Coco, M., La Paglia, R., & Maldonato, N. M. (2022). The moderated mediating effect of hope, self-efficacy and resilience in the relationship between post-traumatic growth and mental health during the COVID-19 pandemic. *Healthcare (Switzerland), 10*(6), 1091. https://doi.org/10.3390/healthcare10061091

Eroglu, D. I., Pamukcu, D., Szczyrba, L., & Zhang, Y. (2020). Analyzing and contextualizing social vulnerability to natural disasters in Puerto Rico. *Proceedings of the International ISCRAM Conference – 17th International Conference on Information Systems for Crisis Response and Management*, 389–395. https://par.nsf.gov/biblio/10171048

Fisher, G. G., Matthews, R. A., & Gibbons, A. M. (2016). Developing and investigating

the use of single-item measures in organizational research. *Journal of Occupational Health Psychology, 21*(1), 3–23. https://doi.org/10.1037/a0039139

Fortuna, L. R., Jiménez, A., & Porche, M. V. (2024). Climate events, displacement, and mental health—Uprooted. *JAMA Psychiatry, 81*(1), 5–6. https://doi.org/10.1001/jamapsychiatry.2023.3561

García, F. E., Páez-Rovira, D., Zurtia, G. C., Martel, H. N., & Reyes, A. R. (2014). Religious coping, social support and subjective severity as predictors of posttraumatic growth in people affected by the earthquake in Chile on 27/2/2010. *Religions, 5*(4), 1132–1145. https://doi.org/10.3390/rel5041132

García, F. E., Páez, D., Reyes-Reyes, A., & Álvarez, R. (2017). Religious coping as moderator of psychological responses to stressful events: A longitudinal study. *Religions, 8*(4). https://doi.org/10.3390/rel8040062

González Nieves, P. L. (2023). *Colonialismo ambiental y formas alternativas de soberanía en Puerto Rico: El caso de Casa Pueblo y Boricuá post huracanes Irma y María* [Environmental colonialism and alternatives for sovereignty in Puerto Rico: The case of Casa Pueblo and Boricuá post hurricanes Irma and María] [Master's thesis, Universidad Pontificia Bolivariana]. UPB Repository. http://hdl.handle.net/20.500.11912/10839

Hagen, I., Huggel, C., Ramajo, L., Chacón, N., Ometto, J. P., Postigo, J. C., & Castellanos, E. J. (2022). Climate change-related risks and adaptation potential in Central and South America during the 21st century. *Environmental Research Letters, 17*(3), 033002. https://doi.org/10.1088/1748-9326/ac5271

Haynes, W. C., Van Tongeren, D. R., Aten, J., Davis, E. B., Davis, D. E., Hook, J. N., Boan, D., & Johnson, T. (2017). The meaning as a buffer hypothesis: Spiritual meaning attenuates the effect of disaster-related resource loss on posttraumatic stress. *Psychology of Religion and Spirituality, 9*(4), 446–453. https://doi.org/10.1037/rel0000098

Henson, C., Truchot, D., & Canevello, A. (2020). What promotes post traumatic growth? A systematic review. *European Journal of Trauma & Dissociation, 5*(4), 100195. https://doi.org/10.1016/j.ejtd.2020.100195

Hernández-Ballester, C., Ferrer-Pérez, C., Montagud-Romero, S., & Blanco-Gandía, M. del C. (2023). Estrés en tiempos de confinamiento: Estrategias de afrontamiento y crecimiento postraumático en población universitaria [Stress in times of confinement: Coping strategies and post-traumatic growth in a university population]. *Revista de Psicología y Educación - Journal of Psychology and Education, 18*(1), 1-10. https://doi.org/10.23923/rpye2023.01.229

Hoeppner, B. B., Kelly, J. F., Urbanoski, K. A., & Slaymaker, V. (2011). Comparative utility of a single-item versus multiple-item measure of self-efficacy in predicting relapse among young adults. *Journal of Substance Abuse Treatment, 41*(3), 305–312. https://doi.org/10.1016/j.jsat.2011.04.005

Hudson, P. (2018). *Cumulative risk of psychological distress in college students affected by Hurricane Harvey* [Master's thesis, Georgia State University]. Scholarworks@GSU. https://doi.org/10.57709/13365953

Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate change 2023 synthesis report. Contribution of working groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647.001

Israel-Cohen, Y., Kaplan, O., Noy, S., & Kashy-Rosenbaum, G. (2016).

Religiosity as a moderator of self-efficacy and social support in predicting traumatic stress among combat soldiers. *Journal of Religion and Health, 55*(4), 1160–1171. https://doi.org/10.1007/s10943-016-0187-x

Jiménez, A. L., Marrero-Centeno, J., Frontera, N. L, & Galarza, L. (2024). Crecimiento postraumático tras desastres naturales y pandemia [Posttraumatic growth after natural disasters and a pandemic]. In G. Cordero-Arrroyo, M. A. Moreno-Torres, I. Serrano-García, K. Calderón Jorge, & R. O. Díaz Juarbe (Eds), *Aportaciones interdiciplinarias a la psicología en el Caribe y Latinoamérica: Colaboración y compromiso social* (pp. 43-58). Asociación de Psicología de Puerto Rico.

Jung, H. O., & Han, S. W. (2023). Post-traumatic growth of people who have experienced earthquakes: Qualitative research systematic literature review. *Frontiers in Psychiatry, 13*, 1070681. https://doi.org/10.3389/fpsyt.2022.1070681

Lalani, N., Drolet, J. L., McDonald-Harker, C., Brown, M. R. G., Brett-MacLean, P., Agyapong,V. I. O., Greenshaw, A. J., & Silverstone, P. H. (2021). Nurturing spiritual resilience to promote post-disaster community recovery: The 2016 Alberta Wildfire in Canada. *Frontiers in Public Health, 9*, 682558. https://doi.org/10.3389/fpubh.2021.682558

Lizarralde, G., Bornstein, L., Robertson, M., Gould, K., Herazo, B., Petter, A. M., Páez, H., Díaz, J. H., Olivera, A., González, G., López, O., López, A., Ascui, H., Burdiles, R., & Bouchereau, K. (2021). Does climate change cause disasters? How citizens, academics, and leaders explain climate-related risk and disasters in Latin America and the Caribbean. *International Journal of Disaster Risk Reduction, 58*, 102173. https://doi.org/10.1016/j.ijdrr.2021.102173

Luszczynska, A., Benight, C. C., & Cieslak, R. (2009). Self-efficacy and health-related outcomes of collective trauma: A systematic review. *European Psychologist, 14*(1), 51–62. https://doi.org/10.1027/1016-9040.14.1.51

Nie, P., Zhao, K., Ma, D., Liu, H., Amin, S., & Yasin, I. (2024). Global climate change, mental health, and socio-economic stressors: Toward sustainable interventions across regions. *Sustainability (Switzerland), 16*(19), 8693. https://doi.org/10.3390/su16198693

Orengo-Aguayo, R., Stewart, R. W., de Arellano, M. A., Suárez-Kindy, J. L., & Young, J. (2019). Disaster exposure and mental health among Puerto Rican youths after hurricane Maria. *JAMA Network Open, 2*(4), e192619. https://doi.org/10.1001/jamanetworkopen.2019.2619

Osofsky, H., Osofsky, J., Saltzman, L. Y., Lightfoot, E., De King, J., & Hansel, T. C. (2022). Mechanisms of recovery: Community perceptions of change and growth following multiple disasters. *Frontiers in Psychology, 13*, 991770. https://doi.org/10.3389/fpsyg.2022.991770

Quezada-Berumen, L., & González-Ramírez, M. T. (2020). Propiedades psicométricas del Inventario de Crecimiento Postraumático en población mexicana [Psychometric properties of the Post-traumatic Growth Inventory in Mexican populations]. *Acción Psicológica, 17*(1), 13-28. https://dx.doi.org/10.5944/ap.17.1.25736

Rhodes, A. M., & Tran, T. V. (2012). Predictors of posttraumatic stress and growth among Black and White survivors of Hurricane Katrina: Does perceived quality of the governmental response matter? *Race and Social Problems, 4*(3-4), 144–157. https://doi.org/10.1007/s12552-012-9074-6

Robles-Bello, M. A., Sánchez-Teruel, D., & Valencia Naranjo, N. (2022). Variables protecting mental health in the Spanish

population affected by the COVID-19 pandemic. *Current Psychology, 41*(8), 5640–5651. https://doi.org/10.1007/s12144-020-01132-1

Rocque, R. J., Beaudoin, C., Ndjaboue, R., Cameron, L., Poirier-Bergeron, L., Poulin-Rheault, R. A., Fallon, C., Tricco, A. C., & Witteman, H. O. (2021). Health effects of climate change: An overview of systematic reviews. *BMJ Open, 11*(6), e046333. https://doi.org/10.1136/bmjopen-2020-046333

Rojas Pérez, O. F. (2019). *Development and initial validation of the Latinx Well-Being Scale* [Doctoral dissertation, University of Missouri-Columbia]. UMC Campus Repository. https://doi.org/10.32469/10355/70007

Romanello, M., Walawender, M., Hsu, S. C., Moskeland, A., Palmeiro-Silva, Y., Scamman, D., Ali, Z., Ameli, N., Angelova, D., Ayeb-Karlsson, S., Basart, S., Beagley, J., Beggs, P. J., Blanco-Villafuerte, L., Cai, W., Callaghan, M., Campbell-Lendrum, D., Chambers, J. D., Chicmana-Zapata, V., … Costello, A. (2024). The 2024 report of the Lancet countdown on health and climate change: Facing record-breaking threats from delayed action. *The Lancet, 404*(10465), 1847–1896. https://doi.org/10.1016/S0140-6736(24)01822-1

Royston, P., Altman, D. G., & Sauerbrei, W. (2006). Dichotomizing continuous predictors in multiple regression: A bad idea. *Statistics in Medicine, 25*(1), 127–141. https://doi.org/10.1002/sim.2331

Sampson, L., Kim, A. H., O'Neill, H. J., Tamez, M., Falcon, L. M., Tuckert, K. L., Acosta-Pérez, E., Rodríguez Orengo, J. F., Kubzansky, L. D., Koenen, K. C., & Mattei, J. (2024). Psychological resilience, resilient coping, and health behaviors among adults in Puerto Rico after multiple adverse events. *Preventive Medicine Reports, 46*, 102874. https://doi.org/10.1016/j.pmedr.2024.102874

Sawyer, J. E., & Gampa, A. (2022). Social movements as parsimonious explanations for implicit and explicit attitude change. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc, 27*(1), 28–51. https://doi.org/10.1177/10888683221095697

Schwarzer, R., & Jerusalem, M. (1995). *General Self-Efficacy Scale* (GSE) [Database record]. APA PsycTests. https://doi.org/10.1037/t00393-000

Sehra, V., & Mishra, A. K. (2022). Stress and self-efficacy as predictors of positive growth in aftermath of urban flooding in Hyderabad, India. *International Journal of Disaster Risk Reduction, 83*, 103349. https://doi.org/10.1016/j.ijdrr.2022.103349

Shultz, J. M., Kossin, J. P., Shepherd, J. M., Ransdell, J. M., Walshe, R., Kelman, I., & Galea, S. (2019). Risks, health consequences, and response challenges for small-island-based populations: Observations from the 2017 Atlantic hurricane season. *Disaster Medicine and Public Health Preparedness, 13*(1), 5–17. https://doi.org/10.1017/dmp.2018.28

Tedeschi, R. G., & Calhoun, L. G. (1996). The Posttraumatic Growth Inventory: Measuring the positive legacy of trauma. *Journal of Traumatic Stress, 9*(3), 455–471. https://doi.org/10.1002/jts.2490090305

Vafeiadou, A., Banissy, M. J., Banissy, J. F. M., Higgins, J. P. T., & Howard, G. (2023). The influence of climate change on mental health in populations of the western Pacific region: An umbrella scoping review. *Heliyon, 9*(11), e21457. https://doi.org/10.1016/j.heliyon.2023.e21457

Valdivieso-Mora, E., Peet, C. L., Garnier-Villarreal, M., Salazar-Villanea, M., & Johnson, D. K. (2016). A systematic review of the relationship between familism and mental health outcomes in Latino population. *Frontiers in Psycho-*

*lo*gy, 7, 1632. https://doi.org/10.3389/fpsyg.2016.01632

Vázquez Torres, J. E. (2021). *The psychological impact of Hurricane Maria on Puerto Ricans* [Doctoral dissertation, The Chicago School of Professional Psychology]. ProQuest One Academic. https://www.proquest.com/dissertations-theses/psychological-impact-hurricane-maria-on-puerto/docview/2561075254/se-2

Weiss, T., & Berger, R. (2006). Reliability and validity of a Spanish version of the Growth Inventory. *Research on Social Work Practice, 16*(2), 191–199. https://doi.org/10.1177/1049731505281374

World Health Organization (WHO). (2023). *Climate change* [Fact sheet]. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

Xu, Y., Yang, G., Liu, L., & Wu, X. (2023). The influence of deliberate rumination on the post-traumatic growth of college students during the COVID-19 pandemic and the moderating role of self-efficacy. *Frontiers in Public Health, 11*, 1043402. https://doi.org/10.3389/fpubh.2023.1043402