



Education Racial and Gender Disparities in COVID-19 Worry, Stress, and Food Insecurities across Undergraduate Biology Students at a Southeastern University

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The global spread of the novel coronavirus first reported in December 2019 led to drastic changes in the social and economic dynamics of everyday life. Nationwide, racial, gender, and geographic disparities in symptom severity, mortality, and access to health care evolved, which impacted stress and anxiety surrounding COVID-19. On university campuses, drastic shifts in learning environments occurred as universities shifted to remote instruction, which further impacted student mental health and anxiety. Our study aimed to understand how students from diverse backgrounds differ in their worry and stress surrounding COVID-19 upon return to hybrid or in-person classes during the Fall of 2020. Specifically, we addressed the differences in COVID-19 worry, stress response, and COVID-19-related food insecurity related to race/ethnicity (Indigenous American, Asian/Asian American, black/African American, Latinx/Hispanic, white, or multiple races), gender (male, female, and gender expressive), and geographic origin (ranging from rural to large metropolitan areas) of undergraduate students attending a regional-serving R2 university, in the southeastern U.S. Overall, we found significance in worry, food insecurity, and stress responses with females and gender expressive individuals, along with Hispanic/Latinx, Asian/Asian American, and black/African American students. Additionally, students from large urban areas were more worried about contracting the virus compared to students from rural locations. However, we found fewer differences in self-reported COVID-related stress responses within these students. Our findings can highlight the disparities among students' worry based on gender, racial differences, and geographic origins, with potential implications for mental health of university students from diverse backgrounds. Our results support the inclusion of diverse voices in university decision making around the transition through the COVID-19 pandemic.

KEYWORDS COVID19, gender, gender expressive, pandemic, race/ethnicity, student stress, worry, disparity

INTRODUCTION

COVID-19 was first reported in December 2019 in Wuhan, China, although new evidence suggests that it likely began spreading unnoticed at least a month earlier (1, 2). Since then, COVID-19 quickly spread across the globe, with the first confirmed case in the United States reported in January 2020.

Travel, education, and commerce restrictions were implemented in highly populated areas of the United States beginning in early March, with restrictions still being imposed nationwide. As of September 2021, the United States was ranked the highest in confirmed coronavirus cases by country, responsible for ~20% of all cases since the start of the pandemic (3–5). While nearly all college campuses transitioned to emergency remote instruction during the Spring and Summer of 2020 (6), during the Fall of 2020 and Spring of 2021, many campuses began transitioning back to in-person or hybrid instruction (7–9).

As the global spread of COVID-19 continued, it disproportionately affected individuals from lower socioeconomic status, individuals living in urban environments, and communities of color (10–13). Communities of color were disproportionately impacted by social conditions (i.e., disparities in poverty,

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housing, education, and wage), systemic and structural racism, limited access to health care, and other health comorbidity factors that led to elevated risks for a COVID-19 infection and deaths in these communities (13, 14). Additionally, a higher proportion of individuals of color were deemed essential front-line workers and suffered from higher rates of COVID-19 exposure as early lockdowns were put into place (15). In San Francisco, CA, Latinx/Hispanic individuals comprised 80% of all intensive care unit (ICU) admissions at Zuckerberg San Francisco General Hospital and 20% to 25% of all COVID-19 cases, despite only making up 15% of the total population (12). In April of 2020, preliminary data reported from the CDC showed that black/African American communities made up 34% of all U.S. COVID-19 cases, while only making up about 13% of the national population (16). Additionally, while only 20% of the U.S. counties are predominantly black/African American, 52% of the COVID-19 diagnoses and 58% of the COVID-19 deaths occurred in these counties (13). Differences in early spread and impact of COVID-19 across urban populations and communities of color possibly shaped worry and concern surrounding contracting COVID-19.

Overall worry about the virus related to an increase in fear and avoidance behaviors as well as compulsive hygiene and health behaviors, such as remaining socially isolated from friends and family, repeated hand washing, temperature checking, or excessive use of personal protective equipment (PPE) (17). Higher reports of fear and anxiety related to the coronavirus pandemic occurred globally (18–23). For example, Akdinez (18) found that 90% of all people surveyed increased the frequency of handwashing due to the virus, as well as a 50% increase in people wearing gloves. Similarly, Li et al. (24) found an increase in sleep disturbance and suicidal thoughts related to the pandemic, commonly caused by worry, decreases in social interactions, and lower perceived social support. Gender differences were found with COVID worry, where female worry was linked to health concerns associated with the COVID-19 virus and male worry more strongly linked to economic and societal changes that accompanied COVID-19 restrictions (25, 26). Gender expressive and non-binary communities reported greater stress due to barriers to gender-affirming health care and legal rights, as well as social isolation (27, 28). Media sources pertaining to the virus appeared to shape anxiety levels, with social media posts reportedly causing more worry than information obtained through academic sources (29).

In early March 2020, most schools and universities transitioned to an emergency virtual format with little to no warning. This transition affected both primary education and university students, with virtual learning reducing students' access to necessary materials and interpersonal interaction, thereby reducing their ability to engage (30–32). This shift in the learning environment affected other academic, social, mental, and physical aspects of the university experience as well, as students reported reduced connections with peers and faculty and greater feelings of isolation (33), a reduced sense of belonging, and higher rates of mental health distress, which could impact student success and retention (34–36). At another university in the

Southeastern United States, 71% of students reported increased levels of stress and anxiety related to the pandemic, resulting in difficulty concentrating, reduced sleep, decreased social interactions, and fear and worry about the health and wellbeing of loved ones (21, 37). Young adults experienced a higher rate of suicidal thoughts as a result of the pandemic (10). Alterations in university function negatively impacted students by reducing their access to core necessities such as reliable food, housing, and Internet, along with disability services and university job income (33). Many schools transitioned from remote to in-person instruction during the Fall of 2020, which brought challenges to both students and faculty in balancing worry with the desire for connection with others.

Students across the country reported increased levels of stress and anxiety associated to the coronavirus; however, student demographics likely play a large impact on student worry and stress surrounding COVID-19. Female students were more likely to report negative effects from social isolation, report higher rates of stress, and more readily used social media to cope with the social isolation associated with the pandemic relative to male peers (38, 39). Additionally, a study by Zhu (40) found that males utilized video games as a distracting coping mechanism during the pandemic, while females turned to social media outlets, which potentially exposed them to more fear-based articles about the pandemic (41), and thus, may have exacerbated their anxiety. Additionally, individuals who previously suffered from mental health concerns, such as depression, anxiety, and obsessive-compulsive disorder (OCD) prior to the pandemic reported a worsening of symptoms during the pandemic (42–44). Mental health struggles plagued black/African American and Latinx/Hispanic communities during the pandemic compared with white Americans (10, 11, 33, 34). Thus, life changes due to disruptions to learning environment, changes in social connections, and social resources may have contributed to student mental health struggles associated with the virus (18, 19, 25, 32, 39).

To understand how individuals from a diverse student body experienced COVID-19 worry, stress responses, and food insecurity upon return to hybrid or in-person classes during Fall 2020, we surveyed 657 undergraduate students enrolled in biology courses as majors or non-majors at the University of South Alabama in Mobile, Alabama from August 21, 2020 to September 29, 2020. At the time of this survey, 5.57 million COVID-19 cases had been reported in the United States, accounting for approximately 24.5% of all cases since the pandemic began (5). Our goal was to explore if there were differences in how COVID-19 impacted everyday lives of students enrolled within biology courses from differing demographic groups. Specifically, we asked how (i) COVID-19 worry, (ii) stress response, and (iii) COVID-19-related food insecurity differs in race/ethnicity (Indigenous American, Asian/Asian American, black/African American, Latinx/Hispanic, white, or multiple races) and gender (cis male, cis female, gender expressive) across students attending the University of South Alabama, and whether the size of the individuals' community of origin relate to overall worry about the pandemic.

TABLE 1
Campus-wide student body demographics at the University of South Alabama

Student gender	Student identity
Male	32.10%
Female	67.90%
Student race/ethnicity	
White, Caucasian	62.60%
Black, African Americans	20.60%
Latinx	4.10%
Asian/Asian American	3.70%
Multiple races	3.30%
Indigenous, Native Americans	1.03%
Native Hawaiian/Pacific Islander	<1%

Data collected from the University of South Alabama Office of Institutional Research in 2021.

METHODS

Participant pool

Our participant sample included 657 undergraduates at the University of South Alabama, a medium-sized, public, R-2 institution in Mobile, Alabama, USA. The student body of the University of South Alabama consists of 63% white, 20.6% African American/black, 4.1% Latinx/Hispanic, and 3.7% Asian/Asian American students (Table 1) with 67% female students, 32% male, and ~1% gender expressive students (45). Students enrolled in biology courses as majors (463 students), and non-majors (194 students) were emailed the survey the first week of courses as

part of a larger pre-course data collection during September 2020 and student participation in the study was completely voluntary. In some courses, students were able to obtain bonus points for participation; however, students that opted-out of participating could still receive bonus points. Survey items and methodology were granted an exemption from full review by the University of South Alabama IRB, #1544421-5 to J.A.H.

Study design and questionnaire development

In this study, we incorporated validated COVID-19 scales of Taylor et al. (17), which included questions related to contracting COVID-19, how effective the survey respondents think the preventative measures are, how worried the survey respondents are about spreading the virus to family members, accessing health care, accessing resources from grocery stores, accessing online information about the virus, and physiological responses to the virus. A full list of questions can be found in Table 2. The survey had students rate their level of agreement on a 0–7 Likert scale ranging from strongly disagree to strongly agree as it relates to the questions in Table 2. Following the questionnaires, we asked students to provide a wide variety of demographic data, which included self-reported gender identity, race/ethnicity, and geographic upbringing i.e., how big of a community the student grew up in (Table 2). Summary statistics including the number of students within each demographic variable can be found within Table S1. Additional demographic information on our student body and the relationship with COVID-19 worry, stress, and food insecurity including year in school, whether student was a biology major, first-generation college student status, transfer student status, commuter student status, and international student status, can be found in Table S2 to S5.

TABLE 2
Social identity facets included within our survey, hypotheses on how COVID-19 impacts worry, mental health, and food insecurities, and categories for each facet

Factors	Logic for inclusion	Categories	References
Gender	Gender differences exist in susceptibility to the virus and the severity of the symptoms. Gender also plays a large role in the degree and source of anxiety.	Male Female Gender expressive	Jin et al. 2020; Spagnolo et al. 2020; van der Vegt and Kleinberg 2020; Mazza et al. 2020
Race/ethnicity	Racial disparities were found in who was most susceptible to this virus, which could cause people in some racial and ethnic backgrounds to have more anxiety over the coronavirus than others.	Indigenous American Asian/Asian American Black/African American Latinx/Hispanic White Multiple races	Fortuna et al. 2020; National Center for Immunization and Respiratory Diseases & the Division of Viral Diseases 2020; Millett et al. 2020
Geographic upbringing	Where people grew up could influence their beliefs or anxiety levels over the virus. This demographic refers to the size of the population that the survey respondent was raised prior to attending the University of South Alabama.	Rural Town < 10,000 City < 80,000 Suburban City < 500,000 City > 500,000	Lederbogen et al. 2011

Data analysis

All statistical analyses were conducted in R version 3.3.2 (46) and RStudio version 1.0.44 (47), with packages cited where applicable. After omitting participants who did not respond to all survey items, 657 total participants were included in this study. To explore patterns in how respondents answered questions regarding the coronavirus pandemic, we performed a maximum-likelihood exploratory factor analysis using the *factanal* function with a varimax rotation. The *nScree* function (*nFactors*, [48]) and *vss* function (*psych*, [49]) were then used to determine the number of factors to include during subsequent analysis. Both Velicer's minimum average partial test and parallel analysis tests converged on the retention of three factors. These final factor groupings were determined based on Comrey and Lee's (50) criteria and any factor loading less than 0.5 was rejected.

Overall, factor groupings conform to logical themes within our survey questions. All the survey questions of interest fell into three factor groupings (Table 3). Our first factor consisted of 12 questions related to the participant's level of worry about the COVID-19 virus, termed "COVID-19 worry." Survey questions consisted of worry about contracting the virus, hygiene, and health care concerns etc. (full list in Table 2); this factor explained 12% of the variation within our questionnaire data. Factor 1 corresponded to a combination of the COVID-19 danger and contamination and COVID-19 contamination measures on the COVID-19 Stress Scales. Factor 2, "COVID-19 stress response," grouped survey questions together that asked students about the extent that the virus was affecting their mental state, including disturbing thoughts, dreams, and mental images relating to COVID-19 (Table 3); this factor explained 9% of variation in questionnaire data. Factor 2 corresponded to a combination of the COVID-19 traumatic stress and COVID-19 compulsive checking measures on the COVID-19 Stress Scales. The third factor, "Food insecurity," explained an additional 3% of variation and grouped questions related to students worrying about grocery stores running out of food and water, as well as grocery store closures related to the pandemic. Factor 3 corresponded to a subset of the COVID-19 socio-economic consequences measure on the COVID-19 Stress Scales.

To reduce the number of statistical models we ran, we created composite outcome measures with the results of our factor analysis using principal-component analysis (PCA). For each of our three factors, we conducted a PCA using the *rda* function (*vegan*, [51]), then extracted scores of the first principal component to serve as our composite outcome measure. The first principal component of each factor of interest made up over 60% of the variation in the data and explained 63% of the data variation for COVID-19 worry, 69% of the variation for COVID-19 stress, and 89% of the variation for food insecurity. Scores from the first principal components of each of our three factor groupings were used as response variables within an analysis of variance (ANOVA) model with race/ethnicity, gender, size of hometown, and interactions between them as predictor variables. If no significant interaction effects were found, we removed interaction

TABLE 3
Outcome measures (bold) and questionnaire items that were included to construct outcome results

Factor 1: COVID-19 worry	
	Contracting the virus
	Basic hygiene (e.g., handwashing) is not enough to keep me safe from the virus
	Healthcare system is unable to keep me safe from the virus
	Can't keep my family safe from the virus
	Healthcare system won't be able to protect my loved ones
	Social distancing is not enough to keep me safe from the virus
	Running out of cleaning or disinfectant supplies
	People around me will infect me with the virus
	Touched something in a public space (e.g., handrail, door handle), I would contract the virus
	Someone coughed or sneezed near me, I would contract the virus
	Might contract the virus from handling money or using a debit machine
	Taking change in cash transactions
Factor 2: COVID-19 stress response	
	Trouble sleeping because I worried about the virus
	Bad dreams about the virus
	Thought about the virus when I didn't mean to
	Disturbing mental images about the virus popped into my mind against my will
	Trouble concentrating because I kept thinking about the virus
	Reminders of the virus caused me to have physical reactions, such as sweating or a pounding heart
	Checked social media posts concerning COVID-19
	YouTube videos about COVID-19
	Sought reassurance from friends or family about COVID-19
	Checked your own body for signs of infection (e.g., taking your temp)
	Asked health professionals (e.g., doctors or pharmacists) for advice about COVID-19
	Searched the Internet for treatments for COVID-19
Factor 3: Food insecurity	
	Grocery stores running out of food
	Running out of water
	Grocery stores will close down

Within the text, Factor 1 encompasses COVID-19 worry, Factor 2 encompasses COVID-19 stress, and Factor 3 encompasses food insecurity related to the COVID-19 pandemic.

terms from our model. Next, to determine differences within treatments, we conducted a Tukey post-hoc test on significant predictor variables using the *TukeyHSD* function. Finally, we plot modeled parameter estimates from predictor variables after accounting for other predictor variables using the *effects* package (52) with the *ggplot2* package (53). Summary statistics including sample size, mean, and 95% confidence intervals can be found in Table S1 for COVID-19 worry, COVID-19 stress response, and COVID-19 related food insecurity. Mean values for COVID-19 Stress Scales by student demographics can be found in Table S6.

TABLE 4

ANOVA table comparing gender, race/ethnicity, and upbringing to worry caused by COVID-19, mental health effects of the virus, and food insecurity relating to the COVID-19 virus

	Sum of Sq	df	F	P
Factor 1: Worry caused by COVID-19				
Gender	2.882	2	10.37	>0.0001
Race/ethnicity	5.088	5	7.32	>0.0001
Upbringing	1.391	5	2	0.077
Factor 2: Stress caused by COVID-19				
Gender	1.43	2	5.18	0.006
Race/ethnicity	1.46	5	2.11	0.063
Upbringing	0.26	5	0.37	0.868
Factor 3: Food insecurity related to COVID-19				
Gender	0.54	2	3.79	0.023
Race/ethnicity	3.42	5	9.7	>0.0001
Upbringing	0.11	5	0.3	0.915

Significant effects were found across gender and race in relation to all three factors studied. Sum of Sq, sums of squares; df, degrees of freedom; F, F statistic; P, P value.

RESULTS

COVID-19 worry

When evaluating how COVID-19 affected local students, we found that gender, race, and geographic origin all contributed to the degree of worry surrounding the pandemic ($F_5 = 10.37$, 7.32 , and 2.00 , respectively; $P < 0.05$; Table 4). When examining the worry associated with COVID-19, we found that white students were significantly less worried about the virus compared to Asian/Asian American ($P = 0.003$; Table S7), black/African American ($P = 0.0004$; Table S7), and Latinx/Hispanic students ($P = 0.032$; Fig. 1, Table S7). Additionally, we found that males were significantly less worried about the novel coronavirus compared to females ($P = 0.0008$; Table S7) and gender expressive individuals ($P = 0.024$; Fig. 1, Table S7). When we compared the size of the community where respondents grew up, people living in areas with a population of greater than 500,000 people were marginally more likely to worry about the virus compared with students that grew up in rural communities ($P = 0.09$; Fig. 1, Table S7).

COVID-19 stress

Overall, we found that the strong patterns of COVID-19 worry did not always translate into higher self-reported stress responses by our student population. Significant differences were found with questions relating to stress responses across gender ($F_5 = 5.17$; $P = 0.006$), with a marginal difference in COVID-19 stress across race/ethnicity demographics ($F_5 = 2.11$; $P = 0.06$). We found no relationship of COVID-19 stress in relation to upbringing location ($F_5 = 0.37$; $P = 0.86$; Table 4). We found that gender expressive individuals ($P = 0.02$; Table S8), but

not female students ($P = 0.18$; Table S8), reported higher stress-responses associated with COVID-19 compared to males (Fig. 2; Table S8).

COVID-19 food insecurity

Gender and race significantly contributed to the level of food insecurity experienced by the student body ($F_5 = 3.78$ and 9.70 , respectively; $P < 0.05$; Table S9). We found that COVID-19 related food insecurity worry was significantly higher in black/African American ($P < 0.0001$; Table S9) and marginally higher in Asian/Asian Americans ($P = 0.07$; Table S9) compared with their white peers (Fig. 3). Female students also reported marginally higher food security worry compared to their male peers ($P = 0.0933$; Fig. 3; Table S9). Similar to COVID-19 stress response, there was no relationship between student geographic origin and food insecurity worry ($F_5 = 0.30$, $P = 0.915$, Fig. 3).

DISCUSSION

We surveyed returning college students enrolled in biology courses during the Fall of 2020 to understand how our student body was experiencing COVID-19-related worry, stress responses, and food insecurity. We found racial and gender differences in worry and food insecurities associated with COVID-19. Overall, we found that black/African American, Asian/Asian American, and Latinx/Hispanic students were significantly more worried about contracting and transmitting COVID-19 compared with white peers, and female and gender expressive students were 15% and 40% more worried about contracting COVID-19 relative to male peers. Students that grew up in larger metropolitan areas were significantly more

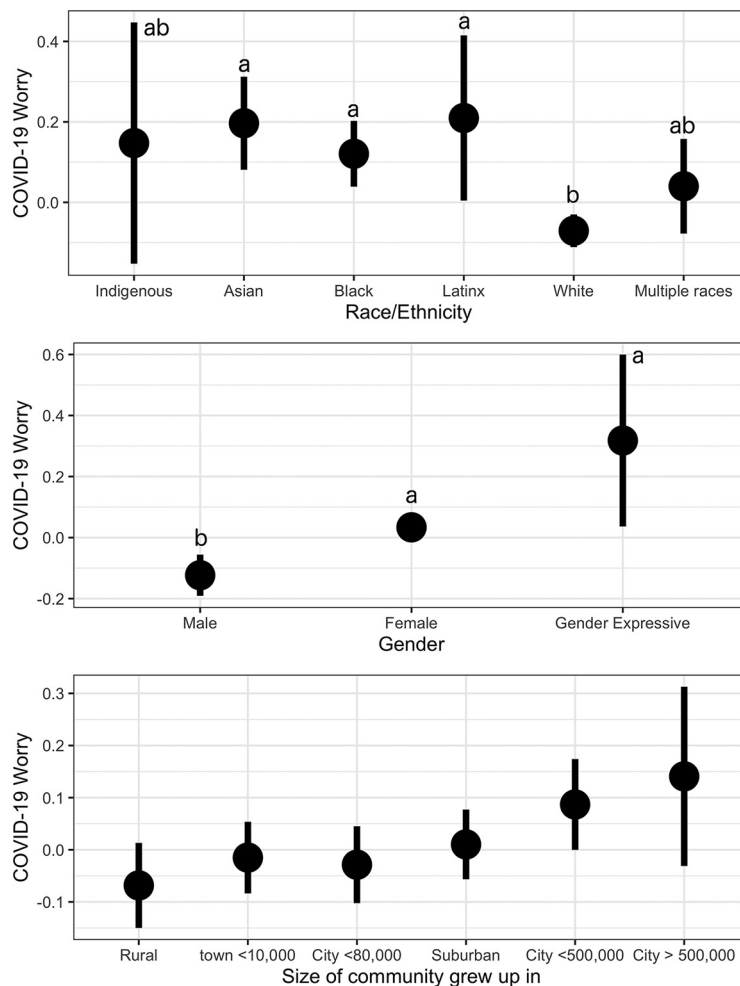


FIG 1. Self-reported student COVID worry versus race/ethnicity (top), gender (middle), and upbringing (bottom). COVID worry metric was calculated as the first principal component of all the questions related to COVID worry in the first factor of our factor analysis. More positive results indicate higher rates of COVID-19 worry. This composite variable corresponds to a combination of the COVID danger and contamination and COVID contamination measures on the COVID Stress Scales. Letters indicate significant differences within a Tukey post-hoc analysis. Outcome measures and statistics can be found in Tables 3 and S7.

worried about contracting and transmitting COVID-19 relative to peers from more rural communities. Additionally, we found that black/African American and Asian/Asian American students significantly more worried about food insecurities associated with COVID-19 relative to their white peers. Surprisingly, the higher rates of worry associated with COVID-19 did not translate to higher self-reported stress responses—sleeplessness, panic attacks, nightmares, etc.—for students of color. Conversely, gender expressive students exhibited greater stress responses. Overall, our results are reflective of the struggles met by communities of color that were evident during early parts of the pandemic. Additionally, it highlights differences in the COVID-19-related stressors and coping among gender.

At the time we conducted our survey, the virus had infected 5.57 million people and resulted in 174,300 deaths in the United States alone (5). The pandemic took an enormous toll on the economy, social structure, and the mental health of many

Americans. Students across the country reported increased levels of stress and anxiety associated to the coronavirus, with some gender disparities being reported. Another university in the Southeastern United States found 71% of students reported increased levels of stress, leading to reductions in sleep, concentration, and social interactions (2, 21). Our results revealed previously reported factors surrounding stress and coping, while illuminating some curious findings as well.

Previous studies have demonstrated that male gender was a protective factor against stress (54), and that females may be more vulnerable to anxiety and stress, which was also present in this study. To date, few studies examined relationships between student demographics and the COVID-19 virus, such as one study looking at gender disparities and found that females were more likely to report negative effects from social isolation compared to males, reported higher rates of stress, and more readily used social media to cope with the social isolation

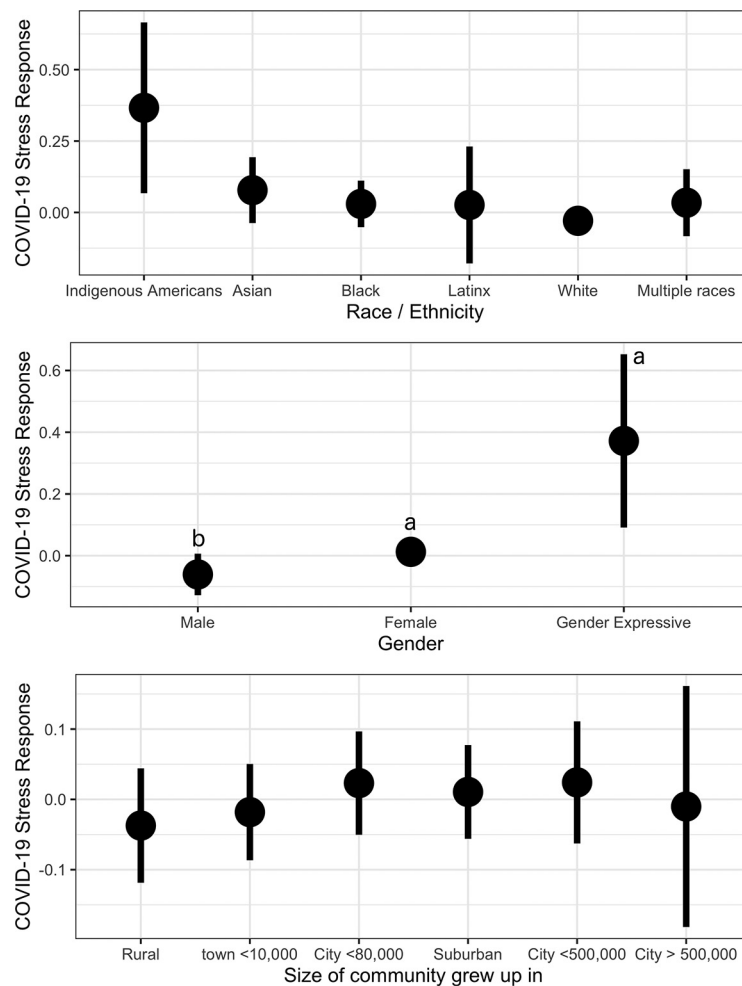


FIG 2. Self-reported student COVID stress response versus race/ethnicity (top), gender (middle), and upbringing (bottom). COVID stress response metric was calculated as the first principal component of all the questions related to COVID stress in the second factor of our factor analysis. More positive results indicate higher rates of COVID-19 stress. This composite variable corresponds to a combination of the COVID traumatic stress and COVID compulsive checking measures on the COVID Stress Scales. Letters indicate significant differences within a Tukey post-hoc analysis. Outcome measures and statistics can be found in Tables 3 and S8.

associated with the pandemic (38, 39). Additionally, a study by Zhu (40) found that males utilized video games as a distracting coping mechanism during the pandemic, while females turned to social media outlets, which potentially exposed them to more fear-based articles about the pandemic (41), and thus, may have exacerbated their anxiety. A recent study by Takmaz et al. (55) reported similar levels of COVID-19 worry associated with virus danger and fears of contamination, contamination worry, and traumatic stress and compulsive checking responses for women surveyed in the Fall of 2020. Our study adds to recent studies highlighting the challenges that female college students have experienced during the COVID-19 pandemic.

Interestingly, gender expressive students—students reporting as non-binary, transgender, gender fluid, gender queer—reported higher worry and stress responses compared to their male counterparts. Because only seven total students that identified as gender expressive participated within our student

questionnaire, we must take our results with a grain of skepticism; however, student experiences from this marginalized group do reflect the results obtained within other recent reports. A recent paper by Woulfe and Wald (28) found that gender expressive individuals reported higher stress during the pandemic because of greater barriers to gender-affirming health care. The pandemic possibly worsened this health care gap and made gender affirming individuals more worried about medical care, should they get sick with COVID-19. The CDC reported in February that gender and sexual minority individuals had higher rates of underlying health conditions that put them at higher risk hospitalization or death due to COVID-19. Another study in major U.S. cities suggested that trans women faced increased harm associated with COVID-19 due to employment, income, and vulnerability to mistreatment in health care (56). Thus, gender-expressive students likely encountered additional stressors during COVID-19, especially in places like the

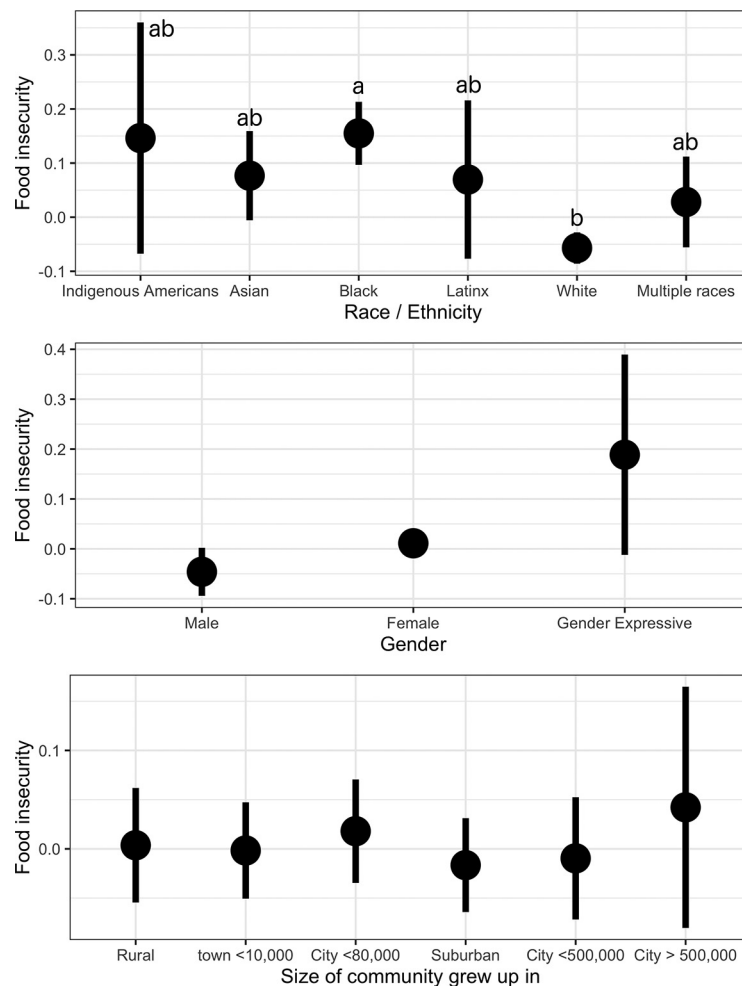


FIG 3. COVID-19 related food insecurities versus race/ethnicity (top), gender (middle), and upbringing (bottom). The COVID-19 food insecurity metric was calculated as the first principal component of all the questions related to COVID-19 food insecurity in the third factor of our factor analysis. More positive results indicate higher rates of COVID-19 food insecurity. This composite variable corresponds to a subset of the COVID socio-economic consequences measure on the COVID Stress Scales. Letters indicate significant differences within a Tukey post-hoc analysis. Outcome measures and statistics can be found in Tables 3 and S9.

Southeastern U.S. where access to culturally competent and gender affirming health and mental care is a challenge.

The most curious finding of this study was the lack of self-reported stress responses in students of color, despite reporting higher worry. We would have expected that the levels of worry reported for students of color would be reflected in stress as well, as the effect size was quite significant. This raised questions about the prospect of how racism and microaggressions may serve as mediating variables in these data. Though blatant racism has appeared to diminish over time (57), systemic and structural racism may be increasing (58), along with more covert forms such as microaggressions (57). The impact of these types of racism can result in racial trauma, which can impact the individual experiencing this with extensive and enduring symptoms that mirror those in posttraumatic stress disorder (59). However, racial trauma is not always considered in a health care setting because of the

diagnostic criteria requiring exposure to a traumatic event, not frequent or persistent occurrences. Research suggests that microaggressions can be predictive of depressive and anxiety symptomology, as well as sleep and somatic issues (60, 61). Most studies suggest that racial microaggressions and trauma symptomology are correlated, however, studies also show that individuals who experience a trauma event do not always report that trauma symptomology are connected to experience with race (62). It is unclear whether life experiences impacted underreporting of trauma symptoms, or whether these individuals may dismiss their own symptomology as “normal” due to the dismissal of race related trauma in health care and educational settings (63). Additionally, we do not know how much the region and culture impact this facet of the study, which should be investigate more thoroughly in the future.

Overall, fear of contracting the COVID-19 virus was directly related to the early transmission and severity of

symptoms associated during early pandemic in the Southeastern U.S. (12, 13). COVID-19 disproportionately impacted communities of color (13) which likely shaped why students of color experienced greater worry and food insecurities while trying to function in an academic setting. The overall demographic makeup of Mobile, Alabama, which is home to 188,720 individuals, is a predominantly black/African American community, with black/African Americans making up approximately 52% of the overall population. Additionally, Mobile, Alabama is a highly urbanized area and about 25% of its citizens living below the poverty line (64). Since 2001, black/African American and Latinx/Hispanic households were twice as likely to experience food insecurity compared with white households at any given time (65, 66). Following the start of the pandemic, hoarding practices also led to mass shortages of food and cleaning supplies in stores all across the country (67), further fueling the fear and worry surrounding the virus. It is logical that individuals from more densely populated regions had higher worry than those from less populated regions, as exposure was greater and ability to isolate from people was less available.

While strong patterns of COVID-19 worry, stress, and food insecurity were observed across gender, race/ethnicity, and size of the community students grew up in, we found no consistent patterns within other demographic groupings that we looked at. For instance, we measured student year in school, first generation college student status, whether students were enrolled in biology courses as majors or non-majors, how far students commuted to campus daily, and whether students were born internationally and none of those demographic variables significantly predicted COVID-19 worry, stress, or food insecurities (Table S2). This suggests that our results may extend beyond the biology department and may help us understand student COVID-19 worry and stress campus-wide and should serve as a guide for helping university campuses future campus closures and transitions to and from virtual learning. Long-term COVID-19 worry, stress, and food insecurities will continue to be monitored as we continue to navigate COVID-19 variants and the subsequent rises and declines in cases and hospitalizations.

Approximately 8 months following the start of the pandemic, many universities, including our Southeastern U.S. university, began transitioning back to in-person and hybrid instruction in order to minimize the pandemic's financial impacts on the university as well as the impacts on student academic success and resources (7, 18, 21, 32). The decision to re-open college campuses to in-person instruction, the start of college athletics, and any other in-person events, highlighted new challenges for the students (7, 30). We found that COVID stress and worry was lower in our study relative to studies using the COVID-19 Stress Scales from the spring and summer of 2020 (43, 68); however, COVID worry and stress was similar in women that were collected during the Fall of 2020 (55). This suggests the COVID-19 worry and stress reduced faster in white Male students compared with women, gender expressive students, and students of color. Our findings highlight the impact of the pandemic on multiple groups of potentially marginalized students including women, gender expressive students,

and students of color. It is unclear whether the worry shifted during in-person campus as COVID-19 infections have reduced and then rapidly increased with the spread the COVID-19 variants. We continue to monitor COVID-19 worry and stress at the University of South Alabama and we intend to follow these data and report on changes over time.

Future potential research

As the pandemic continues it is important to survey changes to people's anxiety and worry concerning the pandemic and assess whether academic accommodations should be made. Vaccine distribution has changed people's concerns for mask wearing, social distancing, and hygiene, but the new strains have proven to be even more infectious. As new challenges are presented, it will be critical to gather this information so universities can ensure proper resources are available to all students. We advocate for the application of lessons that we have learned during the COVID-19 pandemic to alter university policies and procedures during future natural disasters, pandemics, or major disruptions in college learning. It is important to monitor student health during any major shift in societal norms and structure, such as during elections, wars, and campus shootings. When the norms are disrupted, student mental health and well-being can be impacted. Having programs on campus to help with these issues as they arise will be critical to help catch psychiatric distress before it becomes more dysfunctional. Future work should attempt to understand how students develop and implement coping resources to overcome and persevere through worry and stress related to university disruptions (39, 69, 70).

Limitations of this study

This survey was limited to biology undergraduate students at one research institution in the Southeastern United States. Any broad-scale conclusions across all college students or different university contexts based on our findings would be erroneous, although our results are in-line with previously published papers (21, 33–37, 55). All aspects of the students' living situation were not incorporated into this study. We must acknowledge the limitations of the number of participants in our survey that identify as gender expressive ($n=7$) or diverse racial/ethnic groups (Indigenous/Native Americans $n=6$, Latinx $n=13$), which may hinder the interpretation of our findings. We chose to retain these students even if we cannot make strong inferences from these groups rather than omit them from our study. We also did not explore interactions between the demographic variables.

CONCLUSIONS

In conclusion, our findings provide information about the functioning of this University's student body and may guide professors and administration about student factors that are impacted by the pandemic or other major traumatic events. The key findings of this study included a gender and racial

disparity in how students respond to the worry, stress, and food insecurities presented by the COVID-19 pandemic. Female and gender expressive students experienced more distress related to the pandemic than their male counterparts. Students of color experienced higher worry and food insecurities relative to their white peers. It is imperative to incorporate the needs and concerns of diverse students while proceeding with reopening and university functioning plans. Our results underscore the importance of diverse voices at the table when making university-wide decisions especially related to university policies surrounding campus disruptions.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

SUPPLEMENTAL FILE 1, DOCX file, 0.04 MB.

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REFERENCES

- Ivorra B, Ferrández MR, Vela-Pérez M, Ramos AM. 2020. Mathematical modeling of the spread of the coronavirus disease 2019 (COVID-19) considering its particular characteristics. The case of China. *Commun Nonlinear Sci Numer Simul* 88:105303. <https://doi.org/10.1016/j.cnsns.2020.105303>.
- Wei Y, Wang J, Song W, Xiu C, Ma L, Pei T. 2021. Spread of COVID-19 in China: analysis from a city-based epidemic and mobility model. *Cities* 110:103010. <https://doi.org/10.1016/j.cities.2020.103010>.
- Mackey K, Ayers CK, Kondo KK, Saha S, Advani SM, Young S, Spencer H, Rusek M, Anderson J, Veazie S, Smith M, Kansagara D. 2021. Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: a systematic review. *Ann Intern Med* 174:362–373. <https://doi.org/10.7326/M20-6306>.
- Adhikari S, Pantaleo NP, Feldman JM, Ogedegbe O, Thorpe L, Troxel AB. 2020. Assessment of community-level disparities in coronavirus disease 2019 (COVID-19) infections and deaths in large US metropolitan areas. *JAMA Netw Open* 3:e2016938. <https://doi.org/10.1001/jamanetworkopen.2020.16938>.
- Dong E, Du H, Gardner L. 2020. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis* 20:533–534. [https://doi.org/10.1016/S1473-3099\(20\)30120-1](https://doi.org/10.1016/S1473-3099(20)30120-1).
- Sahu P. 2020. Closure of universities due to coronavirus disease 2019 (COVID-19): impact on education and mental health of students and academic staff. *Cureus* 12. <https://doi.org/10.7759/cureus.7541>.
- Harper SR. 2020. COVID-19 and the racial equity implications of reopening college and university campuses. *Am J Educ* 127:153–162. <https://doi.org/10.1086/711095>.
- Walke HT, Honein MA, Redfield RR. 2020. Preventing and responding to COVID-19 on college campuses. *JAMA* 324:1727–1728. <https://doi.org/10.1001/jama.2020.20027>.
- Losina E, Leifer V, Millham L, Panella C, Hyle EP, Mohareb AM, Neilan AM, Ciaranello AL, Kazemian P, Freedberg KA. 2021. College campuses and COVID-19 mitigation: clinical and economic value. *Ann Intern Med* 174:472–483. <https://doi.org/10.7326/M20-6558>.
- Panchal N, Kamal R, Orgera K, Cox C, Garfield R, Hamel L, Chidambaram P. 2020. The implications of COVID-19 for mental health and substance use. *Kaiser Fam Found*.
- Hooper MW, Nápoles AM, Pérez-Stable EJ. 2020. COVID-19 and racial/ethnic disparities. *JAMA* 323:2466–2467. <https://doi.org/10.1001/jama.2020.8598>.
- Fortuna LR, Tolou-Shams M, Robles-Ramamurthy B, Porche MV. 2020. Inequity and the disproportionate impact of COVID-19 on communities of color in the United States: the need for a trauma-informed social justice response. *Psychol Trauma Theory* 12:443–445. <https://doi.org/10.1037/tra0000889>.
- Millett GA, Jones AT, Benkeser D, Baral S, Mercer L, Beyrer C, Honermann B, Lankiewicz E, Mena L, Crowley JS, Sherwood J, Sullivan PS. 2020. Assessing differential impacts of COVID-19 on black communities. *Ann Epidemiol* 47:37–44. <https://doi.org/10.1016/j.annepidem.2020.05.003>.
- Braveman P. 2010. Social conditions, health equity, and human rights. *Heal Hum Rts* 12:31.
- Gemelas J, Davison J, Ing S. 2021. Inequities in employment by race, ethnicity, and sector during COVID-19. *J Racial Ethn Heal Disparities*. 9:350–355.
- Bajema KL, Oster AM, McGovern OL, Lindstrom S, Stenger MR, Anderson TC, Isenhour C, Clarke KR, Evans ME, Chu VT, Biggs HM, Kirking HL, Gerber SI, Hall AJ, Fry AM, Oliver SE, 2019-CoV Persons Under Investigation Team. 2020. Persons evaluated for 2019 novel coronavirus—United States, January 2020. *MMWR Morb Mortal Wkly Rep* 69:166–170. <https://doi.org/10.15585/mmwr.mm6906e1>.
- Taylor S, Landry CA, Paluszczek MM, Rachor GS, Asmundson GJG. 2020. Worry, avoidance, and coping during the COVID-19 pandemic: a comprehensive network analysis. *J Anxiety Disord* 76:102327. <https://doi.org/10.1016/j.janxdis.2020.102327>.
- Akdeniz G, Kavakci M, Gozugok M, Yalcinkaya S, Kucukay A, Sahutogullari B. 2020. A survey of attitudes, anxiety Status, and protective behaviors of the university students during the COVID-19 outbreak in Turkey. *Front Psychiatry* 11. <https://doi.org/10.3389/fpsy.2020.00695>.
- Fisher JRW, Tran TD, Hammarberg K, Sastry J, Nguyen H, Rowe H, Popplestone S, Stocker R, Stubber C, Kirkman M.

2020. Mental health of people in Australia in the first month of COVID-19 restrictions: a national survey. *Med J Aust* 213:458–464. <https://doi.org/10.5694/mja2.50831>.
20. Li D-J, Ko N-Y, Chen Y-L, Wang P-W, Chang Y-P, Yen C-F, Lu W-H. 2020. COVID-19-related factors associated with sleep disturbance and suicidal thoughts among the Taiwanese public: a Facebook survey. *IJERPH* 17:4479. <https://doi.org/10.3390/ijerph17124479>.
21. Wang X, Hegde S, Son C, Keller B, Smith A, Sasangohar F. 2020. Investigating mental health of US college students during the COVID-19 pandemic: cross-sectional survey study. *J Med Internet Res* 22:e22817. <https://doi.org/10.2196/22817>.
22. Wang C, Pan R, Wan X, Tan Y, Xu L, McIntyre RS, Choo FN, Tran B, Ho R, Sharma VK, Ho C. 2020. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain Behav Immun* 87:40–48. <https://doi.org/10.1016/j.bbi.2020.04.028>.
23. Limcaoco RSG, Mateos EM, Fernandez JM, Roncero C. 2020. Anxiety, worry and perceived stress in the world due to the COVID-19 pandemic, March 2020. Preliminary results. *MedRxiv*.
24. Li Y, Cen X, Temkin-Greener H. 2020. Racial and ethnic disparities in COVID-19 infections and deaths across US nursing homes. *J Am Geriatr Soc* 68:2454–2461. <https://doi.org/10.1111/jgs.16847>.
25. Mazza C, Ricci E, Biondi S, Colasanti M, Ferracuti S, Napoli C, Roma P. 2020. A nationwide survey of psychological distress among Italian people during the COVID-19 pandemic: immediate psychological responses and associated factors. *IJERPH* 17:3165. <https://doi.org/10.3390/ijerph17093165>.
26. Van der Vegt I, Kleinberg B. 2020. Women worry about family, men about the economy: gender differences in emotional responses to COVID-19, p 397–409. In Aref S, Bontcheva K, Braghieri M, Dignum F, Giannotti F, Grisolia F, Pedreschi D (ed), *International conference on social informatics*. Springer, Pisa, Italy.
27. Salerno JP, Devadas J, Pease M, Nketia B, Fish JN. 2020. Sexual and gender minority stress amid the COVID-19 pandemic: implications for LGBTQ young persons' mental health and well-being. *Public Health Rep* 135:721–727. <https://doi.org/10.1177/0033354920954511>.
28. Woulfe J, Wald M. 2020. The impact of the COVID-19 pandemic on the transgender and non-binary community. Columbia University, Department of Psychiatry, New York, NY.
29. Ho H-Y, Chen Y-L, Yen C-F. 2020. Different impacts of COVID-19-related information sources on public worry: an online survey through social media. *Internet Interv* 22:100350. <https://doi.org/10.1016/j.invent.2020.100350>.
30. Daniels CJ, Rajpal S, Greenshields JT, Rosenthal GL, Chung EH, Terrin M, Jeudy J, Mattson SE, Law IH, Borchers J, Kovacs R, Kovan J, Rifat SF, Albrecht J, Bento AI, Albers L, Bernhardt D, Day C, Hecht S, Hipkind A, Mjaanes J, Olson D, Rooks YL, Somers EC, Tong MS, Wisinski J, Womack J, Esopenko C, Kratochvil CJ, Rink LD, Simonetti O, Zareba K, Bhatti S, Addison D, Obarski T, Daoud E, Granger M, Smart S, Mayercin-Johnson J, Subramanian P, Glitt J, Mitchell D, Chumita R, Mumford A, Garcia A, Garriss L, Liu H, Hatfield B, Zhang Y, Boersma D, Big Ten COVID-19 Cardiac Registry Investigators, et al. 2021. Prevalence of clinical and subclinical myocarditis in competitive athletes with recent SARS-CoV-2 infection: results from the big ten COVID-19 cardiac registry. *JAMA Cardiol* 6:1078. <https://doi.org/10.1001/jamacardio.2021.2065>.
31. Domina T, Renzulli L, Murray B, Garza AN, Perez L. 2021. Remote or removed: predicting successful engagement with online learning during COVID-19. *Socius* 7. <https://doi.org/10.1177/2378023120988200>.
32. Ramlo S. 2021. COVID-19 response: student views about emergency remote instruction. *Coll Teach* 70:65–73. <https://doi.org/10.1080/87567555.2021.1887071>.
33. Lederer AM, Hoban MT, Lipson SK, Zhou S, Eisenberg D. 2020. More than inconvenienced: the unique needs of US college students during the COVID-19 pandemic. *Heal Educ Behav* 48.
34. Gopalan M, Brady ST. 2020. College students' sense of belonging: a national perspective. *Educ Res* 49:134–137. <https://doi.org/10.3102/0013189X19897622>.
35. Fink JE. 2014. Flourishing: exploring predictors of mental health within the college environment. *J Am Coll Health* 62:380–388. <https://doi.org/10.1080/07448481.2014.917647>.
36. Peltier GL, Laden R, Matrangola M. 2000. Student persistence in college: a review of research. *J Coll Student Retent Res Theory Pract* 1:357–375. <https://doi.org/10.2190/L4F7-4EF5-G2F1-Y8R3>.
37. Son C, Hegde S, Smith A, Wang X, Sasangohar F. 2020. Effects of COVID-19 on college students' mental health in the United States: interview survey study. *J Med Internet Res* 22:e21279. <https://doi.org/10.2196/21279>.
38. Hellemans J, Willems K, Brengman M. 2021. The New adult on the block: daily active users of TikTok compared to Facebook, Twitter, and Instagram during the COVID-19 crisis in Belgium, p 95–103. In Martínez-López FJ, López López D (ed), *Digital marketing & ecommerce conference*. Springer, New York, NY.
39. Prowse R, Sherratt F, Abizaid A, Gabrys RL, Hellemans KGC, Patterson ZR, McQuaid RJ. 2021. Coping with the COVID-19 pandemic: examining gender differences in stress and mental health among university students. *Front Psychiatry* 7. <https://doi.org/10.3389/fpsy.2021.650759>.
40. Zhu L. 2021. The psychology behind video games during COVID-19 pandemic: a case study of Animal Crossing: New Horizons. *Human Behav and Emerg Tech* 3:157–159. <https://doi.org/10.1002/hbe2.221>.
41. González-Padilla DA, Tortolero-Blanco L. 2020. Social media influence in the COVID-19 pandemic. *Int Braz J Urol* 46:120–124. <https://doi.org/10.1590/S1677-5538.IBJU.2020.S121>.
42. Khosravani V, Aardema F, Ardestani SMS, Bastan FS. 2021. The impact of the coronavirus pandemic on specific symptom dimensions and severity in OCD: a comparison before and during COVID-19 in the context of stress responses. *J Obsessive Compuls Relat Disord* 29:100626. <https://doi.org/10.1016/j.jocrd.2021.100626>.
43. Asmundson GJG, Paluszek MM, Landry CA, Rachor GS, McKay D, Taylor S. 2020. Do pre-existing anxiety-related and mood disorders differentially impact COVID-19 stress responses and coping? *J Anxiety Disord* 74:102271. <https://doi.org/10.1016/j.janxdis.2020.102271>.
44. Karantonis JA, Rossell SL, Berk M, Van Rheenen TE. 2021. The mental health and lifestyle impacts of COVID-19 on bipolar disorder. *J Affect Disord* 282:442–447. <https://doi.org/10.1016/j.jad.2020.12.186>.

45. University of South Alabama Office of Institutional Research. 2021. Common data set 2020-2021. Retrieved from <https://www.southalabama.edu/departments/institutionalresearch/commondataset.html>.
46. Team RDC. 2008. R: A language and environment for statistical computing.
47. Racine JS. 2012. RStudio: a platform-independent IDE for R and Sweave. JSTOR. <https://doi.org/10.1002/JAE.1278>.
48. Raiche G, Magis D. 2015. nFactors, version 2.3. 3: parallel analysis and non graphical solutions to the Cattell.
49. Revelle W. 2016. psych: procedures for psychological, psychometric, and personality research [Software].
50. Comrey AL, Lee HB. 1992. Interpretation and application of factor analytic results. Comrey AL, Lee HB A First Course Factor Anal 2:1992.
51. Oksanen J, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'Hara RB, Simpson GL, Solymos P, Stevens MHH, Wagner H. 2015. Package 'vegan'. Community Ecol Packag Version 22-1.
52. Fox J, Wesiberg S, Price B. 2019. Companion to Applied Regression. R package version 3.0-5. Cran R Proj.
53. Wickham H. 2016. ggplot2: elegant graphics for data analysis. Springer, New York, NY.
54. Bell CJ, Boden JM, Horwood LJ, Mulder RT. 2017. The role of peri-traumatic stress and disruption distress in predicting symptoms of major depression following exposure to a natural disaster. Aust N Z J Psychiatry 51:711-718. <https://doi.org/10.1177/0004867417691852>.
55. Takmaz T, Gundogmus I, Okten SB, Gunduz A. 2021. The impact of COVID-19-related mental health issues on menstrual cycle characteristics of female healthcare providers. J Obstet Gynaecol Res 47:3241-3249. <https://doi.org/10.1111/jog.14900>.
56. Poteat TC, Reisner SL, Miller M, Wirtz AL, American Cohort To Study HIV Acquisition Among Transgender Women (LITE). 2020. Vulnerability to COVID-19-related harms among transgender women with and without HIV infection in the eastern and southern US. J Acquir Immune Defic Syndr 85:e67-e69. <https://doi.org/10.1097/QAI.0000000000002490>.
57. Sue DW, Capodilupo CM, Torino GC, Bucceri JM, Holder A, Nadal KL, Esquilin M. 2007. Racial microaggressions in everyday life: implications for clinical practice. Am Psychol 62:271-286. <https://doi.org/10.1037/0003-066X.62.4.271>.
58. Nadal KL, Griffin KE, Wong Y, Davidoff KC, Davis LS. 2017. The injurious relationship between racial microaggressions and physical health: implications for social work. J Ethn Cult Divers Soc Work 26:6-17. <https://doi.org/10.1080/15313204.2016.1263813>.
59. Association AP. 2015. Depressive disorders: DSM-5® selections. American Psychiatric Publishing, Washington, DC.
60. Nadal KL. 2018. Microaggressions and traumatic stress: theory, research, and clinical treatment. American Psychological Association, Washington, DC.
61. Ong AD, Cerrada C, Lee RA, Williams DR. 2017. Stigma consciousness, racial microaggressions, and sleep disturbance among Asian Americans. Asian Am J Psychol 8:72-81. <https://doi.org/10.1037/aap0000062>.
62. Nadal KL, Erazo T, King R. 2019. Challenging definitions of psychological trauma: connecting racial microaggressions and traumatic stress. JSACP 11:2-16. <https://doi.org/10.33043/JSACP.11.2.2-16>.
63. Carter RT. 2007. Racism and psychological and emotional injury: recognizing and assessing race-based traumatic stress. Couns Psychol 35:13-105. <https://doi.org/10.1177/0011000006292033>.
64. Robert Wood Johnson Foundation. 2021. Building a culture of health. Accessed from <https://www.rwjf.org/en/cultureofhealth/what-were-learning/sentinel-communities/mobile-alabama.html>.
65. Waxman E, Gupta P, Gonzalez D. 2020. Food insecurity edged back up after COVID-19 relief expired. Urban Institute, Washington, DC.
66. Morales DX, Morales SA, Beltran TF. 2020. Racial/ethnic disparities in household food insecurity during the COVID-19 pandemic: a nationally representative study. J Racial Ethn Heal Disparities 8:1300-1314.
67. Baddeley M. 2020. Hoarding in the age of COVID-19. J Behav Econ Policy 4:69-75.
68. Montano RLT, Acebes KML. 2020. Covid stress predicts depression, anxiety and stress symptoms of Filipino respondents. Int J Res Bus Soc Sci 9:78-103.
69. Lazarus RS. 1993. Coping theory and research: past, present, and future. Psychosom Med 55. <https://doi.org/10.1097/00006842-199305000-00002>.
70. Matheson K, Anisman H. 2003. Systems of coping associated with dysphoria, anxiety and depressive illness: a multivariate profile perspective. Stress 6:223-234. <https://doi.org/10.1080/10253890310001594487>.