

Time Poverty and Disaster Readiness: How Routine Constraints Shaped Hurricane Preparation?

ABSTRACT

Lead time for disaster preparation is experienced differently depending on individuals' routine time constraints. While prior research has examined the psychological and demographic drivers of disaster preparation, little attention has been paid to the influence of time poverty on people's ability to act during warning periods. Thus, we conduct an in-depth exploration of time poverty and time use in hurricane preparation, focusing on Florida communities affected by at least one of the 2024 consecutive hurricanes Helene and Milton in the United States. We examined how individuals' time-related constraints, along with their socio-economic patterns, shape their time use, perceived stress, and preparation behavior in response to hurricane alerts. Through a geographically targeted survey, we collected responses from 1,069 hurricane-affected residents. We analyzed preparation time use, activities, and disruptions to daily routines. Using Latent Class Analysis, we identified five routine time-poverty profiles, including Young Time-Balanced Workers, Time-Rich Non-Workers, Affluent Professionals, Working Overloaded Caregivers, and Strained Low-Income Caregivers. Moderated regression analysis revealed that both overloaded caregivers and time-poor professionals experienced significantly higher stress and were less likely to complete preparations, while respondents with more flexible routines reported less stress. Timely and specific warnings alleviated perceived time scarcity, though this benefit diminished with the onset of the second hurricane. Our findings emphasize that developing targeted early alerts as well as institutional measures, such as flexible work arrangements and support for caregivers, are critical to addressing structural time poverty and improving disaster readiness.

Keywords: Compound Disasters; Hurricane Preparation; Survey; Time Use; Time Poverty; Warning

1. Introduction

Time is a finite, fundamental resource, shaping both everyday behaviors and urgent responses (Strazdins et al., 2011). Chronic scarcity of discretionary time – often described as time poverty – has profoundly affected well-being, physical health, and productivity, influencing routine activities such as dietary habits and physical activity (Giurge et al., 2020a; Williams et al., 2016). When a disaster strikes, time becomes an acute, urgent constraint that determines the capacity and effectiveness of preparation. Despite its clear importance, the role of time poverty in disaster preparation remains understudied.

Routine time poverty frequently arises from work overload or caregiving responsibilities, forming a structural barrier to flexible time use in emergencies. Caregivers – especially working adults and the so-called ‘sandwich-generation’ responsible for both child and older care – often have limited capacity to respond to disaster warnings (Cong et al., 2021). Similarly, home-bound older adults may experience compounded vulnerabilities from both time scarcity and mobility limitations (Anonymous, 2025), leading to chronically low levels of preparedness even as vulnerability rises (Gershon et al., 2017). In this way, time poverty may exacerbate disparities in disaster readiness as an overlooked social vulnerability alongside factors such as income, age, gender, household size, and health conditions (Giurge et al., 2020a; Hyde et al., 2020).

Perceived scarcity of time for preparation may also alter individuals’ behavioral responses in disaster scenarios. Under compressed decision windows, behaviors shift from analytic to heuristic processing, often simplifying plans and foregoing low-priority actions (M et al., 2018). Combined with resource limitations, people tend to adopt satisficing strategies, which settle for minimally sufficient actions rather than optimizing outcomes (Taheri et al., 2023). However, empirical evidence on both routine time poverty, perceived time stress, and disaster preparation remains scarce. This gap is further exacerbated as time poverty represents a complex psychological construct that lacks a standardized definition across various fields and tasks (Giurge et al., 2020a). To address this insufficiency, we measure and analyze the effects of time poverty on hurricane preparedness, connecting these insights to practical strategies for policymakers and emergency responders.

Florida, situated in the disaster-prone southeastern United States, exemplifies the intersection of recurring hazards and rising social vulnerability. The state faces increasing threats from sea level rise and frequent tropical cyclones, resulting in economic loss, disruptions to daily life, and population displacement (Gori et al., 2022; Haynes et al., 2019). In regions most directly impacted, residents typically received a Tropical Storm or Hurricane Warning from the National Weather Service via cell phone message 36 hours prior to expected landfall (NOAA, n.d.). Within the tight window, individuals are urged to complete storm preparations and evacuate if directed by local officials (Chen and Cong, 2022).

Despite the criticality of this interval, little research concerns whether the *lead time* – *from initial awareness to the hurricane’s actual landfall* – is sufficient, especially for individuals with caregiving responsibilities or inflexible work schedules (Hyde et al., 2020). While institutional closures usually commence no earlier than one day before the storm’s projected impact, often no formal time off is granted for preparation activities (Franzosa et al., 2022), such as buying provisions, securing loose objects around the house, boarding windows, and setting out sandbags, packing for evacuation, among other schedule

adjustments. These preparations are not only time-intensive but also vary widely in their execution across different communities and individuals (Lazo et al., 2015; Mash et al., 2022).

This research marks the beginning of an investigation into time use and stress during hurricane preparation in Florida communities affected by two compounded events, Hurricanes Helene and Milton, which occurred within two weeks at the end of September and the beginning of October 2024. The added stress and time demand due to the need for continuous adjustments in daily routines highlight an urgent need for this study. We posit that time poverty constitutes an under-recognized social vulnerability, limiting the discretionary time and flexibility necessary for effective hurricane preparedness. Specifically, we intend to answer three sets of research questions (RQs).

RQ1: How do individuals allocate time for hurricane preparedness during the lead time from initial awareness of a hurricane warning to the actual landfall?

RQ2: How do factors of time poverty, employment status and roles, family responsibilities (e.g., childcare and eldercare), and socio-economic vulnerability influence preparation behaviors and time stress in response to hurricane alerts? How are these relationships moderated by warning experiences and risk perceptions?

RQ3: Do consecutive hurricanes intensify time stress or preparation difficulty, and which population groups are most affected?

To address these questions, we conducted a geographically targeted survey in Florida counties that issued warnings for one or both hurricanes. This survey measured individual characteristics of socio-economic vulnerability, routine time poverty, preparation activities, and perceived stress levels during the lead time. Drawing on 1,069 responses, we analyzed time-use patterns, identified five distinct latent time poverty profiles, and examined how those profiles, together with warning experiences and risk perception, shaped preparation behaviors. Three preparation behaviors are particularly examined, including actual time spent, objective lack of time, and perceived time stress. For those affected by two hurricanes, we further compared time stress and preparedness across consecutive events to assess the impact of cumulative time constraint across the population. The insights gained from the research are expected to significantly influence institutional management and emergency response strategies by ensuring they are tailored to meet time-sensitive needs in disaster preparedness.

2. Literature Review

2.1. Disaster preparation behaviors and the neglect of time use measures

Research on disaster preparation behaviors has predominantly focused on mitigation measures, evacuation decisions, and the factors that drive those behaviors. Much of the literature emphasizes socio-demographic factors such as income, education, gender, and age, which may influence disaster preparation behaviors due to differences in individuals' coping efficacy (Miao and Zhang, 2023; Tohan et al., 2024). Also, *risk perception* consistently emerges as a strong psychological predictor of preparedness, correlating with stronger intention to prepare, especially in high-frequency or high-impact disaster zones (Guo et al., 2022; Ng, 2022). However, the effect of risk perception is not uniform (Bronfman et al., 2016; Kim and Madison, 2020). It can also vary by socio-demographic factors and past disaster experience (Bronfman et al., 2020; Kim and Madison, 2020), and is often moderated by factors such as self-efficacy (Chen and Cong, 2022) and the broader social context (Lo and Chan, 2017).

Beyond individual-level drivers, broader structural and environmental factors—such as the increasing prevalence of compound disasters—further complicate the landscape of disaster preparedness (UNDRR, 2017). These interconnected challenges demand greater resourcefulness and adaptive capacity from affected populations (Tang et al., 2024), while also producing disproportionate impacts across different social groups (Anonymous, 2023). Social vulnerability further intensifies the unequal burden of disaster preparedness, becoming especially pronounced under compound disaster scenarios (Abazari et al., 2023).

The aforementioned preparation drivers have been captured by process-oriented models. Among them, Protection Motivation Theory has received substantial empirical and theoretical support for explaining the drivers and mechanisms behind preparedness actions (Tang and Feng, 2018). Stage-based frameworks that integrate Protection Motivation Theory with the Transtheoretical Model further elaborate on the process, describing how individuals move from having no preparation to forming an intention and eventually taking action (Ma et al., 2024). However, these models often treat preparedness as a static decision-making process, with limited attention to the time constraints under which such decisions must occur.

In real-world disaster scenarios, time is a pressing limitation and scarce resource—particularly in the final lead hours before shocks. The role of limited lead time in shaping disaster preparedness has received growing attention in recent years. Time is particularly essential while being especially scarce in the context of compounded disasters, which often reduce the available lead time for risk recognition and protective action (Momin et al., 2024). Lead time is closely tied to early warning systems, whose influence of disaster warnings is well established: the timing, clarity and content of early warnings significantly shape individuals' risk perception, and their likelihood to take protective actions (Anonymous, 2021; Guo et al., 2022; Sadiq et al., 2023). Researchers increasingly recognize lead time as

a key moderator or mediator in explaining variation in preparedness behaviors (Chen and Cong, 2022; Lin et al., 2023; Regnier, 2020). Moreover, households with access to the same official warning may experience widely differing capacities for action due to time constraints in their routines (Regnier, 2020). Limited time resources can hinder preparedness efforts, influence decision-making processes, and alter preparation behaviors (Lin et al., 2023; Nichols, 2025; Regnier, 2020; Rezapour et al., 2021). However, empirical data on how people actually use time before a disaster remains limited. We know little about how time is distributed across specific activities, how individuals perceive time stress, and how such perceptions relate to actual behavioral adjustments.

2.2. Time use research and its overlooked role in the disaster preparedness context

Time is a scarce resource not only during disaster preparation, but also for routine lifestyle and well-being (Nichols, 2025). “Time poverty”—a chronic shortage of discretionary time due to work, caregiving, and socioeconomic aspects—has been increasingly recognized as a distinct form of vulnerability, intersecting with and sometimes amplifying other social inequality axes (Giurge et al., 2020a; Hyde et al., 2020). Time poverty has been conceptualized through multiple dimensions and measures, which are typically categorized as either subjective or objective (Kalenkoski et al., 2011).

One common objective method to quantify time poverty draws on data from the American Time Use Survey (ATUS), which records absolute time use across daily activities (Flood et al., 2023). These activities are typically divided into discretionary and non-discretionary types. A reduced amount of time spent on discretionary activities is often seen as an indicator of time poverty, as it reflects limited opportunities for leisure that support overall well-being (Batur et al., 2023). The flexibility to shift or rearrange one’s time commitments constitutes another measure of time poverty. Although its implications for overall well-being remain debated (Kotýnková Krotká, 2025), greater flexibility is generally associated with lower levels of time-related constraint and a higher capacity to respond to unexpected demands or emergencies (Ng et al., 2024).

Subjective measures of time poverty are usually related to two intertwined concepts: time pressure and time stress (Williams et al., 2016). Time pressure refers to the perceived lack of sufficient time to complete daily tasks, while time stress is a psychological response to chronic or repeated experiences of time pressure (Gärling et al., 2014). These measures have predominantly been applied to understand how individuals allocate and perceive time in the course of daily routines, rather than in rapid or disaster-specific contexts.

In particular, time constraints during disaster preparation can critically influence how individuals prioritize tasks, make decisions, and take protective actions. When decision-making occurs under tight time constraints, individuals often shift from deliberate, analytical reasoning to more intuitive, heuristic strategies, frequently simplifying their actions and omitting lower-priority tasks (M et al., 2018). Moreover, preparation for compound disasters is more likely to face barriers to accessing sufficient time or capital (Cann et al., 2025). Such urgent time constraints are often exacerbated by routine time poverty, making it more difficult for individuals to manage and adjust their daily schedules (Kalenkoski et al., 2011).

In situations where time stress is compounded by limited resources, people are more likely to choose preparation strategies that are “good enough” rather than optimal (Taheri et al., 2023). Limited time resources can hinder preparedness efforts, influence decision-making processes, and lead to heightened stress during disasters (Lin et al., 2023; Nichols, 2025; Regnier, 2020; Rezapour et al., 2021). For example, caregivers, sandwich generation adults, and homebound seniors frequently experience limited coping capacity and lower preparedness, not for lack of awareness or resources, but for lack of available time (Cong et al., 2021; Gershon et al., 2017).

However, while previous research has shown that routine time poverty profoundly affects well-being, physical health, and productivity, influencing daily behaviors such as dietary habits and physical activity (Ali et al., 2021), its role in disaster preparedness remains largely overlooked (Giurge et al., 2020b). As an overlooked form of mundane constraint, time poverty may be as influential as other socioeconomic vulnerabilities in producing unequal patterns of disaster preparation, yet it has received little empirical attention in this context. In particular, the mechanisms through which routine time poverty influences perceived time stress and disaster preparation remain unclear. These gaps limit our understanding of the practical dynamics through which preparedness decisions are operationalized in time-constrained scenarios.

3. Geographically Targeted Survey Data Collection following Disasters

In September 2024, Hurricane Helene made landfall in Florida as a Category 3 storm, primarily affecting the Big Bend and central Gulf Coast regions. Less than two weeks later, Hurricane Milton made landfall on October 9, 2024, near Siesta Key on Florida’s west-central Gulf Coast as a Category 3 hurricane, bringing widespread power outages, flooding, and storm-surge impacts (FEMA, 2025; NOAA, n.d.).

To understand residents' event-specific preparedness behavior, time use, and risk perception, we conducted a geographically targeted survey in December 2024 across Florida counties affected by Hurricanes Helene and Milton. Due to the urgent need for timely data collection, we utilized Prolific's Florida-based panel, which included 5,422 active participants over the 90 days preceding October 2024. This panel employs address-based sampling with probability-based recruitment methods to ensure representativeness and high-quality data, as established in prior peer-reviewed studies (Douglas et al., 2023). Additionally, we conducted a pretest of the questionnaire (Krosnick, 1999) with 15-25 respondents to identify any issues with question clarity or interpretation.

For geographically targeted sampling, we employed a combined cluster and stratified sampling strategy. First, we identified all counties that received at least one hurricane warning. We then screened participants using two geolocation questions to ensure they were residing in the affected counties and had actively prepared for at least one of the hurricanes.

To further improve demographic representativeness, we conducted both automated and manual balancing procedures to align our sample's age and gender distribution with Florida's actual population. Surveys were distributed in waves across three age groups (18–44, 45–64, and 65+) to better match population distributions. Using Prolific's prescreening tools, we tailored questionnaire distribution within each age group to reflect gender proportions. Recognizing that older adults (65+) are typically underrepresented in online panels, we prioritized this group by launching their survey earlier and exhausting all possible responses before proceeding with younger cohorts.

3.1. Participants

We collected data from 1,069 adult participants through the Prolific platform, all of whom reported residing in the geo-targeted Florida counties at the time of hurricane preparation. Table 1 presents the detailed demographic composition of our sample compared to the general population in these counties. In general, the sample closely aligns with the population across basic demographic indicators; however, some biases persist. Older adults (65+) are underrepresented, likely reflecting the limitations of online panel recruitment. The sample also includes a disproportionately higher share of participants with higher education and employment. In addition, Hispanic residents are underrepresented relative to their population share.

As the primary objective of this study is to examine associations between socio-demographic patterns rather than to produce population-level estimates, we did not apply post-stratification weighting.

Although certain demographic groups are slightly over- or underrepresented, such deviations are unlikely to bias the interpretation of relational patterns.

Table 1. Demographic Characteristics of Survey Respondents Compared

Variable	Florida Population	Percent (%)	Survey Participants	Percent (%)
All Adults	17,623,515		1,069	
Age 18-24	1,773,216	10.06	118	11.04
Age 25-44	5,518,009	31.31	426	39.85
Age 45-64	5,701,557	32.35	415	38.82
Age 65 Plus	4,630,733	26.28	110	10.29
Female Adult	9,051,414	51.36	543	50.80
Male Adult	8,572,101	48.64	517	48.36
Education Bachelor's or Higher	5,263,931	29.87	602	56.31
Employed Adult	10,209,399	57.93	795	74.37
Housing Type Single	5,514,791	64.49	667	62.39
Race White	13,136,701	59.91	773	72.34
Race Black	3,363,769	15.34	211	19.76
Race Native	66,779	0.30	4	0.38
Race Asian	628,137	2.86	39	3.67
Race Pacific	13,136	0.06	4	0.38
Race Hispanic	5,865,737	26.75	117	10.91
Income Median	71,711	-	58,000	-
Household Size	2.58	-	2.95	-

3.2. Questionnaire design and measures

3.2.1. Hurricane preparedness

Our questionnaire began with a brief introduction that contextualized the consecutive hurricanes and separately addressed preparation activities for Hurricanes Helene and Milton. The questions were designed to examine time use and time stress associated with hurricane preparation. We also asked participants about the specific activities they planned and carried out following their initial awareness of a hurricane warning for their residential area. To assess changes in daily routines, we investigated how preparation activities disrupted participants' schedules by categorizing daily tasks into four groups: work/study, household, personal care, and leisure. Participants were asked to report how their time spent on each category during the preparation period differed from a typical weekday. Time stress was assessed for the overall scarcity of time for the preparedness day and specific activities (Lucas and Heady, 2002). To investigate the impact of experiencing consecutive hurricanes on preparedness behaviors, we asked

participants to compare their level of preparedness for the two hurricanes and to reflect on how their preparation for the first storm influenced their response to the second.

3.2.2. Risk awareness and warning experience

We asked participants about the potential disruptions they anticipated in their local area prior to hurricane landfall. In addition, we collected information on when and from which sources they received both official and unofficial hurricane warnings. Furthermore, we asked participants to evaluate the official warnings in terms of whether they believed these alerts provided sufficient lead time to prepare for the hurricanes.

3.2.3. Routine time use and perceived time poverty

To investigate participants' time poverty under normal conditions, we asked about their time use patterns on a typical workday, unaffected by hurricanes or related preparations. The questions were designed to examine time allocation and time stress associated with non-discretionary commitments, such as employment and caregiving responsibilities. Participants were asked to indicate how they distributed their 24 hours across four categories of daily activity: work/study, household duties, personal care, and leisure. This approach enabled us to differentiate between discretionary and non-discretionary time use, following established time-use research conventions (Williams et al., 2016). In addition to objective time use, we also examined perceived time poverty, defined as the persistent feeling of having too many responsibilities and insufficient time to fulfill them (Zheng et al., 2022). Participants were asked how often they felt overwhelmed by obligations and lacked leisure time.

3.2.4. Social roles and socioeconomic vulnerability

Given that time poverty is often associated with individuals' social and household roles and obligations, we included questions related to caregiving responsibilities (e.g., childcare or eldercare) and employment roles (e.g., occupation type and work-related time use patterns) to assess participants' time poverty characteristics. We also collected key demographic and socioeconomic vulnerability variables, including age, gender, race/ethnicity, household income, and educational attainment.

3.3. Analytical process

Building on responses from the designed survey, this study aims to examine the relationships among key variables across the four aspects (Fig. 1). First, we explored how socio-demographic vulnerability is

associated with routine time poverty. Next, we investigated how individuals' time-use profiles relate to perceived time scarcity and time stress during disaster preparation. Given the uncertain role of warning and risk perception, these factors are examined both as potential moderators and as confounding variables in the analysis.

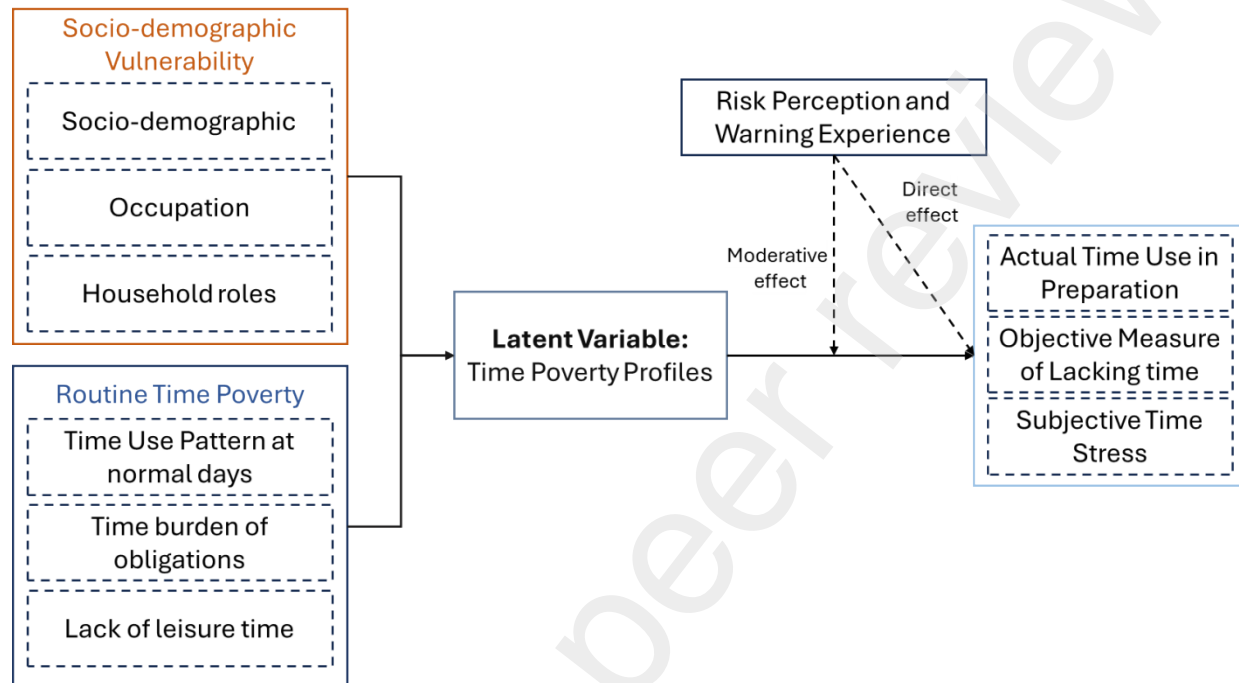


Figure 1. Theoretical Framework Illustrating the Roles of Key Aspects in Disaster Preparedness

3.3.1. Latent class analysis

We conducted LCA using two groups of variables (Fig. 1). The first group included demographic and socioeconomic characteristics such as age, gender, employment status, household composition, income level, housing type, and educational attainment. The second group captured participants' time use patterns under normal (non-disaster) conditions, including the distribution of time across discretionary and non-discretionary activities in a workday, self-reported time stress, and perceived flexibility in time use at work and at home.

To prepare the data for analysis, all categorical variables were converted into dummy variables. We then estimated a series of LCA models with varying numbers of classes. Model fit was assessed using the Bayesian Information Criterion (BIC), and the optimal number of classes was determined by identifying the point at which the BIC curve began to level off (see Fig.S1 in the Supplement). Eventually, a five-

class solution was selected as the most appropriate and meaningful representation of the latent structure in the data.

3.3.2. Moderated multiple regression analysis

To examine how latent class membership predicts outcome variables (e.g., reported time stress, actual preparation time), and whether these effects vary by individual characteristics, we conducted a series of moderated multiple linear regression models. We examined the effect of time poverty profile on three outcome variables related to time use and perceived stress during hurricane preparation: perceived stress, perceived time insufficiency, and total time spent on preparation. Perceived stress was measured using a five-point Likert-scale item. Perceived time insufficiency was calculated as the proportion of intended preparation activities that participants were unable to complete, relative to the total number of completed tasks. The same set of measures was collected for both hurricanes. To assess potential moderation effects, we also considered individual perceptions of risk, whether participants received official hurricane warnings, and the perceived timeliness of those warnings. These factors were included to examine whether risk communication conditions shaped the relationship between class-based vulnerability and time-related outcomes.

The Latent class assignment was treated as a categorical variable and encoded using effect coding (Sum coding), which allows us to interpret coefficients as deviations from the grand mean. To avoid redundancy, one reference group (typically the least vulnerable class) was omitted in the design matrix, and its effect was later recovered analytically to provide a complete picture of all class-specific estimates. Interaction terms between the time poverty profile and moderator variables were included to detect moderation effects. These terms helped identify whether the relationship between class and time use outcome differed across levels of the moderator.

All models were estimated with ordinary least squares (OLS) via the *statsmodels* package in Python. Missing data on dependent variables were handled by listwise deletion. Coefficients, standard errors, t-values, and p-values were computed for all predictors, including the reconstructed estimate for the reference class. Model fit was evaluated using R^2 .

4. Results

4.1. Disaster preparation timing and time use during personal lead time for hurricane preparedness

Minor gap between awareness and preparation actions. Hurricanes are commonly known as disasters with a relatively long lead time for initial awareness and shorter lead time for location-specific, accurate warnings (Regnier, 2020). In our sample, 32.4% of participants became aware of the approaching hurricanes at least seven days before landfall (Fig.2.a). However, most individuals postponed the onset of preparation activities, with the majority reporting that they began preparing two to four days prior to landfall (Fig.2.b). Additionally, 28 participants reported intending to prepare but ultimately did not, largely because they underestimated the risks or lacked time and financial resources.

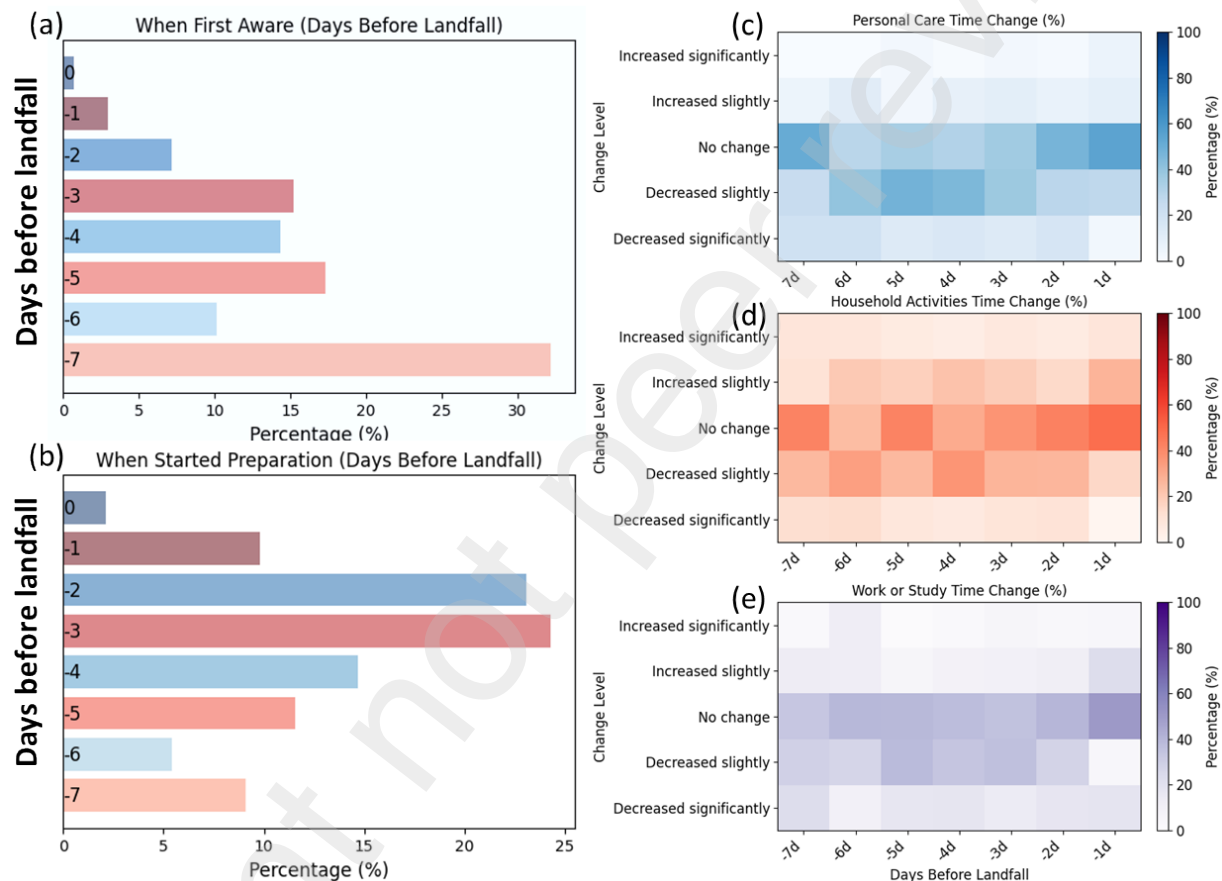


Figure 2. Proportion of participants by timing of hurricane awareness, preparedness onset, and its impact on daily routines. (a) Percentage of participants who became aware of the hurricane on various days before landfall. (b) Percentage of participants who began preparing for the hurricane on various days before the landfall. (c) Changes in routine personal care activities by timing of preparation onset. (d) Changes in household activities by timing of preparation onset. (e) Changes in work or study activities by the timing of preparation onset.

Disturbance of hurricane preparation on personal routine. Hurricane preparation activities significantly altered participants' daily routines and obligations during the lead time (Fig.2). Notably, those who began preparing very late (i.e., only one to two days before landfall) or very early reported minimal changes in their personal care routines. In contrast, participants who engaged in preparation over a longer period (four to six days) were more likely to reduce their time spent on personal activities. The impact on household responsibilities was more varied. While some participants reported sacrificing household care time for hurricane preparation, others indicated that preparation was integrated into household tasks, leading to an increase in time devoted to these activities. Regardless of when preparation began, most participants reported a decrease in time spent on work or study during the preparation period. The only exception was among those who prepared for less than one day; a small number of them reported a slight increase in work- or study-related time, primarily due to job-related preparation tasks, such as securing work equipment.

Preparation and routine activity changed in the lead time. When examining specific routine activities affected by hurricane preparation, we found that time spent on food preparation and household maintenance increased (see Fig.3). Activities such as collecting important documents, maintaining communication plans, and packing for potential evacuation were consistently assigned lower priority in participants' preparation efforts. These tasks were also among the first to be omitted when the available lead time was limited (Fig.3). In contrast, preparation activities reduced the time allocated to health-related self-care and sleep (Fig.4). The time diverted from these routine activities was largely reallocated to hurricane-related tasks such as gathering essential supplies, fueling vehicles, and securing homes (Fig.4). Participants who began preparing earlier were more likely to assist with the needs of family members compared to those who started later. Conversely, packing for evacuation and collecting important documents were among the most commonly planned activities that participants ultimately did not carry out.

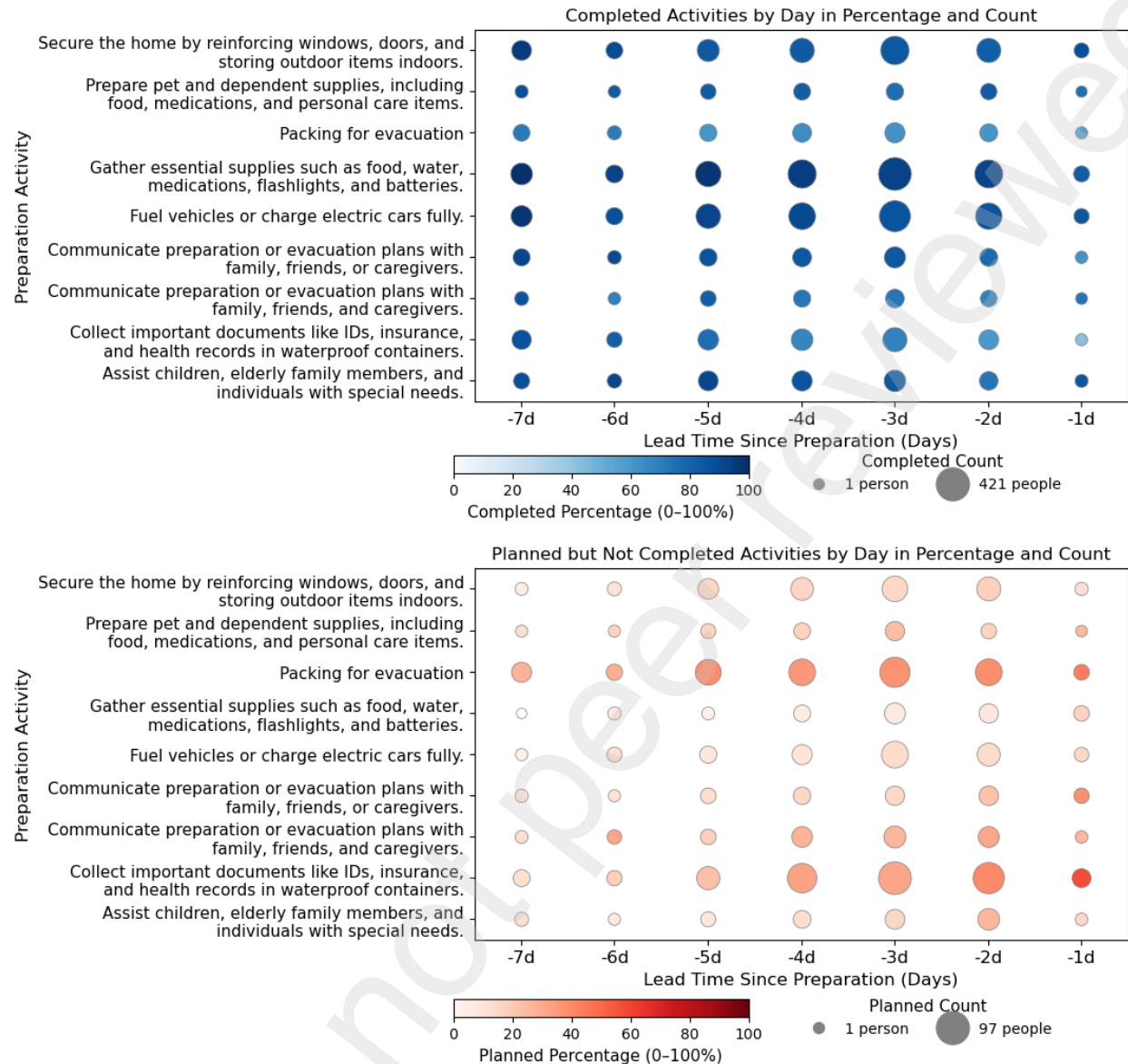


Figure 3. Percentage and count of completed and uncompleted hurricane preparation activities, by day of preparation onset.

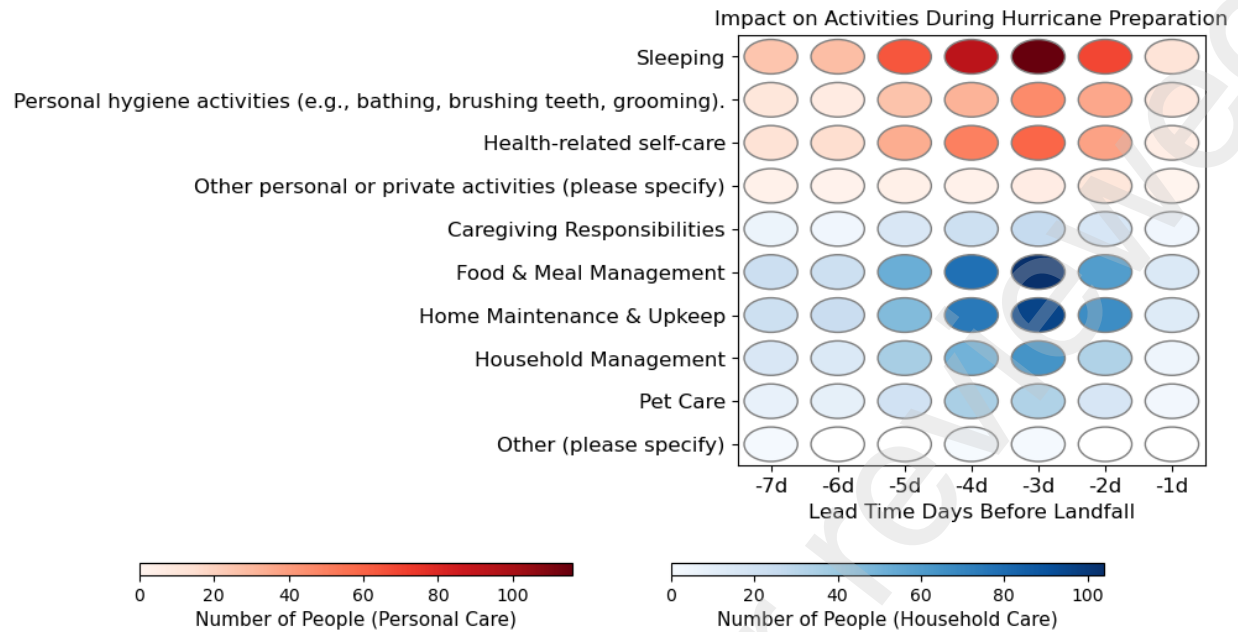


Figure 4. Frequency of routine activities impacted by hurricane preparation, by day of preparation onset.

4.2. Time poverty profiles in relation to time use and time stress for disaster preparation

4.2.1. Classification of routine time poverty profiles

Based on Latent Class Analysis, we identified five distinct time poverty profiles characterized by different socio-demographic profiles and time use patterns under normal conditions. Table 2 summarizes the class definitions and provides a brief description of each class across both dimensions.

Table 2. Five latent time poverty profiles and detailed descriptions emphasize socio-economic and time-poverty characteristics

Class	Label	Socio-economic Characteristics	Time Poverty Characteristics
Class 0	Young Time-Balanced Workers	Educated, full-time employed, younger households with children, moderate income, mostly in multifamily housing.	Moderate work and leisure time, moderate time poverty, medium flexibility at home and work.
Class 1	Time-Rich Nonworkers	Older, mostly retired or unemployed individuals living alone, with low income and education.	High leisure and personal time, very low time poverty, high flexibility, and the least working time.
Class 2	Affluent Professionals	Highly educated, high-income, full-time employed individuals in single-family homes, with small households.	Long work hours, short leisure and household time, high time poverty, moderate flexibility.

Class 3	Working Overloaded Caregivers	Employed adults in medium-to-large households with multiple dependents, moderate income, and racial diversity.	Very high household time, low leisure and personal time, the highest time poverty, and low flexibility.
Class 4	Strained Low-Income Caregivers	Predominantly women with low income, not working, caring for dependents in larger households.	High household and personal time, moderate time poverty, and low flexibility (work data missing).

The latent class structure reveals underlying patterns of co-occurring characteristics that shape individuals. Specifically, those experiencing the highest levels of time poverty tend to fall into Class 3 (Working Overloaded Caregivers) and Class 2 (Affluent Professionals). Despite differences in income and occupation, both groups face significant constraints on discretionary time. For Class 3, time poverty is driven by compounded caregiving and household duties in multi-member, dependent-heavy households, often coupled with limited schedule flexibility. In contrast, Class 2 individuals experience time scarcity due to long working hours and high professional demands, even though they enjoy financial security and smaller households.

Conversely, time poverty is least prevalent in Class 1 (*Time-Rich Nonworkers*), where older adults with low work obligations and high daily flexibility report ample personal and leisure time. Class 0 (*Young Time-Balanced Workers*) and Class 4 (*Strained Low-Income Caregivers*) fall in between: the former balancing job and childcare responsibilities with moderate flexibility, and the latter managing care work under economic precarity and limited institutional support. These findings illustrate how time poverty emerges from both structural demands (e.g., caregiving burden, labor hours) and the degree of control individuals have over their schedules.

4.2.2. Varied relationships between time poverty classes and three hurricane preparation time use patterns

Impact on perceived time stress when preparing for hurricanes. Regression results reveal notable differences in reported perceived stress about preparation time across time poverty classes for both Hurricane Helene (Table 2) and Hurricane Milton (Table 3). For Helene, *Working Overloaded Caregivers* (Class 3) experienced significantly higher levels of stress ($\beta = 0.319$, $p < 0.001$), while *Time-Rich Nonworkers individuals* (Class 1) reported significantly lower stress levels ($\beta = -0.400$, $p < 0.001$). These patterns persist in the second hurricane: Class 3 again showed the highest increase in stress ($\beta = 0.549$, $p < 0.001$), and Class 1 continued to report lower stress ($\beta = -0.406$, $p = 0.001$). Notably, for Milton, *Strained Low-Income Caregivers* (Class 4) also reported a significant increase in stress ($\beta = 0.289$, $p = 0.026$), which was not observed during Helene. These results suggest that time poverty and caregiving

obligations, particularly in Classes 3 and 4, contribute to heightened perceived stress during disaster preparation. In contrast, participants with fewer obligations and greater schedule flexibility (Class 1) consistently experienced lower levels of stress across both events.

Table 2. Effect Size of Multiple Linear Regression with Moderation Effects for Hurricane Helene

Variable	Time Stress(H) coef.	Time Stress(H) p-value	Lack of Time (H) coef.	Lack of Time (H) p-value	Time Use (H) coef.	Time Use (H) p-value
<i>Intercept</i>	1.4560	0.0000	3.5265	0.0000	-7.3451	0.1584
Class 0	0.0848	0.2332	1.3994***	0.0001	3.0783	0.7341
Class 1	-0.4000***	0.0000	-0.3385	0.5261	-13.7409	0.3029
Class 2	-0.0564	0.3556	-0.0580	0.8011	4.1258	0.7372
Class 3	0.3187***	0.0001	-0.5521	0.1324	-14.1412	0.2079
Class 4	0.0529	0.5167	-0.4339	0.2264	21.7479*	0.0136
Official Warning	0.3713***	0.0000			-7.3451	0.1584
Timely Warning			-0.8041***	0.0003	1.4568	0.5033
Risk perception_H	0.2715***	0.0000	-0.9185***	0.0001	10.4348**	0.0004
Class 0:Official Warning					3.0783	0.7341
Class 1:Official Warning					-13.7409	0.3029
Class 3:Official Warning					-14.1412	0.2079
Class 4:Official Warning					21.7479*	0.0136
Class 0:Timely Warning			-0.4126***	0.0001	8.3788*	0.0325
Class 1:Timely Warning			0.0670	0.6607	-3.2821	0.5682
Class 3:Timely Warning			0.1828	0.1004	-2.3705	0.5719
Class 4:Timely Warning			0.1460	0.1852	-4.5678	0.2598
Class 0:Risk perception					-7.5258	0.1252
Class 1:Risk perception					10.1298	0.1620
Class 3:Risk perception					11.9448	0.0831
Class 4:Risk perception					-10.7214*	0.0277
Risk perception:Timely Warning			0.2286**	0.0017		
Model R ²	0.0940		0.1160		0.0880	

(Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Table 3. Effect Size of Multiple Linear Regression with Moderation Effects for Hurricane Milton

Variable	Time Stress(M) coef.	Time Stress(M) p-value	Lack of Time (M) coef.	Lack of Time (M) p-value	Time Use (M) coef.	Time Use (M) p-value
<i>Intercept</i>	1.8747	0.0000	1.1796	0.0000	4.5309	0.4095
Class 0	-0.1782	0.1032	0.6930	0.0829	-2.0667	0.3305
Class 1	0.4059***	0.0007	0.3061	0.6856	9.2999***	0.0002
Class 2	-0.0916	0.2975	-0.5473	0.0662	-4.3866*	0.0173
Class 3	0.5490***	0.0001	0.7752	0.0862	10.2968**	0.0000
Class 4	0.2889*	0.0262	-1.0618*	0.0393	5.4563*	0.0339
Official Warning	0.9772**	0.0100			8.0196***	0.0003
Timely Warning			0.2509***	0.0008		
Risk perception	0.2537**	0.0077			4.5690**	0.0079
Class 0:Official Warning	0.1396	0.3441				
Class 1:Official Warning	-0.0241	0.8894				
Class 3:Official Warning	-0.2564	0.1513				
Class 4:Official Warning	-0.0213	0.9049				
Class 0:Timely Warning			-0.1490	0.2083		
Class 1:Timely Warning			-0.0826	0.6914		
Class 3:Timely Warning			-0.2196	0.0971		
Class 4:Timely Warning			0.2860	0.0552		
Risk perception:Official Warning	-0.2224	0.0684				
Model R ²	0.0810		0.0650		0.0530	

(Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Official warnings and individual risk perception also played a substantial role. Receiving an official warning was strongly associated with increased stress during both hurricanes (Helene: $\beta = 0.371$, $p < 0.001$; Milton: $\beta = 0.977$, $p = 0.010$), as was higher perceived risk (Helene: $\beta = 0.272$, $p < 0.001$; Milton: $\beta = 0.254$, $p = 0.008$). However, the moderation effects of official warnings on the relationships between time poverty classes and preparation time stress were not statistically significant for both hurricanes. The interaction between risk perception and official warning ($\beta = -0.222$, $p = 0.068$) is marginally significant,

indicating that official communication might have slightly buffered the impact of perceived risk on stress, but not conclusively.

Impact of the lack of time when preparing for hurricanes. The perceived lack of time is measured by the ratio of planned but uncompleted tasks to completed ones, exhibited notable differences across time-poverty classes, with variations observed between the two hurricanes. For Hurricane Helene, *Young Time-Balanced Workers* (Class 0) reported a significantly higher level of lack of time ($\beta = 1.400, p < 0.001$). Participants from other classes did not report statistically significant differences from the reference class in the lack of time. For Hurricane Milton, the pattern shifted. *Strained Low-Income Caregivers* (Class 4) reported a significant reduction in lack of time ($\beta = -1.06, p = 0.039$), despite experiencing increased stress. This may suggest a possible shift toward essentialism in preparation, completing fewer but more critical tasks. Meanwhile, *Working Overloaded Caregivers* (Class 3) showed a marginal increase in lack of time ($\beta = 0.78, p = 0.086$). The results for *Affluent Professionals* (Class 2) approached significance as well, with a moderate reduction in lack of time ($\beta = -0.55, p = 0.066$).

Risk perception and warning experience have played an important moderating role in the relationship between time poverty classes and lack of time. In both events, receiving timely warnings significantly reduced the lack of time (Helene: $\beta = -0.80, p < 0.001$; Milton: $\beta = -0.25, p < 0.001$). This suggests that clear and early communication mitigated the sense of being rushed, regardless of actual preparation behavior. Additionally, higher risk perception was strongly associated with lower lack of time in Helene ($\beta = -0.92, p < 0.001$), indicating that increased awareness may have prompted earlier or more focused preparation. However, this effect did not hold for Milton. Despite the fact that the majority of participants (55.85%) indicated an increased concern about the risk, risk perception was not significantly related to lack of time. The moderating effect of timely warnings showed statistically significant reductions in lack of time among Class 0 (Helene: $\beta = -0.41, p < 0.001$), suggesting that young working households particularly benefited from early alerts. In contrast, interactions in Milton were weaker and mostly non-significant, reflecting a possible decline in responsiveness or preparedness momentum across sequential events. The contrast between the two hurricanes further suggests that the effect of time poverty is dynamic and may evolve with cumulative exposure and experience.

Impact on total time spent on hurricane preparation. External factors have played a stronger moderating role in preparing for hurricanes among economically vulnerable caregivers. For Hurricane Helene, only *Strained Low-Income Caregivers* (Class 4) spent significantly more time preparing when interacting with official warning ($\beta = 21.75, p = 0.014$). Risk perception also had a nuanced moderating effect on the relationship between time poverty profiles and total time spent. For *Working Overloaded Caregivers*

(Class 3), higher risk perception was associated with increased time investment ($\beta = 11.94, p = 0.083$), while *Strained Low-Income Caregivers* (Class 4) showed the opposite pattern: greater risk perception was associated with reduced time use ($\beta = -10.72, p = 0.028$).

For Hurricane Milton, *Working Overloaded Caregivers* (Class 3) reported the highest increase in preparation time ($\beta = 10.30, p < 0.001$), followed by *Strained Low-Income Caregivers* (Class 4) ($\beta = 5.46, p = 0.034$). These results reflect substantial time investment by classes facing structural constraints, likely due to heightened perceived need or cumulative exposure effects. In contrast, *Time-Rich Nonworkers* participants (Class 1) and *Affluent Professionals* (Class 2) reported significantly lower time input compared to the reference class (Class 1: $\beta = -9.30, p < 0.001$; Class 2: $\beta = -4.39, p = 0.017$), possibly indicating less perceived urgency or more efficient preparation processes. Meanwhile, receiving an official warning was strongly linked to increased preparation time during Milton ($\beta = 8.02, p < 0.001$), and higher risk perception was consistently associated with greater time input in both events (Helene: $\beta = 10.43, p < 0.001$; Milton: $\beta = 4.57, p = 0.008$).

4.2.3. Varied effects of risk perception and warning experience on time stress across time poverty profiles

Overall, the effect of risk perception on time-related stress was positive and statistically significant across most classes, particularly among Class 1 and Class 2, who exhibited lower levels of time poverty and social vulnerability (Fig.5). These classes were also more likely to experience increased stress in response to official hurricane warnings. In contrast, participants in Class 3 and Class 4, who faced greater obligations related to work or household responsibilities, showed weaker associations between warning experience and time stress, suggesting that their stress levels were less influenced by external alerts. In general, having more time available for preparation was associated with higher levels of time stress. However, this pattern did not hold for Class 2 and Class 3 during Hurricane Milton, indicating possible differences in coping strategies or the timing of preparation activities.

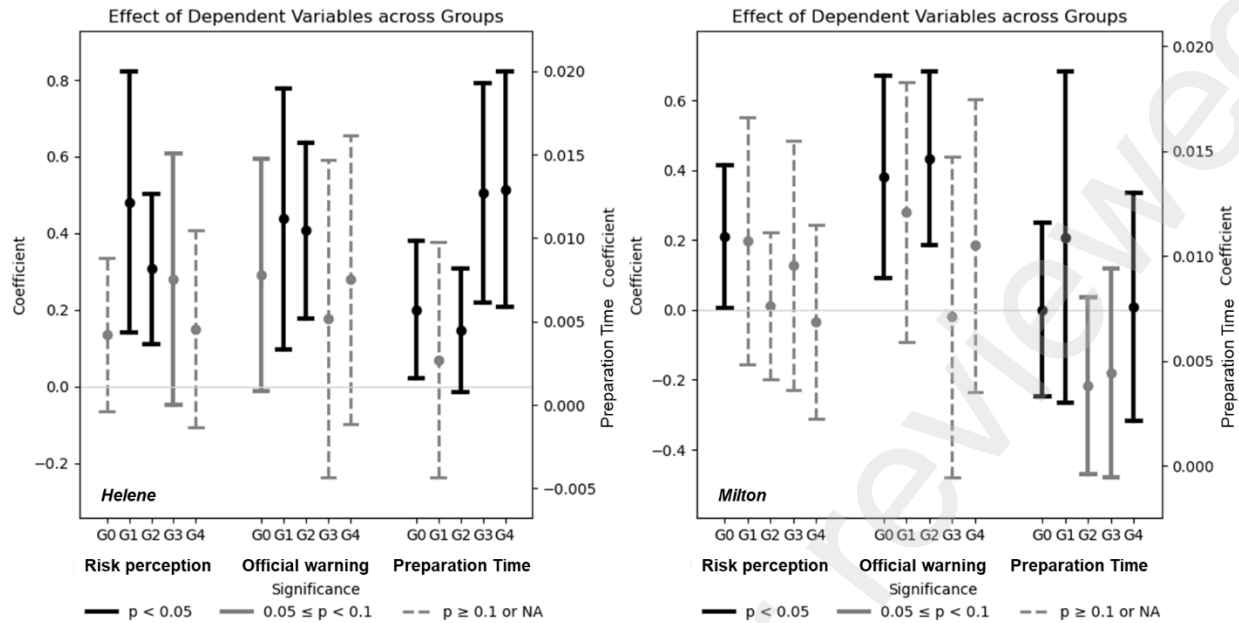


Figure 5. Impact of risk perception, official warning and preparation time on the level of time stress across classes

4.3. Time use and stress change under consecutive hurricane events

Increased level of stress despite the easier preparation for the second hurricane. Among the 709 participants who experienced both hurricanes, 44.9% reported spending less time preparing for the second event, while 30.6% indicated similar or uncertain time use, and 24.5% reported spending more time (Fig. 6a). However, based on their actual reported preparation time, a slightly larger proportion (34.6%) indicated an increase in total time spent (Fig. 6b). This discrepancy suggests a modest divergence between perceived and actual time use, potentially reflecting increased familiarity or a sense of ease during the second preparation effort (Hertzum and Holmegaard, 2013). Despite having fewer uncompleted tasks during the second event (Fig. 6d), a greater number of participants reported heightened stress related to time constraints (Fig. 6c). Overall, 55.8% of respondents indicated that they felt better prepared for the second hurricane, despite 44.9% of total respondents feeling more stress about preparation (Fig. 6).

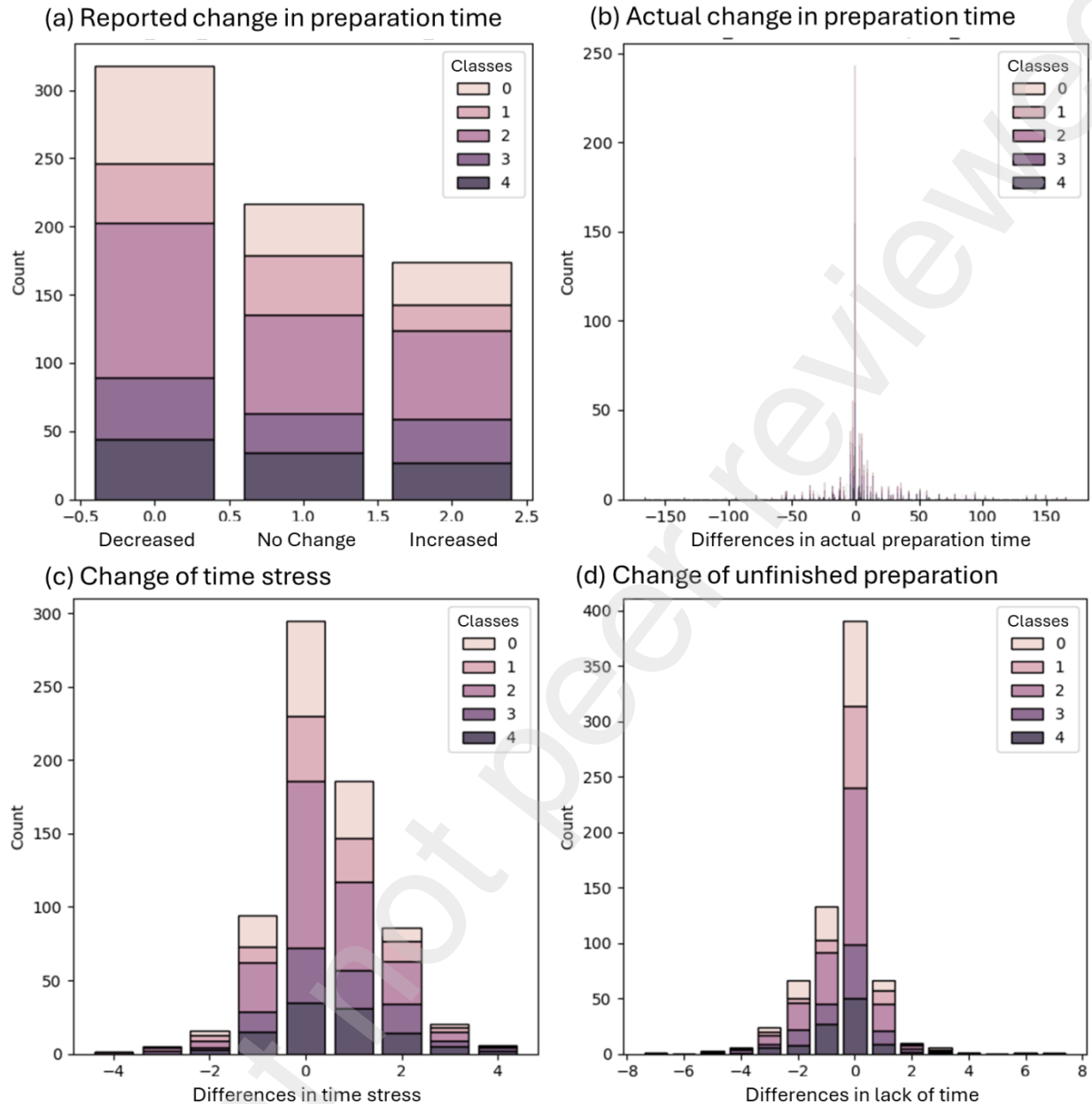


Figure 6. Distribution of the differences comparing the preparation of Hurricane Milton to Hurricane Helene

Class differences in time use and stress responses across hurricanes. *Working Overloaded Caregivers* (Class 3) showed a significant increase in preparation time (coef = 7.31, $p = 0.0037$), while *Strained Housekeepers* (Class 4) also reported a moderate increase (coef = 2.85, $p = 0.259$), although this was not statistically significant (Table 4). In contrast, both *Time-Rich Retired* individuals (Class 1) and *Affluent Professionals* (Class 2) tended to spend less time preparing for the second hurricane, with negative

coefficients (Class 1: coef = -4.19, $p = 0.095$; Class 2: coef = -3.50, $p = 0.061$) that approached significance. Interestingly, although more people overall reported increased time stress during the second event, this was not consistently associated with their time poverty profiles. For instance, *Young Time-Balanced Workers* (Class 0) experienced a statistically significant reduction in time-related stress (coef = -0.19, $p = 0.030$), suggesting improved coping or adaptation. Class 3 (*Working Overloaded Caregivers*) and Class 4 (*Strained Housekeepers*) reported the largest increases in time-related stress (Class 3: coef = 0.15, $p = 0.107$; Class 4: coef = 0.13, $p = 0.171$), although these changes were not statistically significant. However, only Class 1 (*Time-Rich Nonworkers*) showed a significant increase in unfinished assignments (coef = 0.26, $p = 0.009$), reflecting a concrete shortage of time despite their generally low-stress profile.

Table 4. Differences in time use and stress across time poverty classes

Differences between two hurricanes	Report change		Changed preparation time		Time stress change		Unfinished assignment change	
	coef	p	coef	p	coef	p	coef	p
Class 0	-0.0914	0.14	-2.4678	0.2739	-0.1869*	0.0298	-0.0998	0.2702
Class 1	-0.027	0.695	-4.1944	0.0952	0.0035	0.9707	0.2645**	0.0088
Class 2	0.0042	0.935	-3.4951	0.0605	-0.1027	0.1474	0.0177	0.8122
Class 3	0.0768	0.265	7.3103*	0.0037	0.1545	0.1067	-0.1222	0.2252
Class 4	0.0375	0.588	2.8471	0.2589	0.1316	0.1707	-0.0603	0.5513

(Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

5. Discussion

We collected and analyzed a geotargeted survey-based dataset that examined preparation behaviors, time use, and time stress during two consecutive hurricanes. The data captures how individuals allocated their available lead time after first becoming aware of hurricane warnings, and how they prioritized specific preparedness activities once they began taking action. Respondents were also asked about both perceived and actual time constraints during the disaster period and in their routine daily lives. Based on the analysis of time-use patterns, we identified a limitation in the current warning system, which disseminates official information 36 hours before landfall (Sadiq et al., 2023). Many participants reported becoming aware of the hurricane and beginning preparation well before the warning period. This suggests that relying solely on formal alerts may leave insufficient time for essential tasks such as evacuation or coordinating with others. We therefore advocate for technological and institutional improvements in forecasting and communication systems that provide earlier and more actionable warnings, especially for individuals who

are socially isolated or have limited time resources. This research provides much-needed empirical insights into the role of time poverty as a critical, though routinely overlooked, factor in hurricane preparedness. By capturing detailed time-use patterns through a geographically targeted survey, our study fills a key gap in the data landscape. We offer measurements of how varying levels of time poverty shape preparation behaviors and stress, something not covered in broad datasets like the American Time Use Survey (Flood et al., 2023).

Drawing on the latent class analysis, our identification of distinct time poverty profiles reveals how routine time constraints are rooted in broader socio-demographic conditions. We have observed that caregiving burdens or long work hours (Class 3 and Class 2) experienced higher time stress, whereas retirees with higher schedule flexibility (Class 1) reported a significantly lower level of stress. These patterns have the opportunity to further underscore how time constraints, beyond psychological readiness, determine whether people can translate preparedness intentions into action (Lazo et al., 2015). Our following findings developed based on the time poverty profiles inform the identification of particularly vulnerable populations and highlight the importance of considering time poverty into the design of disaster preparedness strategies and targeted early warning infrastructure (Sadiq et al., 2023).

Our empirical results show that disaster preparation is not merely a function of motivational and demographic factors (Regnier, 2020), but is deeply influenced by the routine time schedule and flexibility to reallocate time for preparation activities during the limited lead time before hurricane landfalls (Nichols, 2025). Both routine time poverty and situational demands translated into fewer completed preparation activities and a greater psychological burden (Zheng et al., 2022). Our findings also support prior literature showing that higher perceived risk correlates with more preparation actions (Ng, 2022), and suggest that the timing and clarity of official warnings play a role in shaping the sense of urgency. Our results further suggest that the timing and clarity of official warnings influence individuals' sense of urgency: those who received early and credible alerts reported more available time and engaged in more preparation activities—especially among those experiencing routine time poverty. However, the effects of warnings varied across time-poverty profiles, indicating that even well-designed alerts must account for differential capacities to act. The effectiveness of warning systems, in this sense, depends not only on message quality but also on recipients' available time and scheduling flexibility.

To address the final research question, this study offers a novel examination of how preparation, time use and stress differ by time poverty profiles across two consecutive hurricane events. The results reveal a previously overlooked paradox in disaster preparedness: although many participants felt better prepared for the second hurricane and completed more tasks, a substantial portion still reported increased time

stress. This finding challenges the conventional assumed benefit of experiencing consecutive events reduces perceived stress during subsequent ones (AghaKouchak et al., 2020). It suggests that the cumulative burden of repeated disruptions may outweigh the benefits of increased familiarity, especially for time-poor groups. Furthermore, prior research has rarely accounted for how consecutive disasters can amplify time stress even when actual demands appear to ease (Cann et al., 2025). We highlighted that, beyond the heightened impacts on property and well-being (Anonymous, 2023), compound disasters also impose psychological burdens regarding time that are often overlooked. These insights from our findings advance the understanding of time poverty effects on time constraints under compound hazards.

We acknowledge several limitations of this study that warrant further investigation. First, we did not differentiate responses based on the varying levels of hurricane impact, which may have introduced bias into the analysis. Instead, we used perceived risk and warning as proxies for the severity of the hurricanes in local places. Future analyses should aim to compare responses drawn from events with more comparable levels of actual impact. Second, the psychological mechanisms underlying the observed paradox between reported stress levels and preparedness behaviors were not fully explored. Further research should collect more detailed observational data to better understand this relationship.

6. Conclusion

This study establishes routine time poverty as a central, yet under-addressed, dimension of hurricane vulnerability. Our results demonstrate that even highly motivated individuals may not be able to translate preparedness intentions into action when constrained by inflexible schedules, long work hours, or extensive caregiving demands. The effectiveness of early warnings depends not only on message content and delivery, but also on the population's time availability and flexibility to allocate sufficient time in response. To close the preparedness gap, emergency management and public policy must pursue two complementary strategies: invest in more precise and longer-lead warnings, and address the underlying structures of time poverty. This includes promoting flexible work arrangements, designing supportive programs for caregivers, and providing protected time off for emergency preparedness activities. By integrating time poverty into disaster planning, communities can move toward greater equity and resilience. Ultimately, adaptation to a changing risk landscape will require both technological advances in forecasting and systemic support for those whose daily routines leave them perpetually short on time—and thus, most at risk.

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Time Poverty and Disaster Readiness: How Routine Constraints Shaped Hurricane Preparation?

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