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Health and Mental Health Impact of Tornadoes: Are Older Adults More Resilient?

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Guided by influential theories of disaster research and gerontology, this study examines health resilience associated with tornadoes, particularly focusing on how individuals' tornado-associated stress, financial losses, and family members' well-being affected posttraumatic distress (PTD), posttraumatic growth (PTG), and self-reported changes in health among adults. To reach this goal, this study collected data from residents affected by two violent tornadoes in 2013, with the assistance of a professional survey lab which implemented a random-digit-dialling telephone survey. The working sample included 517 respondents with oversampled older adults. Multinomial logistic regression, Poisson regression, and Ordinary Least Square Regression were conducted separately for younger and older adults. The results indicated a significant effect of stress levels on PTG among older adults only. Nonetheless, the differences in effect sizes between the two groups were not significant. Meanwhile, respondents' financial losses and their family members' declined health were significant predictors of improved health among older adults. Similarly, family members' declined mental health was a significant predictor of PTD among older adults, but not younger adults. Compared to young adults, older adults were more vulnerable to their family members' declined mental health, but also more resilient to stressful situations, financial losses, and family members' declined physical health. Lastly, although risk and resilience factors could be constructed with the same set of items, they function differently among different groups of people. Hence, more studies on heterogeneity are needed to further refine resilience frameworks.

Keywords: Life course perspective, Socioemotional Selectivity Theory, tornado, older adults.

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Natural disasters such as tornadoes can cause severe damage to the physical and social environment and cause death, injuries, and financial losses (Kuligowski et al. 2013; Simmons and Sutter 2013). Tornadoes cause more deaths than hurricanes and earthquakes combined; between 1995 to 2016, there were 472 fatal tornadoes which resulted in 1,730 fatalities, and 2,121 injury-producing tornadoes that produced 24,229 injuries (Kuligowski et al. 2013). Related disasters-associated acute and chronic stresses have contributed to various psychological and health consequences (Norris et al. 2002a; 2002b; Norris, Tracy, and Galea 2009).

Older adults (usually defined as those aged 65 or above) are overrepresented among those killed and injured during tornadoes and hurricanes, and age is regarded as an indicator of vulnerability to disasters (Cutter, Boruff, and Shirley 2003; Deng et al. 2018; Legates and Biddle 1999). For example, it was found that for the 2011 Joplin EF-5 tornado, people over age 65 represented 38 percent of the tornado fatalities, but only accounted for 15 percent of the population (Kuligowski et al. 2013). After disasters, older adults with functional impairments and disadvantaged social and financial resources are particularly vulnerable, and have a hard time accessing resources and recovering from the impact of disasters, thus experiencing long-term social and health consequences (Brown and Frahm 2016; Cherry et al. 2015; Pietrzak et al. 2013).

However, studies are not always consistent concerning age differences and disaster-related health and psychological consequences. The *inoculation hypothesis* proposes that in comparison to younger adults, older adults could be more resistant and resilient to stress because of their life-long exposure to disturbances, more life experiences, and developed wisdom (Eysenck 1983; Norris and Murrell 1988; Shrira et al. 2014). Some studies also indicate unique resources that older adults could own to compensate for disadvantages in their physical conditions and in other resources (Adams et al. 2011; Bei et al. 2013). Nevertheless, other studies reveal unique challenges faced by older adults, who are typically characterized by limitations in mobility, disabilities, and limited financial, cognitive, and social resources. These challenges are associated with excessive deaths and laggard recovery, both physically and psychologically, among older adults after disasters (Brown and Frahm 2016; Bukvic et al. 2018; Campbell 2019; Cruz-Cano and Mead 2019; Lowe et al. 2015).

A less understood area are the mechanisms underlying the potential differences between younger and older adults. Capitalizing on influential disaster research and gerontological theories, this study examines how individual and family contexts affect physical and mental health impacts of disasters differently for younger and older adults, based on a survey conducted of residents affected by two tornadoes in the United States in 2013: the EF5 tornado in Moore, Oklahoma, on May 20, 2013; and the EF4 tornado in Hattiesburg, Mississippi, on February 10, 2013. This study focuses on three indicators of health, namely, self-reported changes in health, posttraumatic distress (PTD), and posttraumatic growth (PTG), as well as differences and predictors of health resilience between those who were 65 years and older and their younger counterparts.

Resilience and Multidimensional Health Consequences

Resilience is an interdisciplinary guiding perspective of recovery after disasters. Resilience, in essence, is a dynamic process over an extended period of time, involving interactions among players at multiple levels, such as individuals, families, communities, built environments, infrastructures, economic systems, public and private agencies, etc. It is multidimensional and includes many dimensions of wellness such as healthy behaviors and functional support networks. It also emphasizes adaptability to a new environment (Aldrich and Meyer 2015; Bonanno et al. 2010; Bonanno, Romero, and Klein 2015; Brown and Frahm 2016; Cutter et al. 2013).

Likewise, health resilience is also a multidimensional outcome. Among long-term health consequences, psychological responses are the most widely studied. Studies have identified several patterns of changes in Posttraumatic Stress Disorder (PTSD) and connected their trajectories to recent definitions of resilience (Bonanno et al. 2015; Cherry et al. 2015). Additionally, some survivors of disasters also demonstrate positive psychological gains, conceptualized as PTG. This suggests that a traumatic experience could serve as an opportunity for future development and adds a dimension of resilience (First et al. 2018; Zoellner and Maercker 2006). Research on self-reported health has been relatively rare. Although self-reported health is a subjective evaluation of health, it represents a personal appraisal which could be consequential for social and psychological well-being (Bombak 2013). Studies have shown only a small decline in the self-perception of health among older adults, and even improvement in some areas, after disasters (Deeg et al. 2005). Although physical and psychological symptoms as a response of exposure to disasters are intertwined, their relationships are not clear. For example, some studies show that physical symptoms could be independent of psychological symptoms among older adults, and when they are combined, reported symptoms tend to last longer (Keskinen-Rosenqvist et al. 2011; Wahlström et al. 2014). It can be assumed that resilience based on multiple outcomes will provide a more comprehensive picture than resilience focusing on one single dimension.

Family Contexts: Linked Lives

Studies related to the health impacts of disasters often focus on the stress process, which regards health outcomes and psychological outcomes as responses to stressors. Different protective factors, such as personality, coping strategies, and social support have been shown to buffer or mediate the development of physical and psychological symptoms (Kaniasty and Norris 1993). But studies of the stress process usually examine individual stress processes together with social vulnerability and social capital at the individual level, and focus on individual characteristics such as age, gender, race, ethnicity, etc. (Bei et al. 2013; Cherry et al. 2010).

A less studied area is how an individual's stress processes and health outcomes are impacted by other individuals, especially family members who constitute individuals' immediate social environment and interactions. Studies have started to investigate the impact of family environments (e.g., support exchanges) on older adults' responses to disaster and related health consequences. These studies have shown the importance of family as the context for resilience, but few studies have examined the interconnected health consequences of family members (Cong, Liang, and Luo 2022; Cutter et al. 2013; Kaniasty and Norris 1993; Kuntz 2015; Lindell 2013; Nejat, Cong, and Liang 2016). Guided by the principle of *linked lives* from the perspective of life course, which emphasizes the importance of the influence of others on an individual's behaviors and health outcomes, one focus of this study is on how family members' conditions affect an individual's health and mental health consequences (Elder and Johnson 2003).

Older and Younger Adults: How are They Different?

This paper is guided by the *resilience* perspective, recognizing the adaptive capacity and heterogeneity among people affected by disasters. It is also guided by the *life course perspective* that acknowledges the different priorities and response mechanisms of younger and older adults related to the different stages in their respective life course (Elder and Johnson 2003). Notably, Socioemotional Selectivity Theory (SST) proposes that people have different life priorities as they get older; for example, older adults tend to put a higher priority on intimate relationships and emotional satisfaction and a lower priority on information seeking and satisfaction from non-emotional related sources (Carstensen, Fung, and Charles 2003; Sullivan-Singh, Stanton, and Low 2015).

Factors that affect the health impact of disasters among older adults usually include exposure to traumatic experience, chronic financial strain, displacement, social vulnerability, pre-disaster physical and mental health conditions, previous experience, coping strategies, personal traits such as personality and optimism, as well as social resources, support, and embeddedness (Bei et al. 2013; Campbell 2019; Cherry et al. 2015; Galea et al. 2008; Kamo, Henderson, and Roberto 2011; Keskinen-Rosenqvist et al. 2011; Pietrzak et al. 2013; Ruggiero et al. 2009; Tracy, Norris, and Galea 2011; Wahlström et al. 2014). This study focuses on the impact of stress associated with tornadoes, financial losses, and the decline in well-being and mental health of family members.

Guided by the above perspectives, this study hypothesizes that financial loss and stress would be less devastating for older adults than for younger adults, but outcomes more associated with emotion such as a decline in the mental health of family members could be more consequential for older adults than for younger adults. In other words, whether older adults are more resilient to disasters is dependent upon the types of risk factors experienced. Older adults could be more resilient to factors that are more closely related to material goods, which are a lower priority during later stages of life, but more vulnerable to factors that are emotional stressors, on which a higher priority is placed at later stages of life.

DESIGN AND METHODS

Sample

A telephone survey was conducted using random digit dialing to collect data between July and September 2014 with the assistance of the Earl Survey Research Lab, approximately one year after the tornadoes in Moore, Oklahoma and Hattiesburg, Mississippi (Cong et al. 2018). The EF-5 Moore tornado on May 20, 2013, killed 24 and injured 207 people. Causing approximately \$2 billion in property damage, it is recognized as one of the costliest tornadoes in U.S. history, in addition to causing long-term mental health consequences (Clay and Greer 2019; NCDC 2021). In comparison, the EF-4 Hattiesburg tornado on Feb 10, 2013, resulted in fewer damages, leaving approximately 82 injured and causing \$39 million in damages (NCDC 2021). For both events, tornado warnings were issued more than 15 minutes before initial touchdown, allowing attempts for protective action (NCDC 2021). These two events were also the focus of several recent studies on disaster risk communication and risk reduction, as well as the long-term psychological impacts of disasters, because of their high social impact related to the inclusion of urban areas with relatively high population densities (Clay and Greer 2019; Cooper Jr. et al. 2015; Mayer et al. 2020). The Oklahoma City metropolitan area, where Moore is located, has one of the highest frequencies of tornadoes in the world; the Hattiesburg area has also experienced tornadoes repeatedly (NCDC 2021).

According to the US Census American Community Survey, in 2012, older adults comprised 8.9 percent of the population of Moore, which was slightly lower than that of Hattiesburg (11.0%). 31.3 percent of residents aged 25 years and older held a bachelor's degree or higher in Hattiesburg, compared to only 22.3 percent in Moore. Additionally, there was a higher percentage of the population in Moore identifying as white-only (78.5%), compared to a more diverse population in Hattiesburg (42.8% white-only; U.S. Census Bureau 2020).

The Institutional Review Board at Texas Tech University approved the data collection method for this study (protocol 504002). Residents aged 18 years and above in selected zip codes on the recorded path of the tornado were interviewed. Older adults were oversampled to be approximately 50 percent of the total sampling frame. Interviews were completed with 536 respondents. Participation rates among young adult residents contacted were 52.5 percent in Moore and 36.7 percent in Hattiesburg, and 50.7 percent and 40.2 percent respectively for the older adult population.

The survey included topics on tornado experience, disaster planning, community recovery, demographics, health and psychological well-being, relocation decisions, social support, and socioeconomic status. With the exception of crucial demographic variables, as well as mental health and wellness variables, many questions were administered to a two-thirds randomly selected proportion of the sample, using planned missing (Little and

Rhemtulla 2013). This technique made it possible to ask more questions without sacrificing the sample size as multiple imputations were used to augment the data (Feng, Cong, and Silverstein 2011).

Measures

Outcome variables included 1) *PTD*, 2) *PTG*, and 3) *self-reported health change*. *PTD* was measured using the K-6 scale (Kessler et al. 2002). *PTG* was measured using a 10-item short-form Post-Traumatic Growth Inventory scale (Cann et al. 2010). The reliability of these two scales yielded $\alpha = 0.83$ and 0.93 , respectively. Self-reported health change was measured by asking participants to compare their current physical health to their health before the tornado (*A lot better* = 1, *Somewhat better* = 2, *Only a little better* = 3, *About the same* = 4, *Only a little worse* = 5, *Somewhat worse* = 6, and *A lot worse* = 7). Responses were then recoded into three categories—*no change* (reference; 4 was ticked), *improved* (either 1, 2, or 3 was ticked), and *declined* (either 5, 6, or 7 was ticked).

Respondents were asked to report their level of stress experienced as a result of the tornado and its aftermath (*Not at all stressful* = 0, *A little stressful* = 1, *Stressful* = 2, *Very stressful* = 3, and *Most stressful thing imaginable* = 4). Next, the questionnaire asked respondents to report their financial losses experienced as a result of the event (*No loss* = 0, *A little bit* = 1, *Some* = 2, *A lot* = 3, *All you had* = 4). Respondents were then asked whether any family members experienced a decline in physical health (*No* = 0, *Yes* = 1) or a decline in mental health (*No* = 0, *Yes* = 1) as a result of the tornadoes. Demographic information collected included marital status (*unmarried* = 0, *married* = 1), age, race (*white* = 1, *other* = 0), education (*high school or less* = 0, *more than high school education* = 1), and gender (*male* = 0, *female* = 1). Health status before the tornadoes was collected (*poor* = 0, *fair* = 1, *good* = 2, *very good* = 3, and *excellent* = 4) as well as the place from which the data were collected (*Moore, OK* = 0, *Hattiesburg, MS* = 1).

Statistical Analysis

Depending on the outcome type, different statistical analyses were conducted. Poisson regression was conducted for the K-6 PTD scale, which measured the number of PTD symptoms (for which scores showed Skewness = 0.83). For PTG, Ordinary Least Squares regression was conducted. Multinomial logistic regression was conducted for self-reported changes in health, which had three categories. PTG was randomly assigned to only a portion of the participants. Thus, multiple imputations were conducted to augment the dataset. Since 517 respondents reported a valid age, the critical classification variable in this study, the dataset was augmented for these 517 respondents with multiple imputations (20 times). Analyses were conducted separately for younger adults (i.e., those who were younger than 65) and older adults (i.e., those who were 65 or older). STATA 15 was utilized for all

statistical analyses. Interactions with $p < .1$ were noted because of the low level of statistical power associated with interactions.

RESULTS

Table 1 presents descriptive statistics with and without multiple imputations. With the exception of PTG, the amount of missing data was not substantial. Older adults and younger adults did not show significant differences in reported PTG, but older adults reported marginally fewer PTD. There was no significant difference in the percentage of older and younger adults in the reporting of changes in health. Most respondents (75%) did not report any change in health, and 16 percent reported declined health. The remainder, 8 percent, reported improved health.

Table 1. Descriptive Statistics

Variables	Before Imputation					Imputed Data (<i>n</i> = 517)			Range	
	Younger <i>n</i>	Mean (<i>S.E.</i>)	Older <i>n</i>	Mean (<i>S.E.</i>)	Total <i>n</i>	Mean (<i>S.E.</i>)	Younger Mean (<i>S.E.</i>)	Older Mean (<i>S.E.</i>)		Total Mean (<i>S.E.</i>)
Self-reported changes in health	204		311		516					
No change		0.74		0.76		0.75	0.74 (0.03)	0.76 (0.02)	0.75 (0.02)	
Improved		0.10		0.07		0.08	0.10 (0.02)	0.07 (0.01)	0.08 (0.01)	
Declined		0.16		0.16		0.16	0.16 (0.03)	0.16 (0.02)	0.16 (0.02)	
Posttraumatic growth (PTG)	120	20.82 (1.35) ^a	187	20.65 (1.03) ^a	307	20.71 (0.82) ^a	21.25 (1.19)	20.77 (0.88)	20.96 (0.73)	0-50
Posttraumatic distress (PTD)	203	1.90	299	1.56	502	1.70 [†]	1.89 (0.14)	1.55 (0.10)	1.69 (0.08)	0-6
Place	205	0.37	312	0.37	517	0.37	0.37 (0.03)	0.37 (0.03)	0.37 (0.02)	0=Moore, 1=Hattiesburg
Age	205	49.75	312	73.80	517	64.26*	49.75 (0.77)	73.80 (0.39)	64.26 (0.65)	21-96
Older group	205	0.00	312	1.00	517	0.60	0.00	1.00	0.60 (0.02)	0=< 65, 1≥ 65
Female	204	0.62	311	0.66	515	0.64	0.62 (0.03)	0.66 (0.03)	0.64 (0.02)	0=male, 1=female
White	200	0.79	307	0.88	507	0.84*	0.79 (0.03)	0.88 (0.02)	0.84 (0.02)	0=others, 1=White
Education	205	0.82	312	0.79	517	0.80	0.82 (0.03)	0.79 (0.02)	0.80 (0.02)	0=high school or less, 1=more than high school
Married	204	0.71	310	0.52	514	0.60*	0.70 (0.03)	0.52 (0.03)	0.59 (0.02)	0=unmarried, 1=married
Health before tornado	204	2.76	312	2.42	516	2.56*	2.76 (0.07)	2.42 (0.06)	2.56 (0.05)	0-4
Family's declined health	203	0.06	312	0.04	515	0.05	0.06 (0.02)	0.04 (0.01)	0.05 (0.01)	0=no, 1=yes
Family's declined mental health	204	0.30	309	0.18	513	0.23*	0.30 (0.03)	0.18 (0.02)	0.23 (0.02)	0=no, 1=yes
Financial loss	203	0.88	310	0.73	513	0.79	0.89 (0.09)	0.73 (0.06)	0.79 (0.05)	0-4
Stress	205	2.30	311	2.19	516	2.24	2.30 (0.08)	2.19 (0.06)	2.24 (0.05)	0-4

^a Only S.E. for PTG were presented for before imputation data because of a large percentage of missing in PTG due to planned missing.

[†] $p < .1$, * $p < .05$ for the results of χ^2 or t-test in testing the differences between younger and older adults age groups.

Overall, only about 5 percent of people reported that their family members experienced a decline in physical health as a result of the tornado, whereas more than 20 percent

reported a decline in the mental health of family members. Older and younger adults were not significantly different in the likelihood of experiencing family members' declined health, but older adults were less likely to report family members' declined mental health.

Older and younger adults did not show significant differences in their reported losses, or levels of stress experienced. Older adults reported poorer before tornado health than younger adults. Older adults also were more likely to be unmarried and White. There was no significant difference in education or gender.

PTD

As seen in Table 2, younger adults experienced a decline in health (Incidence Rate Ratio [IRR] = 1.47, $p < .05$). Additionally, declined (physical) health of family members ($IRR = 1.60, p < .05$), financial losses ($IRR = 1.10, p < .05$), and stress ($IRR = 1.22, p < .05$) were associated with PTD symptoms. For older adults, declined health ($IRR = 1.57, p < .001$), declined mental health of family members ($IRR = 1.59, p < .001$), and financial losses ($IRR = 1.15, p < .01$) were associated with PTD symptoms. Statistical testing of interaction found that the declined mental health of family members was a more prominent factor for higher levels of PTD among older adults than among younger adults ($IRR = 1.37, p < .05$). For other control variables, among younger adults, those married ($IRR = 0.74, p < .05$) and those with better before tornado health ($IRR = 0.77, p < .001$) had fewer PTD symptoms. Those from Hattiesburg ($IRR = 1.44, p < .01$) reported more PTD symptoms. Among older adults, those with better education reported fewer PTD symptoms ($IRR = 0.79, p < .05$).

Table 2. IRR of Poisson Regression for PTD Symptoms

	Younger (n = 205)	Older (n = 312)	Total (n = 517)				
Change in health							
Improved	0.90	1.29	1.16	1.15	1.12	1.12	1.14
Declined	1.47*	1.57***	1.51***	1.49***	1.50***	1.49***	1.48***
PTG	1.02***	1.01**	1.02***	1.02***	1.02***	1.02***	1.02***
Place	1.44**	0.92	1.12	1.11	1.11	1.11	1.11
Age	1.00	1.01	0.99*	1.00	1.00	1.00	1.00
Older group				0.80†	0.70**	0.70*	0.84
Female	0.89	1.25†	1.04	1.03	1.01	1.02	1.03
White	0.99	0.79†	0.89	0.88	0.88	0.88	0.88
Education	0.91	0.79*	0.86†	0.85†	0.86†	0.86†	0.86†
Married	0.74*	0.93	0.77**	0.76**	0.77**	0.76**	0.76***
Health before tornado	0.77***	0.96	0.88**	0.88**	0.88***	0.88**	0.88***
Family's declined health	1.60*	1.13	1.34*	1.47*	1.34*	1.34*	1.38*
Family's declined mental health	1.10	1.59***	1.29**	1.30**	1.11	1.31**	1.30**
Financial loss	1.10*	1.15**	1.11***	1.12***	1.12***	1.08†	1.11***
Stress	1.22*	1.08	1.16**	1.15**	1.15**	1.15**	1.16**
Interaction of age group with							
Family's declined health				0.89			
Family's declined mental health					1.37*		
Financial loss						1.06	
Stress							0.98
Constant	1.36	0.43	1.53†	1.20	1.30	1.29	1.19
Pseudo R ²	0.21	0.17	0.17	0.17	0.18	0.17	0.17

† $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

PTG

As seen in Table 3, for older adults, stress level ($B = 3.46, p < .01$) was associated with higher levels of PTG. The effect was marginally significant among younger adults ($B = 2.02, p < .1$). But the interaction between age group and stress level was not significant ($B = 0.53, n.s.$). For younger adults, females reported more PTG than males ($B = 6.76, p < .01$), and Whites reported less PTG than other races ($B = -7.91, p < .01$). For older adults, females also reported more PTG than males ($B = 5.30, p < .01$).

Table 3. Unstandardized Coefficients of Ordinary Least Square Regressions for PTG

	Younger (<i>n</i> = 205)	Older (<i>n</i> = 312)	Total (<i>n</i> = 517)				
Change in health							
Improved	7.65 [†]	4.85	6.15*	6.31*	6.22*	6.10*	6.18*
Declined	-4.67	-0.19	-1.66	-1.63	-1.66	-1.60	-1.52
PTD	2.38***	1.34*	1.65***	1.66***	1.67***	1.65***	1.66***
Place	-4.27 [†]	1.05	-1.07	-1.03	-1.02	-1.06	-1.10
Age	0.03	-0.06	0.02	0.00	0.00	0.00	0.01
Older group				0.78	0.98	-0.19	-1.15
Female	6.76**	5.30**	5.90***	5.95***	5.95***	5.88***	5.86***
White	-7.91**	-2.62	-5.02**	-5.00*	-4.95*	-5.02*	-4.99*
Education	-2.51	-2.02	-1.99	-2.09	-2.01	-2.04	-2.05
Married	2.97	0.02	1.19	1.23	1.22	1.20	1.21
Health before tornado	0.15	-0.21	-0.28	-0.26	-0.28	-0.26	-0.26
Family's declined health	0.50	-0.10	0.08	1.33	0.07	-0.07	-0.07
Family's declined mental health	-0.43	-1.62	-1.05	-1.07	-0.41	-0.99	-1.04
Financial loss	-0.77	-0.02	-0.43	-0.41	-0.44	-0.67	-0.44
Stress	2.02 [†]	3.46**	2.93**	2.94**	2.94**	2.92**	2.62*
Interaction of age group with							
Family's declined health				-2.42			
Family's declined mental health					-1.26		
Financial loss						0.44	
Stress							0.53
Constant	14.49 [†]	16.11	13.14*	13.68*	13.59*	14.02*	14.39*
Pseudo <i>R</i> ²	0.34	0.27	0.27	0.28	0.28	0.28	0.28

[†] $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

Self-reported Changes in Health

As seen in Table 4, for younger adults, family members' declined health was associated with respondents' own reports of declined health (Relative Risk Ratio [RRR] = 6.87, $p < .05$). Those who reported higher levels of stress had higher relative risks of experiencing declined health ($RRR = 2.90, p < .01$). Older adults who experienced a decline in the physical health of family members ($RRR = 7.23, p < .05$) as well as in mental health ($RRR = 3.36, p < .05$), were more likely to report improved health.

Interaction between stress level and age showed that stress was less impactful for older adults in the reporting declined health than it was for younger adults ($RRR = 0.39, p < .05$). The testing of interactions showed that the association between family members' declined health and reported improved health was slightly stronger for older adults than for younger adults ($RRR = 10.32, p < .1$). Similarly, the association between financial losses and reported improved health was also slightly stronger for older adults than for younger adults ($RRR = 1.76, p < .1$).

Table 4. RRR of Multinomial Logistic Regression for Self-Reported Changes in Health

	Younger (<i>n</i> = 205)		Older (<i>n</i> = 312)		Total (<i>n</i> = 517)							
	Improved	Declined	Improved	Declined	Improved	Declined	Improved	Declined	Improved	Declined	Improved	Declined
PTG	1.05	0.96	1.04	1.00	1.04*	0.99	1.04*	0.99	1.04 [†]	0.99	1.04*	0.99
PTD	0.86	1.39*	1.23	1.43**	1.08	1.40***	1.06	1.41***	1.05	1.40***	1.07	1.39***
Place	1.49	0.81	1.87	1.11	1.42	0.87	1.46	0.86	1.49	0.88	1.48	0.88
Age	1.03	1.04	1.01	1.01	1.03	1.04*	1.03	1.04*	1.02*	1.04*	1.02	1.03 [†]
Older group					0.37 [†]	0.55	0.35	0.74	0.15**	0.82	0.36	17.60*
Female	0.14**	1.37	0.59	0.40*	0.33**	0.72	0.32**	0.72	0.30	0.74	0.32**	0.72
White	0.50	0.17**	0.46	0.51	0.57	0.42*	0.55	0.43*	0.52	0.43*	0.56	0.41*
Education	1.05	4.54 [†]	1.62	1.11	1.33	1.69	1.17	1.73	1.16	1.73	1.16	1.82 [†]
Married	1.68	2.32	0.76	0.42*	1.03	0.89	1.05	0.88	1.06	0.88	1.04	0.85
Health before tornado	0.41**	0.45*	0.64 [†]	0.60**	0.57**	0.58***	0.57**	0.57***	0.57**	0.57***	0.57**	0.56***
FDPH	1.91	6.87*	7.23*	2.70	1.12	3.10	4.57*	3.03*	4.15*	3.13*	4.35*	3.74*
FDMH	2.63	2.44 [†]	3.36*	2.02	2.75*	2.19*	2.11	3.34*	2.95**	2.14*	2.70*	2.23*
Financial loss	0.86	1.20	1.46 [†]	1.22	1.13	1.17	1.18	1.15	0.87	1.30	1.16	1.18
Stress	1.32	2.90**	0.92	0.88	1.09	1.19	1.10	1.19	1.11	1.18	1.12	2.22**
Interaction of age group with												
FDPH					10.32 [†]	0.98						
FDMH							1.76	0.47				
Financial loss									1.76 [†]	0.82		
Stress											1.07	0.39**
Constant	0.15	0.00	0.02	0.93	0.05*	0.05*	0.05*	0.05**	0.07 [†]	0.04**	0.05*	0.01
Pseudo <i>R</i> ²	0.34		0.20		0.20		0.20		0.20		0.21	

FDPH = Family's declined health, FDMH = Family's declined physical health

[†] *p* < .1, * *p* < .05, ** *p* < .01, *** *p* < .001

Concerning control variables, for younger adults, females were less likely to have improved health ($RRR = 0.14, p < .05$) and Whites were less likely to report declined health ($RRR = 0.17, p < .01$). Those who reported better before tornado health were less likely to have improved health ($RRR = 0.41, p < .05$), but were also less likely to report declined health ($RRR = 0.45, p < .05$). In addition, older adults who were female ($RRR = 0.40, p < .05$), married ($RRR = 0.42, p < .05$), and with better before tornado health ($RRR = 0.60, p < .01$) were less likely to report declined health.

Relationships among PTD, PTG, and Changes in Reported Health

A causal relationship among PTD, PTG, and self-reported changes in health could not be assumed. These findings generally suggested a positive relationship between PTD and PTG and between PTD and declined health among both younger and older adults.

DISCUSSION

Our results indicated that older adults and younger adults showed differences in their vulnerability and resilience to disasters. Different factors affected PTD, PTG, and self-reported changes in health. Some of these differences were statistically significant. As hypothesized, stress and financial loss were experienced as less devastating for older adults than for younger adults, but more emotionally significant problems such as the declined mental health of family members was more consequential for older adults than for younger adults.

We found that the decline in physical health of family members was associated with more PTD symptoms and with a higher likelihood of reporting declined health among younger adults, but it was associated with improved health among older adults. It could be that the declined health of family members may motivate older adults to play the caregiver role and thus have higher levels of self-efficacy and a more optimistic evaluation of their own health (Carbonneau, Caron, and Desrosiers 2010). Having family members who experienced declined health may also present a different point of reference that positioned older adults to feel that they were enjoying better health than before the tornadoes.

However, the declined mental health of family members is a risk factor for PTD among older adults. While the declined health of family members could suggest more practical needs, it could also be particularly emotionally challenging to the psychological well-being of older adults, which is consistent with literature showing compromised psychological well-being of older caregivers of family members suffering from dementia (Schulz et al. 2017). In addition, the analysis indicated that the impact of family members' declined mental health on PTD was statistically significant for older and younger adults, indicating higher levels of vulnerability of older adults to family members' declined mental health. This may be a result of increased dependence of older adults on family members, especially for emotional relatedness, which could be a source of vulnerability. This provides support for the socioemotional selectivity theory such that older adults are more vulnerable to

emotionally important factors, especially those associated with significant others (Carstensen et al. 2003).

Intriguingly, declined mental health of family members was also associated with improved self-reported health among older adults. The fact that family members' declined mental health had both positive and negative impacts suggests heterogeneities among older adults. This finding was consistent with other findings where caregiving could have a positive impact on caregivers, including outcomes of caregiving satisfaction, quality of relationships, and self-efficacy (Carbonneau et al. 2010; López, López-Arrieta, and Crespo 2005; Van Durme et al. 2012). Declined mental health of family members may also result in respondents' change of reference and thus a more positive evaluation of their own health.

Stress is a risk factor for declined health among younger adults, but not for older adults. Under similar stress levels, older adults were statistically less likely to report declined health. This finding suggests that older adults are less vulnerable than younger adults to stress. Furthermore, higher levels of stress were associated with higher levels of PTG among older adults, but not among younger adults. Higher levels of stress were also associated with PTD symptoms among younger adults but not older adults. Although the differences were not statistically significant, these findings taken together were consistent with an overall pattern suggesting that older adults were less vulnerable to stress than younger adults, and experience related negative physical and mental health consequences. This is also consistent with the inoculation effect, i.e., life-long exposure to stress and developed coping strategies and wisdom may protect older adults against stress associated with disasters (Eysenck 1983; Norris and Murrell 1988; Shrira et al. 2014). For example, one study showed that older adults were more resilient to exposure during Hurricane Sandy and to experiencing related PTSD (Shrira et al. 2014). Another study found that older adults attributed their resilience to Hurricane Katrina to their life experience, including previous experiences with disasters and other challenging situations (Adams et al. 2011).

Financial losses were associated with PTD symptoms among both younger and older adults. But there was some evidence that older adults showed stronger resilience and improved health in the face of financial losses than younger adults, with a marginally significant interaction effect. This finding may provide some evidence that older adults put less value on material goods that do not necessarily carry emotional connections, supporting the socioemotional selectivity theory. This finding would also be consistent with one study of Hurricane Katrina victims, showing that material losses were less important than family losses to older adults' sense of well-being (Adams et al. 2011).

In addition to addressing major research questions, our findings also indicated important gender and racial differences in health consequences for different age groups. Recently, the social vulnerability approach has highlighted intersectionality, which is sometimes termed *layered vulnerability*, and directs attention to the intertwining of different vulnerability characteristics such as age, gender, and racial differences (Bolin and Kurtz 2018; Campbell 2019; Tierney 2019). Some studies have specifically examined the layered vulnerability perspective, focusing on the interaction of old age with other vulnerabilities, sometimes from a multilevel perspective (Adams, Eisenman, and Glik

2019; Cong and Feng 2022). The empirical findings of this study provide further evidence of complicated interactions among these factors. For example, females from the young adult sample were less likely to report improved health, and females from the older adult sample were less likely to report declined health. Although this finding is not the focus of this study, and no statistical test of the difference was conducted, the gender differences observed could suggest a life course pattern, as older age is a gendered experience, with a greater percentage of older women than men surviving to advanced old age and taking the more salient role of caregiving, especially for their spouses (Moen 2001; Silver 2003). Those identifying as White reported less PTG and were less likely to report declined health than other races, only among younger adults. Previous studies have shown significant racial differences concerning PTG and self-rated health (Bellizzi et al. 2010; Spencer et al. 2009), however, this study supports that racial differences could be dependent on life stage.

There has been long-standing research interest in refining resilience frameworks, as some individuals show resilience and even positive growth after disasters, while others experience considerable long-term negative physical and psychological consequences (Norris et al. 2009; Walker et al. 2017). Although it is beyond the scope of this study to further examine those frameworks, the findings of this study suggest that risk factors and resilient factors could be one in the same, and disaster impacts on different groups of people can have very different outcomes. Particularly, while declines in the health of family members, declines in mental health, and financial losses are typically regarded as negative life events, the same experiences could be resilient factors for a special group of older adults who reported improved health against a general decline in functioning as people grow older. In addition, even when older adults overall show better resilience in some areas, it is important to keep the heterogeneity of older adults under consideration when interpreting those findings, as advantages and disadvantages accumulate over the course of one's life. The findings of this study have direct implications for the well-being of older adults as related to the COVID-19 pandemic- a disaster that has presented practical challenges as well as psychological stress for older adults and their family members. Future studies should further examine heterogeneity among older adults to identify those who are particularly vulnerable or resilient.

One major limitation is that this study was conducted one year after the disaster events. Since the questions were asked retrospectively, respondents could have recall bias and be limited by their ability to recollect their situation before the tornadoes- a typical limitation in this type of research (Lindell 2013). Moreover, survival and self-selection bias may present an overoptimistic perspective, as less healthy older adults may choose to opt out of the study. Previous studies have noted higher mortality rates among older adults during disasters, especially among those with preexisting health conditions (Fernandez et al. 2002). Additionally, while previous research has shown that self-reported health is stable over time and has good validity and reliability, subjective evaluations should be interpreted with caution (Bombak 2013). For example, witnessing a decline in the health of others could change the evaluation of one's own health. As previously noted, self-reported health

assessments are subject to recall bias and selection bias. Furthermore, as this was a cross-sectional study, the possibility of reverse causation cannot be excluded.

Despite these limitations, this study adopted theoretical perspectives grounded in disaster research and gerontology, and compared older and younger adults with regard to three psychological and physical health indicators. It revealed unique vulnerability and resilience factors found in older adults relative to their younger counterparts. Relative to their younger counterparts, older adults were more vulnerable to declined mental health of family members; but they were more resilient to stressful situations, financial losses, and to the declined physical health of family members. Those findings were generally consistent with the inoculation hypothesis and socioemotional selectivity theory in that older adults put less value on material goods that do not carry emotional connections, and could be less vulnerable to stress than younger adults in experiencing negative physical and mental health consequences. Nevertheless, older adults were more vulnerable to emotional related stress, such as declined mental health of family members. Thus, the simple assumption that either older adults are more vulnerable or less vulnerable than young adults could miss the complicated picture of multi-dimensional life-course experiences.

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