Social Psychology

# Two's Company, but Four's a Crowd: The Relationship Among COVID-19 Stress, Household Size, and Life Satisfaction

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## Collabra: Psychology

COVID-19 has induced stress motivated by individuals' fears of infection and death, while mitigation efforts have also exacerbated stress by reducing individuals' income, creating feelings of social isolation, and imposing barriers to obtaining basic resources. In this study, we use a representative sample of 693 adults in Michigan to investigate the association between COVID-19 stress and life satisfaction. We find that COVID-19 stress is significantly negatively related to life satisfaction, and that this association is strongest among those living alone and those living in households with many other adults. Exploratory analyses suggest that shopping challenges are most strongly associated directly with stress and indirectly with life satisfaction, while income and boredom challenges are less important. We conclude by discussing the implications of declines in life satisfaction due to an ongoing and potentially worsening stressful event, and consider some strategies for mitigating this non-trivial form of COVID-19 harm.

Since the initial detection of COVID-19 in the United States in January 2020, millions of Americans have been infected and/or died. The magnitude of this public health crisis has induced significant stress motivated by individuals' fears of infection and death. Moreover, attempts to mitigate transmission through social distancing and the closure of workplaces may have exacerbated COVID-19 stress by reducing individuals' income, creating feelings of social isolation, and imposing barriers to obtaining basic resources such as groceries or toilet paper. Although these stressors are specifically related to the COVID-19 pandemic, they have the potential to impact Americans' life satisfaction more broadly. Moreover, the way that these stressors may impact Americans' life satisfaction may be related to the number of others in their household because these additional household members may be sources of social support, but also be potential sources of exposure and consumers of hard-to-get resources. Therefore, this study responds to the recent calls by Horesh & Brown (2020) and Holmes et al. (2020) for research on the stressors and mental health impacts associated with COVID-19, with a particular focus on individuals in small and large households as a uniquely vulnerable group.

In this study, we use a representative sample of 693 adults in Michigan to investigate two pre-registered hypotheses: that COVID-19 stress is negatively associated with life satisfaction, and that this association is quadratically moderated by household size. We find support for the direct effect, and partial support for the moderated ef-

fect. Specifically, we find that while total household size does not moderate the stress-satisfaction relationship, total number of adults in the household does. COVID-19 stress has the strongest negative association with life satisfaction among those living alone and those living in households with many other adults. We also use these data to explore the types of daily life challenges that may be responsible for COVID-19 stress and reductions in life satisfaction. We find that shopping-related challenges are most strongly associated directly with stress and indirectly with life satisfaction, while income-related challenges are more weakly associated, and boredom-related challenges are not significantly associated.

The remainder of the paper is organized in four sections. In the first section, we introduce life satisfaction and its links with stress and household size, then situate these phenomena in the COVID-19 pandemic context. In the second section, we describe the Michigan State of the State survey data and our pre-registered analytic plan. In the third section, we first describe our sample and use stratified sampling weights to estimate population means for Michigan adults' on each variable, including COVID-19 stress and life satisfaction. We then present the results of our pre-registered hypothesis tests examining the association between COVID-19 stress and life satisfaction moderated by household size, followed by the results of a series of exploratory mediation models examining potential sources of COVID-19 stress. We conclude by discussing the implications of declines in life satisfaction due to an ongoing and

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potentially worsening stressful event, and consider some strategies for mitigating this non-trivial form of COVID-19 harm.

## Background

Life satisfaction is the cognitive component of subjective well-being and refers to a person's global judgment of their lives based on their own standards (Diener et al., 1985; Pavot & Diener, 2008). Since promoting life satisfaction is an important individual and societal goal, research has continued to examine correlates of life satisfaction. For instance, several demographic characteristics have been found to predict life satisfaction: income and education (Fernández-Ballesteros et al., 2001) are positively linked with life satisfaction while age is often found to have a non-linear association with life satisfaction across the lifespan—life satisfaction declines in the teens and early twenties, is stable until early fifties before it increases and declines again at late life (Qu & de Vaus, 2015). Previous research has also examined situational factors. For example, life satisfaction is lower after experiencing life events such as divorce and unemployment and especially so after experiencing multiple negative life events (Luhmann & Eid, 2009). This is not surprising because those events are likely stressful and stress consistently predicts lower life satisfaction (e.g., Csikos et al., 2020; Hamarat et al., 2001).

Indeed, stress is frequently associated with lower life satisfaction for people in diverse contexts, including injured athletes (e.g., Malinauskas, 2010), students in college (e.g., Mahmoud et al., 2012), and people who have experienced natural disasters (e.g., Calvo et al., 2015; Galatzer-Levy et al., 2018; Hamama-Raz et al., 2017; A. L. D. Lau et al., 2008; Murakami et al., 2018). Conversely, the presence of others is associated with higher life satisfaction. For instance, positive relationships (Gustavson et al., 2016) and greater social support are linked with higher life satisfaction, leading older people living with family to be more satisfied with their lives than the older people living alone (Shin & Sok, 2012).

The higher life satisfaction observed among those living with others may occur because the social support provided by others can help people manage and cope with stress (Malinauskas, 2010), suggesting that household size may mitigate the negative association between stress and life satisfaction. For example, in a stressful situation such as parenting a child with ASD, social support moderated the link between stress and life satisfaction (Lu et al., 2018). However, other work suggests it is also possible to be surrounded by too many others. For example, although there is a positive association between social contact and health at low to moderate levels of contact, high levels of social contact have null or negative associations with health (Stavrova & Ren, 2020). This may be why older people living with three generations also were less satisfied with their lives (Fengler et al., 1983).

Together, this past work on stress, life satisfaction, and household size suggests that stress is associated with lower life satisfaction. However, that association can be moderated by household size, such that it is weaker (i.e. less negative) when an individual is living with some (but not too many) others. Because the COVID-19 pandemic was a key source of stress in 2020, and the associated quarantine measures restricted individuals' activities to their own households, it presents an ideal context for examining how stress and household size work are jointly associated with life satisfaction.

## Life satisfaction, household size and stress during COVID-19

In 2020, the COVID-19 pandemic presented a new context that induced stress motivated by individuals' fears of infection and death, while mitigation efforts have also exacerbated stress by reducing individuals' income, creating feelings of social isolation, and imposing barriers to obtaining basic resources. Thus, Horesh & Brown (2020) and Holmes et al. (2020) called for research on the stressors and mental health impacts associated with COVID-19. There has been some evidence that COVID-19 related stress is negatively linked with life satisfaction and that related constructs such as loneliness (Groarke et al., 2020) and post-traumatic stress disorder (PTSD; Hyland, Shevlin, Karatzias, et al., 2020; Hyland, Shevlin, Murphy, et al., 2020; B. H. P. Lau et al., 2020; Murphy et al., 2020; Park et al., 2020) were high during the initial phase of the pandemic lockdown orders. In the United States, worry or stress about COVID-19 has been associated with anger (Charles, 2020) and depression (Kujawa et al., 2020) among adults, and emotional problems among adolescents (Miller et al., 2020). Outside the United States, stress surrounding COVID-19 has been associated with reduced life satisfaction in Hungary (Csikos et al., 2020), Japan (Sugawara et al., 2020), Poland (Trzebiński et al., 2020), and Turkey (Satici et al., 2020), while in China the severity of the outbreak in one's hometown was associated with reduced life satisfaction (Zhang et al., 2020). Accordingly, the negative association between aspects of COVID-19 stress and aspects of psychological well-being exhibits remarkable cross-cultural stability.

One key pandemic mitigation strategy was the 'lockdown,' during which individuals' activities were severely restricted. For example, in May 2020 when the state of Michigan was experiencing among the largest number of confirmed COVID-19 cases and deaths (57,601 and 5,479, respectively, by May 25), the governor placed the state's residents under a stay-at-home order. Because this order restricted individuals' interactions to members of their own household, households became a key context within which the association between COVID-19 stress and life satisfaction emerged. It therefore offers an opportunity to more closely examine the potential contextual role of household size in moderating a stress-satisfaction association that has been hinted at in prior work (Fengler et al., 1983; Lu et al., 2018; Malinauskas, 2010; Stavrova & Ren, 2020). Drawing on this earlier work, we anticipated that the negative association between COVID-19 stress and life satisfaction would be non-linearly moderated by household size, with the strongest association occurring among those living alone or living in large households. However, the reasons for a strong stress-satisfaction association in small households likely differ from the reasons for a strong association

in large households.

The negative association between COVID-19 stress and life satisfaction may be particularly strong for those in *small* households, and especially for those *living alone*, due to isolation and lack of social support. Loneliness has repeatedly been found as a negative predictor of life satisfaction (Salimi, 2011), and loneliness levels have been high during the pandemic (Groarke et al., 2020). Moreover, previous research suggests that social support is a protective factor for life satisfaction for people experiencing consequences of natural disasters (Calvo et al., 2015; Glass et al., 2009). Following Hurricane Katrina, most people's happiness recovered from the drop following Hurricane Katrina; however, those who were single or living alone after the hurricane continued to show lower happiness (Calvo et al., 2015). This work suggests that living alone may reduce access to social support, thereby strengthening negative association between stress and life satisfaction.

The negative association between COVID-19 stress and life satisfaction may also be particularly strong for those in *large* households for two reasons. First, there may be diminishing marginal returns to social support derived from cohabitants, such that while the first or second cohabitants are a source of social support, third and subsequent cohabitants are not. Second, additional cohabitants may induce a multiplier effect on the satisfaction-reducing effects of stress. That is, while stress may always reduce life satisfaction *ceteris paribus*, stress may reduce life satisfaction even more when surrounded by many others (who are likely also dealing with stress) in the house. In the context of COVID-19, there are several ways that additional cohabitants might lead the satisfaction-reducing effects of stress to be multiplied. First, each additional cohabitant represents an additional COVID-19 exposure risk. Second, because individuals could not leave their homes during lockdown, additional cohabitants reduced opportunities for alone time and privacy, while also creating challenges for working from home (Adams et al., 1996; Ernst Kossek & Ozeki, 1998). Third, the presence of additional cohabitants, and especially children or older family members, may mean additional care-giving responsibilities during a period when even basic activities (e.g., grocery shopping) was challenging (Abramson et al., 2008).

In sum, we expect that COVID-19 stress and life satisfaction have a negative association because stressors often reduce satisfaction with life. However, because restricting individuals' activities to their own households was a common pandemic mitigation strategy, we expect that the household is a particularly important context whose features may alter this negative association between stress and satisfaction. Individuals living alone lack sources of social support and therefore may experience a stronger negative association between COVID-19 stress and life satisfaction. Individuals in households with a few other cohabitants do have sources of social support, which can serve to mitigate the deleterious effects of stress, and therefore may experience a weaker negative association between COVID-19 stress and life satisfaction. Finally, individuals living in households with many other cohabitants, whose presence may not offer any additional social support and indeed may multiply the effects of already existing stress, may experience a stronger

negative association between COVID-19 stress and life satisfaction. Accordingly, there may be an optimal household size that ensures social support while also limiting the risks and challenges of a large household, and thereby minimizes the negative association between COVID-19 stress and life satisfaction. However, because household size has not previously been investigated as a moderator for the link between stress and life satisfaction in the context of COVID-19, this remains an open question.

## Pre-registered hypotheses

Based on prior work concerning the associations among stress, life satisfaction, and household size during the COVID-19 pandemic, we pre-registered two hypotheses (see https://osf.io/683bp/). First, we hypothesized that *greater COVID-19 stress is associated with lower life satisfaction* (**H1**). This hypothesis has previously been observed only in non-representative convenience samples (e.g., Charles, 2020; Csikos et al., 2020; Kujawa et al., 2020; Miller et al., 2020; Satici et al., 2020; Sugawara et al., 2020; Trzebiński et al., 2020), however here we investigate it in a representative sample of Michigan adults. Second, we hypothesized that *the association between COVID-19 stress and life satisfaction is quadratically moderated by household size*, such that the effect of COVID-19 stress will be stronger for individuals living alone or with many others (**H2**). This hypothesis is informed by the few COVID-19 studies that have found associations between COVID-19 stress and household structure (e.g., Flesia et al., 2020; Shevlin et al., 2020), but also by a broader literature on the impacts of household size on life satisfaction (e.g., Adams et al., 1996; Ernst Kossek & Ozeki, 1998; Salimi, 2011).

## Method

### Data

We use data from the State of the State Survey (SOSS), which was collected by YouGov for the Institute For Public Policy and Social Research (IPPSR) at Michigan State University between May 8 and 25, 2020. During this period, data was collected from 1086 respondents, whom YouGov matched on gender, age, race, and education to a sampling frame constructed from the 2016 American Community Survey, to yield a final representative sample of 1000 Michigan adults. The timing of the data collection is significant for two reasons. First, it occurred while Michigan residents were under a stay-at-home order, and at a time that Michigan had among the largest number of confirmed COVID-19 cases and deaths (57,601 and 5,479, respectively, by May 25). Second, YouGov completed their data collection on the day that George Floyd was murdered by then-officer Derek Chauvin in Minneapolis, which sparked widespread protests against police brutality, particularly toward Blacks. Thus, these data offer insight into Michigan residents' stress and life satisfaction during the initial COVID-19 outbreak in Michigan, but before these could these variables were impacted by Mr. Floyd's murder or the subsequent protests (c.f., Anderson-Carpenter & Neal, 2021; Neal & Neal, 2021).

## Key variables

Our pre-registered analyses focus on three key variables: life satisfaction (DV), COVID-19 stress (IV), and household size (moderator).

*Life satisfaction* was measured using the satisfaction with life scale (SWLS), which includes 5 items, such as "In most ways, my life is close to my ideal," each measured on a 7-point scale ranging from strongly disagree to strongly agree (Diener et al., 1985). The scale was constructed by computing the mean across all five items. In this sample, the SWLS exhibits an acceptable reliability of $\alpha = 0.91$.

*COVID-19 stress* was measured using responses to the question "How has the COVID-19 impacted how stressed or anxious you are overall?" which ranged from 1 for "much less stressed/anxious" to 5 for "much more stressed/anxious." This question was asked after the SWLS items, and the two were separated by more than 100 unrelated questions covering diverse topics including community involvement, reproduction, personality, and media consumption.

*Household size* was measured as the total number of additional adults and children living in the respondent's household. The pre-registered hypothesis referred to total household size, however because adults and children were measured separately, we also constructed disaggregated household size variables that measured (a) the total number of additional adults in the respondent's household, not including the respondent, and (b) the total number of children in the respondent's household.

## Exploratory variables

Our exploratory analyses also examined three kinds of challenges experienced as a result of COVID-19. *Income challenges* were measured using responses to the question "How has the COVID-19 crisis impacted your household income?" which ranged from 1 for "increased a lot" to 6 for "eliminated all income." *Shopping challenges* were measured using 5 items that asked respondents how much difficulty they had getting the following items due to COVID-19: cleaning supplies and hand sanitizer, groceries, prescription medications, toilet paper, and fruits and vegetables. The items were measured on a 4-point scale that ranged from 1 for "I haven't had any difficulty" to 4 for "I haven't been able to get it at all" and were averaged to yield a shopping challenges scale. The shopping challenges scale exhibits an acceptable reliability of $\alpha = 0.69$. Finally, *boredom challenges* were measured as the number of the following selected outside-the-home activities permitted under Michigan's stay-at-home order that the respondent nonetheless had refrained from participating in: work, shopping, picking up prescriptions, walking around the neighborhood, and visiting a local park or trail. This vari-

able is coded such that larger values indicate refraining from more permitted activities, and thus greater risk of boredom.

## Covariates

All models controlled for several individual characteristics previously shown to be associated with life satisfaction: age (Qu & de Vaus, 2015), gender, relationship status (Joshanloo & Jovanović, 2019), education, household income (Fernández-Ballesteros et al., 2001), race (Barger et al., 2009), and political ideology (Schlenker et al., 2012). This set of covariates was included in the pre-registration; their inclusion in the models as statistical controls is essential to correctly estimate the independent effect of the variables of interest.

Sex was measured using a binary indicator variable coded 0 for males and 1 for females. Due to small numbers of respondents identifying with specific non-White racial groups, race was measured using a binary indicator variable coded 0 for white alone, and 1 for not white alone. Relationship status was measured using a categorical variable with categories for married (omitted), formerly married (i.e., divorced, separated, or widowed), partnered, and single. Education was measured on a 7-point scale that ranged from 0 for no high school, to 6 for graduate degree.[1] Household income was measured on a 10-point scale with $10,000 intervals from $10,000 to $100,000, plus intervals for $100,000 - $149,000, and $150,000 or more.[2] Finally, political ideology was measured on a 7 point scale that ranged from 1 for very conservative, to 7 for very liberal.

## Analytic Plan

We estimate population means for all variables using the complete $N = 1000$ sample, incorporating sampling weights that ensure representiveness by sex, age, race, education, and 2016 presidential vote choice using the survey package for R (Lumley, 2010). For all other analyses, we use listwise deletion to obtain an analytic sample of $N = 693$, and do not use sampling weights because they are a function of covariates already included in the models (Winship & Radbill, 1994). All continuous independent variables are mean-centered prior to analysis, and prior to the construction of squared and interaction terms.

We use OLS regression to test both our pre-registered hypotheses (**H1** and **H2**), and a modified version of our pre-registered hypothesis using a disaggregated measure of household size (**H2a**). These models controlled for demographic variables that were pre-registered because of their links with life satisfaction found in previous research (as described in the Introduction)–age, $age^2$, race/ethnicity, gender, education, income, political ideology and relationship

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[1] The original pre-registration inadvertently omitted education as a proposed covariate. It is included in the models below for completeness, however its exclusion does not change any of the findings.

[2] An error by YouGov in the survey design meant that one interval represented $70,000 to $89,999 household income. Analyses omitting this variable yield nearly identical results.

**Table 1. Sample descriptives (N = 693) and estimated population characteristics.**

| Variable | Sample (N=693) | | | | Population[a] | |
| --- | --- | --- | --- | --- | --- | --- |
| | Mean/Proportion | SD | Min | Max | Mean | SE |
| COVID Stress | 3.71 | 0.89 | 1 | 5 | 3.69 | 0.04 |
| Life Satisfaction (α = 0.91) | 4.34 | 1.55 | 1 | 7 | 4.25 | 0.08 |
| Additional Residents | 2.59 | 1.5 | 1 | 12 | 2.72 | 0.08 |
| Additional Adults[b] | 1.19 | 1 | 0 | 6 | 1.21 | 0.05 |
| Children[c] | 0.4 | 0.89 | 0 | 6 | 0.5 | 0.05 |
| Age | 54.34 | 16.9 | 19 | 95 | 52.1 | 0.95 |
| Race: White | 0.83 | 0.37 | 0 | 1 | 0.82 | 0.02 |
| Race: Non-white | 0.17 | 0.37 | 0 | 1 | 0.18 | 0.02 |
| Sex: Male | 0.44 | 0.5 | 0 | 1 | 0.48 | 0.02 |
| Sex: Female | 0.56 | 0.5 | 0 | 1 | 0.52 | 0.02 |
| Education | 2.77 | 1.79 | 0 | 6 | 2.47 | 0.09 |
| Income | 5.89 | 2.76 | 1 | 11 | 5.77 | 0.15 |
| Political Ideology | 4.15 | 2.06 | 1 | 7 | 3.97 | 0.1 |
| Relationship Status: Formerly Married | 0.17 | 0.37 | 0 | 1 | 0.16 | 0.02 |
| Relationship Status: Married | 0.54 | 0.5 | 0 | 1 | 0.48 | 0.02 |
| Relationship Status: Partnered | 0.07 | 0.26 | 0 | 1 | 0.07 | 0.01 |
| Relationship Status: Single | 0.22 | 0.42 | 0 | 1 | 0.29 | 0.03 |
| COVID Challenges: Income | 3.49 | 1.01 | 1 | 6 | 3.57 | 0.06 |
| COVID Challenges: Shopping (α = 0.69) | 1.71 | 0.52 | 1 | 4 | 1.74 | 0.03 |
| COVID Challenges: Boredom | 2.42 | 1.22 | 0 | 5 | 2.44 | 0.05 |

[a] Estimated population parameters from a stratified N = 1000 sample with sampling weights.

[b] This includes 143 respondents living with no other adults, 378 living with 1 adult, 104 living with 2 adults, 48 living with 3 adults, 12 living with 4 adults, and 8 living with 5+ adults.

[c] This includes 533 respondents with no children at home, 85 living with 1 child, 47 living with 2 children, 19 living with 3 children, 4 living with 4 children, and 5 living with 5+ children.

status. For the sake of completeness, and following recommendations from the editor and a peer reviewer, we also report estimates from reduced models that exclude these covariates.

In our exploratory analyses, which were not pre-registered, we examine whether the association of several types of COVID-19 challenges with life satisfaction is mediated by COVID-19 stress. In these exploratory mediation models, the indirect effect is estimated nonparametrically as an Average Causal Mediation Effect (ACME) with 1000 bootstraps following recommendations from Imai et al. (2010) as implemented in the R `mediate` package (Tingley et al., 2014). In all analyses, we use an alpha level of 0.05 to assess statistical significance.

The replication code and data for these analyses are available at https://osf.io/683bp/.

## Results
### Sample and population characteristics

Table 1 presents sample and estimated population characteristics, while Table 2 presents the bivariate correlations among all variables in the sample. All characteristics of the sample closely match the estimated characteristics of the adult population of Michigan, indicating that it is a representative sample of the population.

### Pre-registered hypotheses

**Association between COVID-19 stress and life satisfaction (H1).** Table 3 reports estimates of the association between COVID-19 stress and life satisfaction from a pre-registered full model that includes covariates and a bivariate reduced model for comparison. Consistent with our hypothesis (**H1**), we find that COVID-19 stress has a significant negative association with life satisfaction in both the reduced model and the pre-registered full model. This effect size can be contextualized with reference to the association between the covariates and life satisfaction. For example, the difference in life satisfaction associated with each level of COVID-19 stress is similar to the difference in life satisfaction between men and women, or to a more than $50,000 difference in household income.

**Household size as a moderator (H2).** Table 4 reports estimates of the association between COVID-19 stress and life satisfaction, moderated by household size, from a pre-registered full model that includes covariates and a reduced model without covariates for comparison. Contrary to our hypothesis, we find no evidence of moderation by total household size in both models.

**Table 2. Sample bivariate correlations (N = 693)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) COVID Stress | 1 | | | | | | | | | | | | | | | | | | | |
| (2) Life Satisfaction | -0.24 | 1 | | | | | | | | | | | | | | | | | | |
| (3) Additional Residents | -0.02 | -0.03 | 1 | | | | | | | | | | | | | | | | | |
| (4) Additional Adults | -0.05 | -0.03 | 0.82 | 1 | | | | | | | | | | | | | | | | |
| (5) Children | 0.02 | -0.01 | 0.77 | 0.27 | 1 | | | | | | | | | | | | | | | |
| (6) Age | -0.15 | 0.17 | -0.36 | -0.22 | -0.36 | 1 | | | | | | | | | | | | | | |
| (7) Race: White | 0.05 | 0.05 | -0.04 | -0.02 | -0.04 | 0.03 | 1 | | | | | | | | | | | | | |
| (8) Race: Non-white | -0.05 | -0.05 | 0.04 | 0.02 | 0.04 | -0.03 | -1 | 1 | | | | | | | | | | | | |
| (9) Sex: Male | -0.15 | -0.03 | -0.06 | -0.04 | -0.06 | 0.14 | -0.05 | 0.05 | 1 | | | | | | | | | | | |
| (10) Sex: Female | 0.15 | 0.03 | 0.06 | 0.04 | 0.06 | -0.14 | 0.05 | -0.05 | -1 | 1 | | | | | | | | | | |
| (11) Education | 0.07 | 0.07 | -0.02 | -0.08 | 0.05 | -0.16 | -0.08 | 0.08 | 0.1 | -0.1 | 1 | | | | | | | | | |
| (12) Income | -0.01 | 0.22 | 0.19 | 0.20 | 0.1 | -0.04 | 0.05 | -0.05 | 0.11 | -0.11 | 0.33 | 1 | | | | | | | | |
| (13) Political Ideology | 0.28 | -0.22 | 0 | -0.05 | 0.05 | -0.25 | -0.14 | 0.14 | -0.03 | 0.03 | 0.20 | 0.03 | 1 | | | | | | | |
| (14) Rel. Status: Formerly Married | -0.02 | -0.07 | -0.18 | -0.18 | -0.1 | 0.26 | -0.05 | 0.05 | -0.14 | 0.14 | -0.06 | -0.19 | -0.02 | 1 | | | | | | |
| (15) Rel. Status: Married | -0.03 | 0.32 | 0.18 | 0.18 | 0.11 | 0.26 | 0.07 | -0.07 | 0.13 | -0.13 | 0.01 | 0.33 | -0.18 | -0.49 | 1 | | | | | |
| (16) Rel. Status: Partnered | 0.03 | -0.12 | -0.01 | 0 | -0.02 | -0.20 | 0.03 | -0.03 | 0 | 0 | 0.01 | -0.09 | 0.19 | -0.12 | -0.3 | 1 | | | | |
| (17) Rel. Status: Single | 0.04 | -0.25 | -0.05 | -0.05 | -0.03 | -0.43 | -0.07 | 0.07 | -0.04 | 0.04 | 0.04 | -0.16 | 0.12 | -0.24 | -0.58 | -0.15 | 1 | | | |
| (18) COVID Challenge: Income | 0.16 | -0.14 | 0.06 | 0.07 | 0.02 | -0.14 | -0.02 | 0.02 | -0.06 | 0.06 | 0.06 | 0.03 | 0.11 | -0.01 | -0.07 | 0.03 | 0.07 | 1 | | |
| (19) COVID Challenge: Shopping | 0.22 | -0.19 | 0.07 | 0.03 | 0.09 | -0.16 | 0.03 | -0.03 | -0.14 | 0.14 | -0.01 | -0.05 | 0.09 | -0.01 | -0.05 | 0.02 | 0.06 | 0.13 | 1 | |
| (20) COVID Challenge: Boredom | -0.02 | -0.07 | -0.06 | -0.06 | -0.04 | 0.16 | -0.09 | 0.09 | -0.12 | 0.12 | -0.16 | -0.15 | 0.04 | 0.09 | -0.08 | -0.01 | 0.03 | -0.04 | 0.1 | 1 |

**Table 3. Direct Association of COVID Stress and Life Satisfaction (N = 693)**

| | Reduced Model | | | | Pre-Registered Full Model | | | |
|---|---|---|---|---|---|---|---|---|
| | β | b | s e | p | β | b | s e | p |
| Intercept | — | 4.34 | 0.06 | < 0.01 | — | 4.29 | 0.10 | < 0.01 |
| COVID Stress | -0.24 | -0.42 | 0.06 | < 0.01 | -0.20 | -0.35 | 0.06 | < 0.01 |
| Age | | | | | 0.09 | 0.01 | 0 | 0.03 |
| Age$^2$ | | | | | 0.20 | 0 | 0 | < 0.01 |
| Non-white | | | | | -0.01 | -0.03 | 0.14 | 0.85 |
| Female | | | | | 0.11 | 0.33 | 0.11 | < 0.01 |
| Education | | | | | 0.09 | 0.08 | 0.03 | 0.01 |
| Income | | | | | 0.11 | 0.06 | 0.02 | < 0.01 |
| Ideology | | | | | -0.12 | -0.09 | 0.03 | < 0.01 |
| Formerly Married | | | | | -0.16 | -0.66 | 0.15 | < 0.01 |
| Partnered | | | | | -0.15 | -0.90 | 0.22 | < 0.01 |
| Single | | | | | -0.29 | -1.09 | 0.16 | < 0.01 |
| R$^2$ | | 0.06 | | | | 0.24 | | |

All continuous variables were grand-mean centered.

**Table 4. Direct Association of COVID Stress and Life Satisfaction, Moderated by Household Size (N = 693)**

| | Reduced Model | | | | Pre-Registered Full Model | | | |
|---|---|---|---|---|---|---|---|---|
| | β | b | s e | p | β | b | s e | p |
| Intercept | — | 4.37 | 0.06 | < 0.01 | — | 4.30 | 0.11 | < 0.01 |
| COVID Stress | -0.22 | -0.39 | 0.07 | < 0.01 | -0.19 | -0.33 | 0.07 | < 0.01 |
| Additional Residents | 0 | 0 | 0.05 | 0.97 | -0.16 | -0.16 | 0.06 | < 0.01 |
| Additional Residents$^2$ | -0.06 | -0.01 | 0.01 | 0.27 | 0.05 | 0.01 | 0.01 | 0.30 |
| Stress × Additional Residents | 0.02 | 0.02 | 0.06 | 0.69 | 0.04 | 0.04 | 0.05 | 0.42 |
| Stress × Additional Residents$^2$ | -0.07 | -0.01 | 0.01 | 0.26 | -0.07 | -0.01 | 0.01 | 0.21 |
| Age | | | | | 0.03 | 0 | 0 | 0.58 |
| Age$^2$ | | | | | 0.20 | 0 | 0 | < 0.01 |
| Non-white | | | | | 0 | 0.02 | 0.14 | 0.89 |
| Female | | | | | 0.11 | 0.34 | 0.11 | < 0.01 |
| Education | | | | | 0.07 | 0.06 | 0.03 | 0.05 |
| Income | | | | | 0.14 | 0.08 | 0.02 | < 0.01 |
| Ideology | | | | | -0.12 | -0.09 | 0.03 | < 0.01 |
| Formerly Married | | | | | -0.18 | -0.74 | 0.16 | < 0.01 |
| Partnered | | | | | -0.17 | -1.01 | 0.23 | < 0.01 |
| Single | | | | | -0.33 | -1.24 | 0.16 | < 0.01 |
| R$^2$ | | 0.06 | | | | 0.27 | | |

All continuous variables were grand-mean centered.

### Modification of pre-registered hypotheses

**Disaggregated household size as a moderator (H2a).** We did not find support for our pre-registered hypothesis that *total* household size moderates the association between COVID-19 stress and life satisfaction. However, the variables provided in the SOSS data allowed us to test a modified version of this pre-registered hypothesis that dis-aggregates household size into adults and children. Table 5 reports estimates of the association between COVID-19 stress and life satisfaction moderated by disaggregated household size, from a model that includes covariates from the pre-registration and a reduced model without covariates for comparison. Contrary to our hypothesis, the number of children in the household did not moderate the association between stress and life satisfaction in both models.

**Table 5. Direct Association of COVID Stress and Life Satisfaction, Moderated by Disaggregated Household Size (N = 693)**

| | Reduced Model | | | | Pre-Registered Full Model | | | |
|---|---|---|---|---|---|---|---|---|
| | $\beta$ | $b$ | $s\,e$ | $p$ | $\beta$ | $b$ | $s\,e$ | $p$ |
| Intercept | — | 4.43 | 0.07 | < 0.01 | — | 4.33 | 0.11 | < 0.01 |
| COVID Stress | -0.20 | -0.35 | 0.07 | < 0.01 | -0.17 | -0.30 | 0.07 | < 0.01 |
| Additional Adults | 0.02 | 0.04 | 0.08 | 0.63 | -0.14 | -0.22 | 0.08 | 0.01 |
| Additional Adults$^2$ | -0.12 | -0.08 | 0.03 | 0.01 | 0.02 | 0.01 | 0.03 | 0.67 |
| Stress × Additional Adults | 0.05 | 0.08 | 0.09 | 0.38 | 0.08 | 0.13 | 0.08 | 0.11 |
| Stress × Additional Adults$^2$ | -0.13 | -0.07 | 0.04 | 0.10 | -0.19 | -0.10 | 0.04 | 0.01 |
| Children | 0.03 | 0.05 | 0.12 | 0.67 | 0.01 | 0.02 | 0.12 | 0.9 |
| Children$^2$ | -0.02 | -0.01 | 0.05 | 0.77 | -0.05 | -0.03 | 0.04 | 0.47 |
| Stress × Children | 0.01 | 0.02 | 0.14 | 0.90 | -0.04 | -0.06 | 0.13 | 0.61 |
| Stress × Children$^2$ | 0 | 0 | 0.05 | 0.97 | 0.10 | 0.05 | 0.05 | 0.27 |
| Age | | | | | 0.04 | 0 | 0 | 0.35 |
| Age$^2$ | | | | | 0.21 | 0 | 0 | < 0.01 |
| Non-white | | | | | 0 | 0.01 | 0.14 | 0.96 |
| Female | | | | | 0.11 | 0.34 | 0.11 | < 0.01 |
| Education | | | | | 0.07 | 0.06 | 0.03 | 0.07 |
| Income | | | | | 0.14 | 0.08 | 0.02 | < 0.01 |
| Ideology | | | | | -0.12 | -0.09 | 0.03 | < 0.01 |
| Formerly Married | | | | | -0.18 | -0.76 | 0.16 | < 0.01 |
| Partnered | | | | | -0.17 | -1.02 | 0.23 | < 0.01 |
| Single | | | | | -0.32 | -1.20 | 0.17 | < 0.01 |
| $R^2$ | | 0.08 | | | | 0.27 | | |

All continuous variables were grand-mean centered.

However, consistent with our hypothesis, the number of adults in the household did quadratically moderate the association between and stress and life satisfaction in the full model. Notably, this moderation effect is not significant when the covariates are excluded.

Figure 1A illustrates the simple slopes of the stress and life satisfaction association for different numbers of additional adults in the household, while Figure 1B plots the magnitude of the simple slope as a function of adult household size. COVID-19 stress has the smallest negative association with life satisfaction in households with one or two additional adults, and a stronger negative association with life satisfaction for those living alone and for those living with many other adults.

## Exploratory analyses: Sources of COVID-19 stress

After observing the negative association between COVID-19 stress and life satisfaction, we wanted to know what may be responsible for COVID-19 stress, and whether those factors directly and indirectly influence life satisfaction. We explored this in the context of three specific types of challenges respondents may have encountered: income loss, shopping difficulty, and boredom during the stay-at-home order. Table 6 presents the results of these mediation analyses. We find that shopping and income challenges, but not boredom challenges, had a significant negative indirect association with life satisfaction that was mediated by COVID-19 stress. That is, individuals who lost income and who had difficulty shopping for basic supplies experienced more COVID-19 stress, and in turn had lower life satisfaction.

## Discussion

Using a representative sample of adults in Michigan, we investigated the association between COVID-19 stress and life satisfaction moderated by household size. Consistent with previous research (Charles, 2020; Csikos et al., 2020; Dymecka et al., 2020; Satici et al., 2020), we found support for our pre-registered hypothesis that COVID-19 stress predicted lower life satisfaction. We did not find support for our pre-registered hypothesis that *total* household size moderates the association between COVID-19 stress and life satisfaction. However, we did find support for a modified version of this hypothesis: the number of *adults* in the household moderates the association between COVID-19 stress and life satisfaction, such that COVID-19 stress has the strongest negative association with life satisfaction among people living *alone* or with *several* other adults. Importantly,

**Table 6. The indirect and direct effects of the number of COVID-19 challenges on life satisfaction, mediated by COVID-19 stress (N = 693)**

| Model | b | 95% CI | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| Shopping Challenges | | | | |
|     Indirect effect | -0.07 | -0.14 | -0.02 | 0.01 |
|     Direct effect | -0.31 | -0.52 | -0.11 | < .01 |
| Income Challenges | | | | |
|     Indirect effect | -0.03 | -0.05 | 0.00 | 0.03 |
|     Direct effect | -0.08 | -0.18 | 0.04 | 0.18 |
| Boredom Challenges | | | | |
|     Indirect effect | 0.01 | -0.01 | 002 | 0.46 |
|     Direct effect | -0.05 | -0.14 | 0.04 | 0.33 |
| Component path estimates | | | | |
|     Shopping -> COVID-19 stress | .28 | .16 | .40 | < .01 |
|     Income -> COVID-19 stress | .10 | .03 | .16 | < .01 |
|     Boredom -> COVID-19 stress | -.02 | -.08 | .03 | .41 |
|     COVID-19 stress -> life satisfaction | -.26 | -.40 | -.12 | < .01 |

Continuous variables were grand-mean centered. Models include all covariates from the full model in Table 5. 1000 bootstraps used.
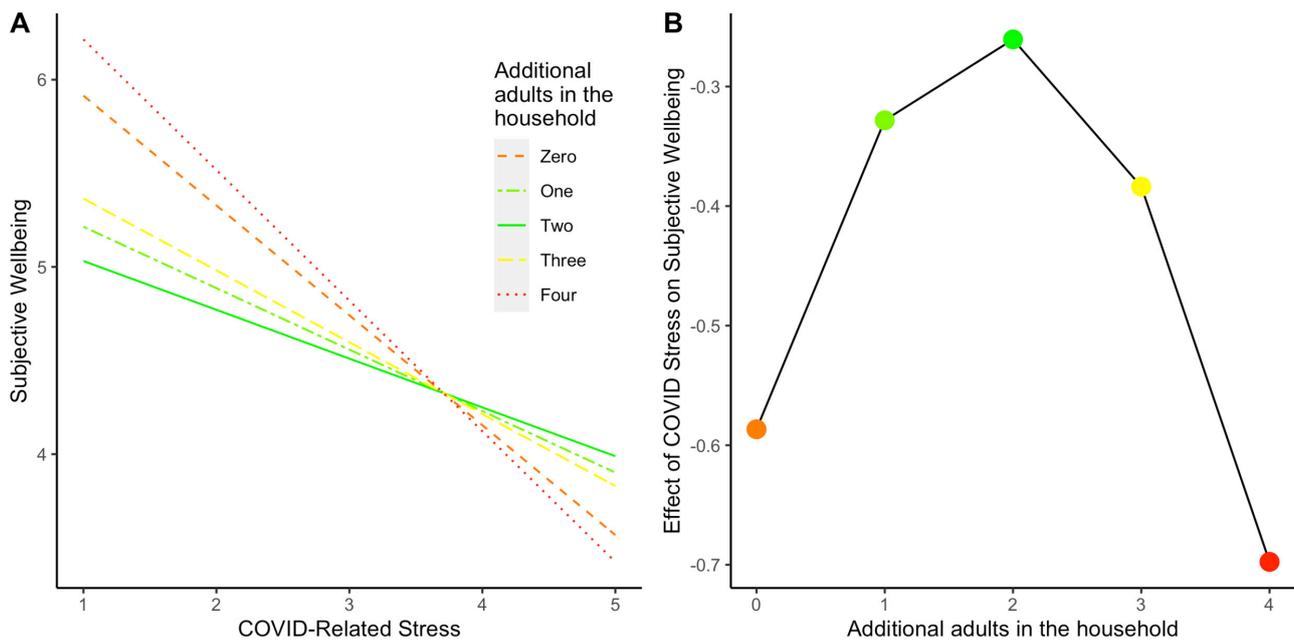


**Figure 1. (A) Association between COVID-19 stress and life satisfaction for different adult household sizes, (B) Simple slopes for the association between stress and life satisfaction by adult household size.**

In both plots, color indicates slope on a red-yellow-green continuum where red indicates more negative slopes and green indicates less negative slopes.

this moderation is significant only when pre-registered demographic characteristics are included as control variables, indicating that one or more of these characteristics functions as a suppressor. Observing a negative association between COVID-19 stress and life satisfaction, we also conducted a series of exploratory mediation analyses to understand what situations may lead to experiencing COVID-19 stress, and subsequently to declines in life satisfaction. We observe that experiencing challenges with shopping and a loss of income both had indirect negative associations with life satisfaction, mediated by COVID-19 stress. Experiences of boredom, due to refraining from activities during a pandemic lockdown period, did not exhibit these associations.

Due to the potential for loneliness (Groarke et al., 2020) and possible difficulties with balancing work and family life

during the lock-down (Adams et al., 1996), we had hypothesized household size would moderate the the association between COVID-19 stress and life satisfaction. Although COVID-19 stress was detrimental to the life satisfaction of individuals in small and large households, this could be driven by different mechanisms. For example, social isolation and too much solitude could amplify the life satisfaction-reducing effects of COVID stress for those living alone, while fear of exposure or the diminishing marginal value of additional social support may amplify this effect for those living in large households. This pattern is consistent with recent evidence suggesting that the frequency of social contact has an inverted U-shaped relationship with self-rated physical health and longevity across a large number of countries–increasing contact was associated with positive outcomes at lower levels of contact but after a certain point, increasing contact was no longer linked with health improvements and sometimes even linked with higher mortality risks (Stavrova & Ren, 2020).

Contrary to our original hypothesis, we found that only the number of *adults* in the household moderated the stress-satisfaction association. There are several possible reasons that the number of adults, but neither the number of children nor total people, in the household moderated this association. First, only 23% of respondents reported having children in their household, so there was limited variation in household size due to the presence of children. Second, while children's movements can be more easily monitored and constrained, adults have more freedom to go out, and therefore may present (or be perceived as presenting) a greater risk of exposure and infection (Flesia et al., 2020). Third, negotiating what constitutes appropriate household pandemic behaviors (e.g., how often to sanitize surfaces) with adult co-habitants that hold different standards could be stressful. Fourth, it is possible that the amount of social support received from co-habitants, and thus the extent to which they reduce or exacerbate the stress-life satisfaction association, depends not merely on the number of co-habitants, but on who they are (Okabe-Miyamoto et al., 2021). Future research can investigate which, if any of these explanations accounts for the partial support of our moderation hypothesis.

Results from the exploratory analyses suggested that experiencing more challenges with shopping (e.g., getting groceries, medicine, hand sanitizer) was particularly difficult for people as it was directly associated with lower life satisfaction, but was also indirectly associated with lower life satisfaction because it increased COVID-19 stress. This is consistent with research on Hurricane Katrina that found experiencing more hurricane-related stressors –not having access to water, food, medicine/medical care (similar to our shopping variable)– predicted lower life satisfaction both one year and four years after the storm (Calvo et al., 2015). Recent work suggested that people who feel more threatened by COVID-19 engaged in stockpiling behavior, which provides a sense of psychological safety (Garbe et al., 2020). Our findings suggest that when people have trouble buying not only necessities directly related to saving and/or maintaining their lives but also products that provides a psychological sense of safety and normalcy, this predicts lower life satisfaction both directly and through increasing stress.

Given previous research that identifies unemployment as a reliable predictor of lower life satisfaction during non-pandemic times (Lucas et al., 2004), it was surprising to find that income challenges had only a weak, indirect effect on life satisfaction. One possibility is that government supports in the form of Paycheck Protection Program loans to businesses and temporary increases to unemployment insurance payments insulated individuals from income losses, mitigating their stress-inducing and life satisfaction-reducing impacts. A second possibility is that income loss is a challenge many people in the past have experienced, and this familiarity may have mitigated its potential negative impact or that they expected such reductions to be temporary, whereas individuals were relatively unprepared for unfamiliar challenges such as difficulty buying toilet paper.

These findings and interpretations are subject to some important limitations, which suggest directions for future research. First, these data are cross-sectional, and therefore we are unable to make causal inferences. Specifically, we are unable to determine the causal direction of the observed association between COVID-19 stress and life satisfaction; we believe increases in stress lead to decreases in life satisfaction, but it is possible that individuals with lower life satisfaction experience or perceive greater stress during the pandemic (e.g., Trzebiński et al., 2020). Moreover, even if COVID-19 stress does reduce life satisfaction, the effect may be temporary to the extent that individuals are often resilient to trauma (Galatzer-Levy et al., 2018). Second, these analyses relied on a single-item measure of COVID-19 stress and therefore may be less stable than the multi-item measures that have been developed since these data were collected (Chung et al., 2020; Pulido, 2020; Satici et al., 2020; Taylor et al., 2020). Similarly, they relied on a measure of boredom that only included refraining from selected outside-the-home activities permitted during the stay-at-home order, and thus does not capture engagement in prohibited activities or inside-the-home activities. Third, the number of individuals in our sample who reported living in a large household containing four or more additional adults was small (N = 20), and although representative of Michigan's adult population, this 'large household' subgroup may be driving part of the quadratic moderation we observe. A related issue is that we do not know how or whether these adults are related, and thus cannot distinguish between, for example, households of young adult roommates from intergenerational households, which may have differing COVID-19 dynamics (Bernstein, 2020). Finally, although these analyses are based on a representative sample of, and therefore our conclusions should generalize to, the adult population of Michigan, they nonetheless represent only one US state experiencing a specific phase (i.e., the peak of wave 1) of the COVID-19 outbreak. Associations between COVID-19 stress and life satisfaction may be different in places where the outbreak was more or less widespread, and in later phases when the nature of the illness and potential treatments are better understood.

Despite these limitations, our findings point to some potential implications for mitigating declines in life satisfaction as a consequence of the COVID-19 pandemic. First, it may be useful for local authorities to identify physical and mental health supports for those living alone and those

living in group settings, whom we find are at greater risk of declines in life satisfaction due to COVID-19 stress. For single-person households, this could include resources for staying socially connected through virtual social events. For large multi-person households, this could include information about reducing within-household illness transmission. However, future research that directly investigates loneliness, social support, and fear of transmission as a function of the number of adults in the household is necessary to make stronger recommendations. Further, future studies should also consider the intersection between living arrangements and individual differences as recent studies highlight the importance of character strengths, personality and emotion regulation strategies for people's life satisfaction as the pandemic continues (e.g. Gubler et al., 2020). For example, higher transcendence was linked with less distress while controlling for the effect of having a child at home (Casali et al., 2020). Second, it may be useful to anticipate and cope with pandemic-induced challenges that are not commonly encountered during non-pandemic periods and therefore are unfamiliar. For example, few households have likely experienced challenges purchasing basic household products such as toilet paper, so this challenge may have been particularly stressful. However, again, further research on the sources of COVID-19 stress is needed to develop clear recommendations for mitigating stress and the associated declines in life satisfaction.

## Data Availability Statement

These analyses are based on the 79th State of the State Survey, conducted by the Institute for Public Policy and Social Research at Michigan State University. Data and materials to replicate these analyses are available at https://osf.io/683bp/

## Competing interests

The authors declare they have no competing interests.

## Author contributions

Both authors contributed equally to the design, analysis, interpretation, writing, and revision.

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