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The Silver Lining of the COVID-19 Pandemic: Undergraduate Research Experiences, Mentorship, and Posttraumatic Growth

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Abstract
Although previous research has documented benefits of undergraduate research experiences (UREs), posttraumatic growth from COVID-19 has never been examined. Based on data collected from 891 students from 114 US universities in July 2020, this study shows that among undergraduates who conducted research during COVID-19, underrepresented minorities (URMs) reported greater posttraumatic growth than non-URMs. URMs who had more competent mentors or more URM/women mentors experienced more growth than URMs who had less competent mentors or less URM/women mentors. Women reported greater posttraumatic growth than men, but same-gender mentor-mentee relationships did not foster more growth in them. LGBQ+students experienced less posttraumatic growth than non-LGBQ+students. UREs have the potential to provide a safety net for many students during a major crisis.

Keywords Posttraumatic Growth · Mentoring · COVID-19 · Race · Gender · LGBQ+Students

Introduction

In late December 2019, the first outbreak of COVID-19 caused by the novel SARS-CoV-2 was reported in Wuhan, China. The disease then rapidly evolved to pandemic status in spring 2020. The COVID-19 pandemic has had a profound impact on people worldwide, causing unprecedented loss, illness, and socioeconomic turmoil. The effects of the pandemic have touched almost every aspect of people's lives, and this includes young adults in

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college. College is a particularly vulnerable time for young people, as they are navigating new levels of independence and autonomy, while also facing academic, social and personal challenges (Arnett, 2014). Due to the pandemic, college students have been forced to adapt to new modes of learning and living, which can exacerbate feelings of uncertainty. Social support systems, extracurricular activities, and future plans have been disrupted, further compounding the stressors that students face (Aucejo et al., 2020; Sahu, 2020). Researchers have noted that the pandemic has led to a significant increase in mental health concerns among college students (Elmer et al., 2020; Giuntella et al., 2021; Grineski et al., 2021; Son et al., 2020; Tang et al., 2020; Wathelet et al., 2020).

While negative psychological outcomes are predictable following a major global crisis like COVID-19, experiences of pain and hardship may also catalyze positive transformation, i.e., posttraumatic growth. Posttraumatic growth refers to positive changes that occur after traumatic experiences or life crises that often involve improved interpersonal relationships or a greater sense of appreciation for life (Frazier & Kaler, 2006; Helgeson et al., 2006; Tamiolaki & Kalaitzaki, 2020; Tedeschi & Calhoun, 1996). College students may be particularly primed for posttraumatic growth. As emerging adults, they have been learning to accept responsibilities, make independent decisions, and become financially independent (Arnett, 2014). Difficult events may force them to deeply reflect upon how they view the world and themselves. To date, only a few studies have examined the extent to which COVID-19 has caused personal growth (e.g., Hyun et al., 2021; Kowalski et al., 2021; Van & Godor, 2022; Vazquez et al., 2021; Zhou et al., 2020). Among them, two studies focused on young adults and found that COVID-19-related concerns, resilience, and family connectedness were positively associated with posttraumatic growth in the beginning of the pandemic (Hyun et al., 2021; Van & Godor, 2022.

Social support is crucial to posttraumatic growth. Supportive people, such as family members, friends, or partners, provide an outlet for traumatized individuals to talk about their experiences. This allows those individuals the opportunity to receive emotional support and tangible assistance to cope with stressors (Swickert & Hittner, 2009). As a result of those supportive experiences, traumatized people may over time see themselves and others in more positive ways and may feel more confident in responding to the stressful event (Cryder et al., 2006; Tedeschi & Calhoun, 1996). During the COVID-19 pandemic, supportive others were less available for many college students. A study conducted in Switzerland found that students' social networks became sparser during the pandemic (Elmer et al., 2020).

In addition to family, friends, and significant others, faculty members provide another potential source of social support for college students. Aside from their interactions with professors in the classroom, many students receive mentorship from faculty through undergraduate research experiences (UREs), which constitute a high-impact educational practice in US colleges and universities (Kuh, 2008). Undergraduate research experiences (UREs) have been extensively studied in the higher education literature, with numerous studies documenting their benefits. Students who participate in UREs have reported receiving high-quality mentorship, as well as access to various programmatic resources (Collins et al., 2017; Stanford et al., 2017). These experiences have also been associated with greater gains in science competency, personal growth, and research skills, as well as increased retention and motivation to pursue graduate education (Collins et al., 2017; Daniels et al., 2016). According to the National Survey of Student Engagement, as of 2022, 22% of US college

seniors had participated in UREs (National Survey of Student Engagement, 2022). Many students continued their research during COVID-19 (Morales et al., 2021a a). In addition to faculty, some students involved in UREs are mentored by graduate students and/or postdoctoral fellows (postgraduates) (Dolan & Johnson, 2010).

Previous research has documented positive outcomes for undergraduate students when they engage in mentored research with faculty and postgraduates, such as improved critical thinking, more extracurricular engagement, enhanced academic achievement and retention, and greater persistence to STEM degree completion (Collins et al., 2017; Dolan & Johnson, 2010; Hurtado et al., 2009; Laursen et al., 2010; Little, 2020; Sell et al., 2018). However, posttraumatic growth has never been examined. This is understandable because, over the past 25 years, scholars, university administrators, and program directors have mainly focused on using UREs to prepare students, especially those from underrepresented backgrounds, for graduate education and research careers in STEM. Yet, the year 2020 marked the beginning of a new era for US higher education, in which the potential for major disruptions caused by disasters or large-scale sociopolitical unrest must be taken seriously. In this shifting context, university programs (including UREs) must play a more active role in protecting and enhancing participating students' well-being amid disruption. Responding to this challenge requires new evidence based on research exploring previously overlooked outcomes, such as the role of mentoring in facilitating posttraumatic growth following adverse events among students participating in UREs as well as other university programs. Therefore, our study answers the question: *during the early months of the COVID-19 pandemic, to what extent did mentorship in undergraduate research experiences (UREs) facilitate posttraumatic growth among undergraduates?* We analyzed survey data collected in July 2020 from 891 US college students across 114 universities who conducted research in STEM with a faculty mentor during the pandemic. In the next section, we review previous research on posttraumatic growth in college students as well as mentoring in UREs.

Theoretical Background and Hypotheses

Determinants of Posttraumatic Growth in College Students

Previous research has documented factors that contribute to posttraumatic growth. Among them, social support from family members and friends is critical to positive personal growth after a variety of different types of traumatic events (Levi-Belz, 2019; Sehgal & Sethi, 2016; Wolfe & Ray, 2015). In the general population, perceived social support emerged as a key predictor of posttraumatic growth before (Michael & Cooper, 2013) and during (Zhou et al., 2020) the COVID-19 pandemic. Specific to college students but not the pandemic, Lipp and O'Brien (2020) found that familial social support was significantly predictive of greater posttraumatic growth in students who suffered an interpersonal loss (e.g., the death of a close relative or friend).

In research conducted pre-COVID-19, researchers found a gender difference in posttraumatic growth, with women reporting higher levels of growth than men following same traumatic events (e.g., Jaarsma et al., 2006; Laufer & Solomon, 2006; Linley & Joseph, 2004; Vishnevsky et al., 2010). This gendered pattern was also found among college students. For instance, Tedeschi and Calhoun (1996) used the Posttraumatic Growth Inventory

to measure posttraumatic growth in 604 undergraduate students who had experienced a significant negative life event during the past 5 years (e.g., bereavement, injury-producing accidents, separation or divorce of parents, relationship break-up). They found that women reported greater growth than men (Tedeschi & Calhoun, 1996). Parallel findings were noted by Park et al. (1996) using a related measure, i.e., Stress-Related Growth Scale, in a college sample. More recent studies have also confirmed women students' higher levels of posttraumatic growth while controlling for the level of trauma (e.g., Shigemoto & Poyrazli, 2013; Swickert & Hittner, 2009), although some researchers found no gender differences (e.g., Taku et al., 2007).

Racial/ethnic minorities also tend to experience greater posttraumatic growth than Whites do, although there are fewer studies on race than gender. Zebrack et al. (2012) studied 6,425 childhood cancer survivors and found that individuals from racial/ethnic minority groups exhibited greater posttraumatic growth. Specific to college students, El-Gabalawy (2010) surveyed 188 undergraduates in the US to measure their growth after five of their most traumatic life experiences. The results show that White students reported lower posttraumatic growth than students from other racial/ethnic groups (El-Gabalawy, 2010).

Other sociodemographic factors, such as sexual orientation and social class, have rarely been examined in research on posttraumatic growth in college students, but there is evidence to suggest they are relevant. For example, Zavala and Waters (2021) recently surveyed LGBTQ+individuals who had disclosed their sexual and/or gender identity to their parents (N=208) and their results showed that the experiences of coming out caused posttraumatic growth. A study conducted after Hurricane Harvey found that higher household income was significantly associated with greater posttraumatic growth among community members (Shigemoto, 2020). Intersectionality of multiple critical identities might also be important when examining posttraumatic growth, yet it has been overlooked by previous studies.

Mental health problems are linked to reduced posttraumatic growth (Eisma et al., 2019; Hyun et al., 2021; Schneider et al., 2019). For example, Hyun et al. (2021) found that students with depression and anxiety disorders had lower levels of posttraumatic growth during COVID-19. While rarely examined in the literature due to the lack of traumatic events disrupting entire URE programs, students' academic characteristics, such as GPA or science self-efficacy, may also be associated with their posttraumatic growth due to COVID-19. For example, it is known that traumatic events experienced by college students can negatively affect their GPA (Long-Mitchell & Karagiorgakis, 2021; Rakhmanov & Dane, 2020). Finally, the experience of recent traumatic events is associated with posttraumatic growth. College students who experienced at least one recent traumatic event in the last year reported more positive posttraumatic growth than those who did not (Tedeschi & Calhoun, 1996).

Mentoring Relationships in UREs and Posttraumatic Growth

Mentorship is one of the central elements of Undergraduate Research Experiences (UREs). Faculty mentors can positively affect students' research gains, motivation, persistence, and research productivity (Daniels et al., 2016; Morales et al., 2021a, 2021b; Thiry & Laursen, 2011). Like faculty, postgraduate mentors also provide research and psychosocial support to undergraduate researchers. Unlike faculty, postgraduates often have more opportunities to interact individually with undergraduates and may develop even stronger relationships

with them (Dolan & Johnson, 2010; Thiry & Laursen, 2011). Both faculty and postgraduate mentors vary in terms of their mentoring competencies. A competent mentor is someone who can effectively communicate with the mentee, establish a shared expectation for the mentoring relationship, assess the mentee's understanding, recognize the potential impact of conscious and unconscious biases on mentoring relationships, and identify concrete strategies to address issues of equity and inclusion, promote the mentee's professional development, and foster the mentee's independence (Fleming et al., 2013). Morales et al. (2021a a) found that competent faculty and postgraduate mentors motivated students to pursue graduate school during COVID-19.

During the pandemic, competent mentors may have played a crucial role in students' abilities to cope with its challenges and achieve posttraumatic growth. By feeling supported and connected to their mentors, students may enhance their resilience and better navigate the hardships caused by COVID-19. Competent mentors can serve as role models for positive qualities associated with posttraumatic growth, such as adaptability and problem-solving. They can also provide guidance and help mentees develop skills such as critical thinking and emotional regulation, which are linked to posttraumatic growth (Orejuela-Dávila et al., 2019). Therefore, we hypothesize that high-quality mentorship from competent faculty and postgraduate mentors during the pandemic led to greater posttraumatic growth among students ($\mathbf{H^1}$).

Although mentoring has been traditionally seen as happening within a dyadic relationship, scholars are turning their attention to mentoring as an evolving network of support (Chandler & Kram, 2007; McBride et al., 2017). Multiple mentors are particularly important for UREs because mentoring undergraduates is a multifaceted process involving many different activities, such as teaching, counseling, coaching, advising, and sponsoring. Those activities can easily exceed the limits of a dyadic relationship. In fact, many URE participants work with multiple faculty and/or postgraduate mentors. Students gain myriad advantages from multiple mentors. For example, Frederick et al. (2021) suggest that having the opportunity to work with multiple mentors strengthened Latinx students' confidence and helped them recognize the broad range of opportunities available to them for graduate school, while providing additional professional and psychosocial benefits. We propose that the benefits of having multiple mentors extend to students' experiences with COVID-19. This supports the hypothesis that students who worked with more mentors during the pandemic exhibited greater posttraumatic growth ($\mathbf{H^2}$).

A third critical aspect of mentoring in UREs is the demographic structure of the relationship—i.e., mentor-mentee gender or racial/ethnic concordance. Previous research suggests that demographic concordance can be beneficial for undergraduate mentees because they feel comforted by guidance from those who share a similar background. For gender concordance, the majority of research has focused on women. Lockwood (2006) found that women students were more inspired by a woman role model than a man role model. Women students also reported receiving more psychosocial support when they had women vs. men mentors (Ensher & Murphy, 1997; Kark & Shilo-Dubnov, 2007). Similarly, for racial/ethnic concordance, minority mentors may be particularly important to minority students because they represent role models that enable students to gain a sense of academic self-efficacy (Syed et al., 2011). When mentor and mentee are both racial/ethnic minorities, they tend to have better communication and develop closer and more effective relationships than

mentor-mentees in racially/ethnically discordant dyads (Blake-Beard et al., 2011; Byars-Winston et al., 2016; Campbell & Campbell, 2007).

The effects of mentor-mentee concordance continue to be debated in the literature. For example, a handful of studies have concluded that mixed-gender/race mentoring relationships are more beneficial to students than same-gender/race mentoring relationships (e.g., Morales, 2021b; Mullen, 2017; Mullen & Klimaitis, 2021; Sosik & Godshalk, 2005; Spalter-Roth et al., 2011), and others suggest that mentor-mentee concordance does not affect student outcomes (e.g., Byars-Winston et al., 2015; Hernandez et al., 2017). However, the majority of previous research asserts that women and racial/ethnic minority students benefit from demographically concordant mentoring relationships. Following this line of research, we hypothesize that during the pandemic, women students experienced greater posttraumatic growth if they had more women mentors (**H^3**), and racial/ethnic minority students had greater posttraumatic growth if they had more minority mentors (**H^4**). To guide our investigation, we next introduce a conceptual model based on the extant literature.

Conceptual Model

As depicted in Fig. 1, the conceptual model illustrates factors related to posttraumatic growth in college students participating in mentored UREs during COVID-19. The model is based on a systems perspective, which was first introduced to research on learning and development by Bronfenbrenner (1977;, 1979), and has since been used in the literature on higher education (e.g., Hurtado et al., 2012). According to Bronfenbrenner (1977), person–environment interactions take place at different levels of systems. The ***ontogenic*** system includes individual characteristics, and the ***microsystem*** is where people's immediate interactions happen, such as school and family (Bronfenbrenner, 1979).

Following Bronfenbrenner's thinking, we examine factors influencing students' posttraumatic growth within ontogenic and microsystems (see Fig. 1). Within the ontogenic system, students' individual characteristics include sociodemographic background, academic characteristics, and mental health. At the level of microsystems, we measure student perceived social supports from primary sources, such as family, friends, and partners. To capture the experience of traumatic events, we control for students' perceptions of how severely the COVID-19 pandemic impacted their life.

More importantly, we argue that college students who conduct research have an additional microsystem that encompasses their UREs. Faculty and postgraduate mentorship within this microsystem may provide an additional layer of protection and support for undergraduate researchers during the pandemic. In particular, we conceptualize mentoring in UREs as a multi-dimensional phenomenon, and propose that the three dimensions (quality, quantity, demographic structure of the relationship) are all associated with student posttraumatic growth during COVID-19 (**H^1-H^4**). Following the conceptual model, we collected and analyzed quantitative data to test the four hypotheses.

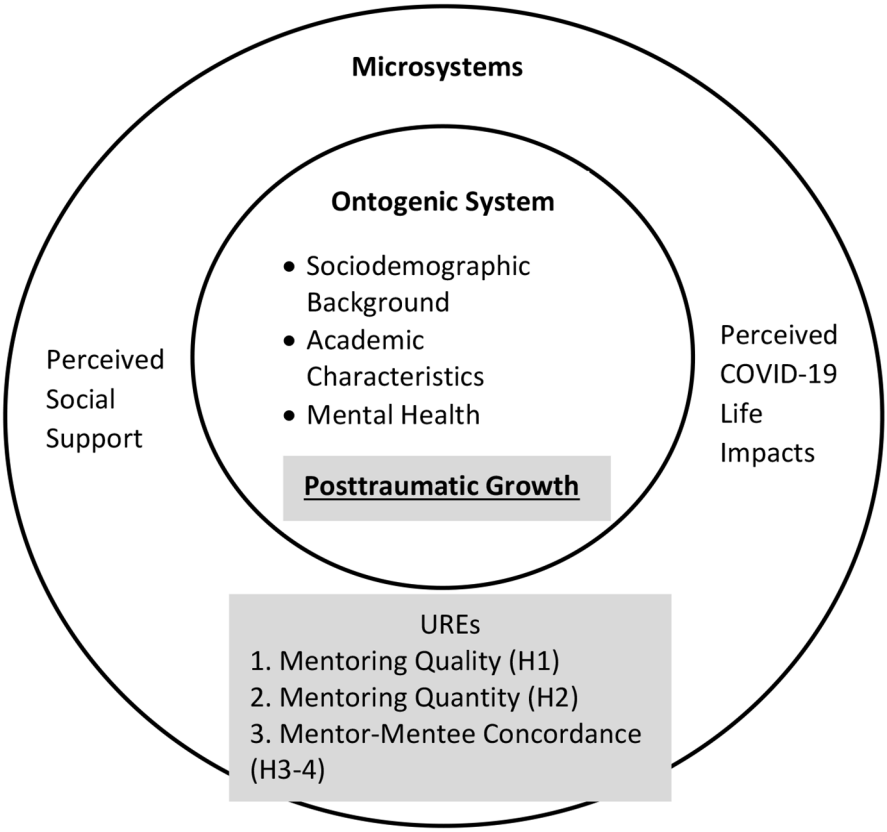

Fig. 1 Conceptual Model

Data and Methods

Participants and Procedure

Participants of this study consisted of 891 undergraduate students from 114 US universities who participated in UREs during the pandemic and worked with at least one faculty mentor. Most of the students attended flagship state universities, second-tier state universities with doctoral programs and high or very high research activity, or private universities. The name of each institution is not included in the paper due to an abundance of caution with regard to not sharing identifying information. Participant recruitment involved two steps. First, we established working relationships with URE program directors across the country. We individually contacted URE program directors affiliated with a National Institutes of Health-funded multi-institutional partnership and also posted to the Council on Undergraduate Research list-serve. Second, after URE program directors agreed to participate, they recruited their students for this study.

A structured survey was developed to collect data. Survey questions are related to students' personal and educational circumstances in spring 2020, research disruption due to COVID-19, prior research experiences, mentoring relationships, general COVID-19 experiences, and sociodemographic characteristics. We administered the survey online between July 6–31, 2020, using the online survey software, QuestionPro. URE program directors initially invited their students to take the survey using scripts provided by the authors. They also sent weekly reminders for non-respondents for two weeks. Participants received a $20 Amazon gift card as an incentive. The survey was approved by the IRB board at the second and third authors' institution (#00133477), and it took approximately 30 min to complete. Before finalizing the survey, we piloted it with undergraduate and graduate researchers (n = 12).

Variables

In this section, we describe how we operationalize the conceptual model using analysis variables.

Outcome Variables

We used the short form of the Posttraumatic Growth Inventory (PTGI-SF) to measure participants' posttraumatic growth. Previous studies have demonstrated the high validity and reliability of the PTGI-SF (Cann et al., 2010; Tedeschi & Calhoun, 1996). Ten statements are included in PTGI-SF, with two items pertaining to each of the five subscales (i.e., relating to others, new possibilities, personal strength, spiritual change, appreciation of life). In the survey, we asked students to indicate: "for each of the statements the degree to which this change occurred in your life as a result of the COVID-19 pandemic," using a 6-point Likert scale (from 1="I did not experience this as a result of COVID-19" to 6="I experienced this change to a very great degree as a result of COVID-19"). Following previous studies (Cann et al., 2010; Garrido-Hernansaiz et al., 2022; Tedeschi & Calhoun, 1996), we weighted the five subscales equally and calculated an overall PTGI score for each student by summing the 10 items. We found high reliability for the PTGI-SF within our study (Cronbach's alpha coefficient = 0.885). Overall PTGI scores can range from 10 to 60; the higher the score, the greater the growth. Then, we calculated five sub-scale PTGI scores by summing the two items, and each sub-scale score ranges from 2 to 12.

Ontogenic-System Factors

For student sociodemographic background, we first included three binary variables (1 = yes, 0 = no) for gender, i.e., man, woman, and those outside the gender binary. We also generated five binary variables (1 = yes, 0 = no) to capture students' race/ethnicity, including White, Hispanic, African American, Asian and Native Hawaiian/Pacific Islander, and other racial groups. These variables were utilized in the overall analysis for all students. However, in subgroup analysis, owing to a limited sample size, we consolidated students into two groups (1 = underrepresented minority (URM) [Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial]; 0 = non-underrepresented minority (non-URM) [White, Asian]). The rationale behind categorizing Asian students as non-URMs stems from their

overrepresentation in STEM fields (National Science Board, 2022). As such, Asians have been consistently classified as non-URM students in the majority of STEM education studies (e.g., Estrada et al., 2016; Van Sickle et al., 2020; Whitcomb & Singh, 2021). In addition, we used a LGBQ+status variable (1=lesbian, gay, bisexual, pansexual, asexual or other sexuality, 0=non-LGBQ+) to measure sexual orientation, and a first-generation college student status variable (1=yes, 0=no) to measure social class.

In terms of academic characteristics, we used two variables. We used self-reported cumulative major grade point average (GPA). Following other studies on undergraduate researchers (Estrada et al., 2011; Hanauer et al., 2016), we also measured students' science self-efficacy. Specifically, in the survey, students were asked to rate the importance of each of the following—"obtaining recognition from colleagues for contributions to my special field;" "making a theoretical contribution to science;" and "becoming an authority in my field"—on a scale of 0 (not important) to 4 (essential). We averaged responses to create a score of science self-efficacy. These questions are from the Cooperative Institutional Research Program (CIRP) Freshman Survey, through the Higher Education Research Institute at the University of California at Los Angeles (Higher Education Research Institute, 2020).

Two variables were used to measure students' mental health. First, we used the 7-item Generalized Anxiety Disorder Scale (GAD-7), which is one of the most widely used instruments for screening for anxiety disorders (Johnson et al., 2019; Spitzer et al., 2006). The GAD-7 score was calculated by summing the 7 items of the scale, ranging from 0 (not at all) to 3 (nearly every day). Second, we used the Patient Health Questionnaire (PHQ-9), which is a self-administered depression scale (Spitzer et al., 2006). Each of the 9 items of the scale were scored as "0" (not at all) to "3" (nearly every day) and then summed. Higher scores correspond to more severe anxiety and depression, respectively.

Measuring Mentoring in the Microsystem of UREs

We created series of variables to operationalize the three dimensions of mentoring relationships in UREs. First, for mentoring quality, we used the Mentoring Competency Assessment (MCA), which is a validated mentoring skills inventory (Fleming et al., 2013). It was designed specifically for undergraduate researchers to assess six specific competencies of their mentors (i.e., maintaining effective communication, aligning expectations, assessing understanding, addressing diversity, promoting professional development, and fostering independence) (Fleming et al., 2013). In the survey, students were asked to answer 26 Likert survey items (1=low competency to 5=high competency) from the MCA. We then averaged the 26 items to create a MCA score for each mentor with higher scores reflecting greater competency. The overall mentor competency was calculated by averaging MCA scores of all mentors each student had, including both faculty and postgraduate mentors. To account for the variability in mentor competency across the mentors of each student, we calculated the standard deviation of MCA scores and included it in our analyses as a control variable.

Second, the quantity of mentoring relationships was measured by the total number (ranging between 1 and 4) of mentors each student had concurrently during the pandemic. Third, we measured mentor-mentee concordance as related to gender and race/ethnicity. As students reported their mentors' demographic information in the survey, we calculated percent-

ages of women and URM mentors for each student. Demographic concordance between mentors and mentees were operationalized through sub-group analyses, which is discussed in the next section.

Other Microsystem Factors

We used the multidimensional scale of social support (MSPSS) which is a validated scale used to measure perceived social support from family, friends, and significant others (Dahlem et al., 1991; Zimet et al., 1988). MSPSS scores were calculated by averaging responses to 12 items of MSPSS, scored on a 7-item Likert scale ranging from 1 = very strongly disagree to 7 = very strongly agree. A higher score represents more social support from their family, friends and significant others.

In terms of student-perceived COVID-19 life impacts, we asked students to report which areas of their life were impacted by the pandemic (with Yes/No response options), including physical health, mental health, family and close friends' physical health, family and close friends' mental health, coursework/GPA, research, finances, living conditions, employment status, immigration status, and social life. A summed score was calculated for each student, ranging from 0 to 11. Then we coded students who had a score greater than 7 as severely impacted by the pandemic. Table 1 reports descriptive statistics of all analysis variables.

Statistical Analysis

We started our analyses by first providing univariate descriptive statistics for the outcome and mentoring variables, as they are the focus of our hypothesis testing. We also calculated Pearson correlation coefficients between the outcome and mentoring variables. Among the 23 analysis variables, 18 of them had missing values, which ranged from 1.1% (SD MCA) to 11.9% (Overall PTGI) (see Table 1). We used the multiple imputation (MI) approach to address those missing values. MI is a simulation-based statistical technique that applies regression modeling to predict missing values through an iterative approach (Enders, 2010; Hayati et al., 2015; Murray, 2018). In estimating the missing values, we used all analysis variables and additional variables related to students' attitudes and characteristics such as research motivation, nativity, disability status, and the number of dependents. Our MI process involved 200 iterations, and the imputed values at the maximum iteration were saved to the imputed dataset. We created 20 complete multiply imputed datasets and utilized them to calculate pooled results in the multivariable analyses, with each dataset containing n = 891.

After MI, we developed the first generalized estimating equation (GEE) model (Model 1) for all participating students to test $\mathbf{H^1}$ and $\mathbf{H^2}$. In Model 1, the overall PTGI score was the dependent variable, and variables in the ontogenic system and microsystems were used as independent variables. To examine the effects of gender and racial/ethnic concordance on overall PTGI scores (test $\mathbf{H^3}$ and $\mathbf{H^4}$), we conducted additional sub-group analyses: GEE models were estimated for women (Model 2) versus men (Model 3), and URM (Model 4) versus non-URM (Model 5) students. Models 2–5 used the same independent and dependent variables as Model 1.

The 891 students in the sample attended 114 different home universities. This indicates that our data had a clustered structure. Ignoring this structure in our statistical models would lead to underestimation of standard errors and incorrect statistical inference (Liang & Zeger,

Table 1 Descriptive Statistics for Analysis Variables (n = 891)

Variable	N	Min.	Max.	Mean	St. Dev.	% Missing
Outcome Variable:						
Overall PTGI	785	32.00	82.00	51.44	12.50	11.9
Relating to Others	793	2.00	12.00	5.49	2.97	11.0
New Possibilities	796	2.00	12.00	5.60	3.00	10.7
Personal Strength	795	2.00	12.00	6.44	3.05	10.8
Spiritual Change	794	2.00	12.00	5.04	3.24	10.9
Appreciation of Life	797	2.00	12.00	6.86	2.80	10.5
Ontogenic-System Variables:						
Gender						
Man student	310	-	-	-	-	9.2
Woman Student	485	-	-	-	-	9.2
Beyond Binary	14	-	-	-	-	9.2
Race						
White	287	-	-	-	-	9.4
Hispanic	267	-	-	-	-	9.4
African American	41	-	-	-	-	9.4
Asian/Native Hawaiian/Pacific Islander	168	-	-	-	-	9.4
Other Racial Groups	44	-	-	-	-	9.4
Underrepresented Minorities (URM)	358	-	-	-	-	9.4
Non-URM student	449	-	-	-	-	9.4
Sexual Orientation						
LGBQ + Student	153	-	-	-	-	10.3
Non-LGBQ + student	646	-	-	-	-	10.3
First Generation Status						
First Generation Student	267	-	-	-	-	0.0
Continuing Generation Student	624	-	-	-	-	0.0
GPA	868	2.00	4.00	3.73	0.35	2.6
Science Self-efficacy Score	886	1.00	4.00	2.70	0.68	0.6
GAD-7	803	0.00	21.00	7.43	5.83	9.9
PHQ-9	804	0.00	27.00	9.21	6.54	9.8
Microsystem Variables:						
Overall MCA	852	1.35	5.00	4.03	0.72	4.4
SD MCA	881	0.00	2.09	0.16	0.33	1.1
Number of Mentors	891	1.00	4.00	1.47	0.60	0.0
% Women Mentors	891	0.00	100.00	40.85	44.11	0.0
% of URM Mentors	891	0.00	100.00	24.96	39.35	0.0
MSPSS	805	1.00	7.00	5.39	1.12	9.7
COVID-19 life Impacts						
Severe COVID-19 life impacts	329					0.0
No severe COVID-19 life impacts	562					0.0

Note: GAD-7: Generalized Anxiety Disorder Scale; GPA: Grade Point Average; MCA: Mentoring Competency Assessment; MSPSS: Multidimensional Scale of Social Support; PHQ-9: Patient Health Questionnaire; PTGI: Posttraumatic Growth Inventory; Underrepresented Minority (Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial); SD: Standard Deviation

1986). Moreover, university context plays a crucial role in shaping research experiences and faculty mentorship, and, potentially students' posttraumatic growth, as universities provide unique opportunities and resources that can support or hinder students' personal and academic development. Therefore, controlling for university clusters is necessary to account for the potential confounding effects of institutional factors on our outcome of interest. We used GEEs to account for these clusters, because GEEs relax the assumptions of traditional regression models (e.g., normality of variable distribution) and are suitable to analyze clustered data (Liang & Zeger, 1986; Zeger & Liang, 1986; Zorn, 2001).

To identify the best fitting GEEs, we tested normal, gamma, and inverse Gaussian distributions with logarithmic (log) and identity link functions under different specifications of the intracluster dependency correlation matrix (i.e., independent, exchangeable, unstructured) for model fitting (Garson, 2012; Liang & Zeger, 1986; Zeger & Liang, 1986). The gamma distribution with a log link function and the exchangeable correlation matrix was the best fitting specification for all models because it resulted in the lowest quasi-likelihood under the independence model criterion (QIC) values. Although the dependent variable was continuous, due to the log link function of the model, we exponentiated each coefficient (Exp(B) to calculate the associated percentage of change in the dependent variable.

Multicollinearity testing was conducted for all models. Based on variance inflation factor (VIF) and tolerance values, our inferences from the five models were not affected by multicollinearity.

Results

Descriptive Analyses

Of the 891 undergraduates who conducted research during COVID-19, the average overall PTGI score was 29.4. In terms of sub-scale scores, students reported the most posttraumatic growth in the appreciation of life and personal strength domains. Undergraduate researchers also experienced complex mentoring dynamics during the pandemic. Among the 891 students in our sample, 515 (58%) worked with only one faculty mentor, 119 (13%) had two faculty mentors, 215 (24%) worked in a faculty-postgraduate-undergraduate triad, 35 (4%) students had two faculty mentors and one postgraduate mentor, 4 students worked with a faculty mentor and two postgraduate mentors, and 3 students had two faculty and two postgraduate mentors.

Pearson correlation results (see Table 2) suggest that the mentorship students received from UREs during COVID-19 related to their PTGI scores. Having more competent mentors was correlated with higher overall and sub-scale PTGI scores; if the student had more mentors during COVID-19, she/he reported higher PTGI sub-scale scores in relating to others or personal strength; having more URM or women mentors was also correlated with higher PTGI sub-scale scores in new possibilities, personal strength, spiritual change, and appreciation of life.

Table 2 Correlation Matrix

	Overall MCA	SD MCA	Numbers of Mentors	URM Mentors %	Women Mentors %
Overall PTGI	0.159***	0.048	0.066	0.126***	0.092*
Relating to Others	0.168***	0.056	0.094**	0.066	0.049
New Possibilities	0.130***	0.027	0.057	0.117**	0.105**
Personal Strength	0.164***	0.035	0.070*	0.087*	0.113**
Spiritual Change	0.096**	0.040	0.010	0.119**	0.013
Appreciation of Life	0.106**	0.036	0.044	0.132***	0.102**

Note: MCA: Mentoring Competency Assessment; PTGI : Post-Traumatic Growth Inventory; SD: Standard Deviation; Underrepresented Minority (Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial)

*** $p<0.001$, ** $p<0.01$, * $p<0.05$

Multivariable Analyses

GEE Modeling Results

Multivariable analyses allow us to determine if the bivariate results—which suggested that greater mentor competency, more mentors, and higher percentages of women and URM mentors were associated with higher PTGI scores—persist after adjusting for other factors known to be related to PTG. Table 3 depicts results from Model 1. In terms of the mentoring variables, while mentor competency and the number of mentors were not significant, having a higher percentage of URM mentors was associated with 0.04% higher overall PTGI scores ($p=0.011$). In the ontogenic system, students from African American, Hispanic, and Asian/Native Hawaiian/Pacific Islander backgrounds reported significantly higher overall PTGI scores compared to White students. Specifically, the percentage differences were 21%, 14%, and 7%, respectively, with statistical significance ($p<0.005$). Women reported 5% higher overall PTGI scores than men ($p=0.003$), and being LGBQ+was associated with a 7% reduction in overall PTGI scores ($p<0.001$). With every one unit increase of the science self-efficacy score, there was a 5% increase of the overall PTGI score ($p=0.001$). In microsystems, every one unit increase of the MSPSS score was associated with a 5% increase of the overall PTGI score ($p<0.001$). Students who perceived severe life impacts due to COVID-19 reported 6% higher overall PTGI scores than those who did not ($p=0.002$).

Table 4 shows results from the Models 2 (subgroup of women) and 3 (subgroup of men). For both women and men, gender concordance of their mentoring relationships was not significantly associated with overall PTGI scores ($p>0.05$). A 1% increase in URM mentorship composition was associated with 0.05% higher overall PTGI scores for women ($p=0.02$), but the association was not significant for men ($p=0.794$). Women who perceived severe life impacts due to COVID-19 reported 5% higher overall PTGI scores than those who were not ($p=0.006$), but this association was not significant for men ($p=0.052$). For both men and women, having higher MSPSS scores, being a URM, and having a higher science self-efficacy score were associated with higher overall PTGI scores, while being a LGBQ+student was associated with lower overall PTGI scores ($p<0.05$).

Turning to the Models 4 (subgroup of URM students) and 5 (subgroup of non-URM students), racial/ethnic concordance was a significant predictor for URM students, as a 1% increase in URM mentorship composition was associated with 0.05% increase in overall

Table 3 Model 1: Results of Pooled Generalized Estimating Equations Predicting PTGI Scores for All Students (n = 891)

	EXP (B)	B	Lower 95% CI for B	Upper 95% CI for B	p
Intercept	30.898***	3.431	3.178	3.683	<0.0001
Ontogenic-System Variables:					
Man Student	*ref*	*ref*	*ref*	*ref*	*ref*
Woman Student	1.055**	0.053	0.019	0.088	0.003
Beyond Binary	1.071	0.068	-0.068	0.204	0.318
White	*ref*	*ref*	*ref*	*ref*	*ref*
Hispanic	1.140***	0.131	0.089	0.172	<0.0001
African American	1.209***	0.190	0.121	0.259	<0.0001
Asian/Native Hawaiian/Pacific Islander	1.066**	0.064	0.018	0.109	0.006
Other Racial Groups	1.061	0.059	-0.009	0.126	0.091
LGBQ + Student	0.926***	-0.076	-0.116	-0.037	<0.0001
First-generation Student	1.002	0.002	-0.035	0.039	0.909
GPA	0.968	-0.033	-0.079	0.013	0.160
Science Self-efficacy Score	1.048**	0.047	0.019	0.075	0.001
GAD-7	1.001	0.001	-0.003	0.005	0.584
PHQ-9	1.000	0.0003	-0.004	0.005	0.878
Microsystem Variables:					
Overall MCA	1.023	0.023	-0.003	0.049	0.088
SD MCA	1.044	0.043	-0.019	0.105	0.173
Number of Mentors	0.992	-0.008	-0.042	0.027	0.667
% Women Mentors	1.0003	0.0003	0.000	0.001	0.082
% of URM Mentors	1.0004*	0.0004	0.000	0.001	0.011
MSPSS	1.055***	0.053	0.034	0.072	<0.0001
Severe COVID-19 life Impacts	1.059*	0.057	0.020	0.093	0.002

Note: GAD-7: Generalized Anxiety Disorder Scale; GPA: Grade Point Average; MCA: Mentoring Competency Assessment; MSPSS: Multidimensional Scale of Social Support; PHQ-9: Patient Health Questionnaire; PTGI: Posttraumatic Growth Inventory; Underrepresented Minority (Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial); SD: Standard Deviation

Notes: Model used gamma with log link with an exchangeable correlation matrix, and control for clustering at the level of students' home institution

*** p < 0.001, ** p < 0.01, * p < 0.05

PTGI scores ($p = 0.015$) (see Table 5). However, racial/ethnic concordance did not significantly predict overall PTGI scores for non-URM students ($p = 0.397$). With every one unit increase of the overall MCA score ($p = 0.047$) or the percentage of women mentors ($p = 0.045$), there was a 3% or 0.05% increase in URM students' overall PTGI scores respectively, while those variables were not significant predictors for non-URM students ($p > 0.05$). URM women students reported 7% higher overall PGTI scores than URM men students ($p = 0.001$), but this gender difference was not found in non-URM students ($p = 0.065$). Among non-URM students, those self-identified as LGBQ + reported 9% lower overall PTGI scores than their straight peers ($p = 0.002$). Yet, LGBQ + status was not a significant predictor for URM students ($p = 0.079$). Finally, for both URM and non-URM students,

Table 4 Models 2–3: Results of Pooled Generalized Estimating Equations Predicting PTGI Scores for Women (n=485) vs. Men (n=310)

	Model 2 (Women)					Model 3 (Men)				
	EXP (B)	B	Lower 95% CI for B	Upper 95% CI for B	p	EXP (B)	B	Lower 95% CI for B	Upper 95% CI for B	p
Intercept	31.187***	3.440	3.154	3.726	<0.0001	36.691***	3.603	3.198	4.007	<0.0001
Ontogenic-System Variables:										
URM Student	1.126***	0.119	0.073	0.165	<0.0001	1.106***	0.101	0.055	0.146	<0.0001
LGBQ+Student	0.929**	-0.074	-0.124	-0.024	0.004	0.913*	-0.091	-0.163	-0.018	0.014
First-generation Student	0.991	-0.009	-0.052	0.034	0.688	1.010	0.010	-0.055	0.075	0.754
GPA	0.984	-0.016	-0.073	0.040	0.568	0.944	-0.057	-0.127	0.012	0.104
Science Self-efficacy Score	1.047**	0.046	0.017	0.074	0.002	1.045*	0.044	0.004	0.084	0.033
GAD-7	1.001	0.001	-0.004	0.006	0.785	1.004	0.004	-0.003	0.012	0.244
PHQ-9	1.000	0.000	-0.006	0.005	0.860	0.999	-0.001	-0.008	0.007	0.826
Microsystem Variables:										
Overall MCA	1.023	0.023	-0.006	0.052	0.128	1.021	0.020	-0.040	0.081	0.509
SD MCA	1.037	0.036	-0.036	0.107	0.326	1.062	0.061	-0.051	0.172	0.285
Number of Mentors	1.002	0.002	-0.032	0.035	0.931	0.978	-0.022	-0.092	0.047	0.530
% Women Mentors	1.0002	0.0002	0.000	0.001	0.455					
% Men Mentors						0.999	-0.001	-0.001	0.000	0.064
% of URM Mentors	1.001*	0.001	0.000	0.001	0.020	1.0001	0.0001	-0.001	0.001	0.794
MSPSS	1.053***	0.051	0.034	0.069	<0.0001	1.057**	0.055	0.016	0.094	0.005
Severe COVID-19 life Impacts	1.049**	0.048	0.014	0.083	0.006	1.065	0.063	-0.001	0.126	0.052

Note: GAD-7: Generalized Anxiety Disorder Scale; GPA: Grade Point Average; MCA: Mentoring Competency Assessment; MSPSS: Multidimensional Scale of Social Support; PHQ-9: Patient Health Questionnaire; PTGI: Posttraumatic Growth Inventory; URM: Underrepresented Minority (Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial); SD: Standard Deviation

Notes: Models used gamma with log link with an exchangeable correlation matrix, and control for clustering at the level of students' home institution

*** p<0.001, ** p<0.01, * p<0.05

Table 5 Models 4–5: Results of Pooled Generalized Estimating Equations Predicting PTGI Scores for URMs (n=358) vs. Non-URMs (n=449)

	Model 4 (URM)					Model 5 (non URM)				
	EXP (B)	B	Lower 95% CI for B	Upper 95% CI for B	p	EXP (B)	B	Lower 95% CI for B	Upper 95% CI for B	p
Intercept	37.471***	3.624	3.393	3.854	<0.0001	29.513***	3.385	3.028	3.742	<0.0001
Ontogenic-System Variables:										
Women Student	1.074**	0.071	0.028	0.114	0.001	1.041	0.040	-0.002	0.083	0.065
Beyond Binary	1.047	0.046	-0.114	0.205	0.573	1.079	0.076	-0.118	0.269	0.435
LGBQ+Student	0.954	-0.047	-0.099	0.005	0.079	0.908**	-0.096	-0.156	-0.037	0.002
First-generation Student	0.995	-0.005	-0.044	0.034	0.807	1.009	0.009	-0.045	0.064	0.738
GPA	0.954	-0.048	-0.099	0.003	0.068	0.978	-0.022	-0.098	0.053	0.555
Science Self-efficacy Score	1.055*	0.053	0.012	0.094	0.012	1.044**	0.043	0.011	0.074	0.008
GAD-7	1.001	0.001	-0.003	0.006	0.546	1.001	0.001	-0.005	0.006	0.788
PHQ-9	0.997	-0.003	-0.007	0.002	0.200	1.003	0.003	-0.003	0.008	0.306
Microsystem Variables:										
Overall MCA	1.027*	0.026	0.000	0.052	0.047	1.019	0.019	-0.017	0.055	0.303
SD MCA	1.038	0.037	-0.038	0.112	0.330	1.053	0.052	-0.037	0.140	0.250
Number of Mentors	0.972	-0.028	-0.070	0.013	0.183	1.009	0.009	-0.036	0.053	0.705
% Women Mentors	1.0005*	0.0005	0.000	0.001	0.045	1.0002	0.0002	0.000	0.001	0.347
% URM Mentors	1.0005*	0.0005	0.000	0.001	0.015					
% non-URM Mentors						0.9998	-0.0002	-0.001	0.000	0.397
MSPSS	1.049**	0.047	0.016	0.079	0.004	1.060***	0.058	0.034	0.082	<0.0001
Severe COVID-19 life Impacts	1.064*	0.062	0.001	0.124	0.048	1.062**	0.060	0.015	0.106	0.009

Note: GAD-7: Generalized Anxiety Disorder Scale; GPA: Grade Point Average; MCA: Mentoring Competency Assessment; MSPSS: Multidimensional Scale of Social Support; PHQ-9: Patient Health Questionnaire; PTGI: Posttraumatic Growth Inventory; URM: Underrepresented Minority (Hispanic, Black, Native American, Native Hawaiian/Pacific Islander, Multiracial); SD: Standard Deviation

Notes: Models used gamma with log link with an exchangeable correlation matrix, and control for clustering at the level of students' home institution

*** $p<0.001$, ** $p<0.01$, * $p<0.05$

having higher MSPSS scores, having a higher science self-efficacy score, and perceiving severe life impacts due to COVID-19 were all associated with higher overall PTGI scores ($p < 0.05$).

Hypothesis Testing

Our first hypothesis, $\mathbf{H^1}$ was partially supported by the findings. Although mentor competency was not a significant predictor in Model 1, in Model 4, we found that having more competent mentors was associated with an increase in overall PTGI scores in URM students. $\mathbf{H^2}$ was not supported, as the number of mentors was not a significant predictor across all models. The results from Model 4 provide evidence to support $\mathbf{H^3}$: having a higher percentage of URM mentors was associated with higher overall PTGI scores for URM students. However, we did not find evidence to support $\mathbf{H^4}$, because Model 2 suggests that having a higher percentage of women mentors was not a significant predictor of higher overall PTGI scores for women students.

Discussion and Conclusion

The COVID-19 pandemic has caused adversities for US college students. Yet, despite the hardships, many students were able to find a silver lining in this crisis. Rather than focusing on negative psychological outcomes like previous studies (Giuntella et al., 2021; Grineski et al., 2021; Son et al., 2020; Tang et al., 2020), we sought to understand the complex correlates of posttraumatic growth due to COVID-19, by theorizing that factors in the ontogenic system and various microsystems would account for variance in the prediction of students' growth.

We measured mentoring relationships in the microsystem of UREs through three dimensions: quality, quantity, and mentor-mentee demographic concordance. In terms of the quality of mentorship, previous studies have documented the positive effects of competent mentors on undergraduates before (Bernier et al., 2005; Daniels et al., 2016; Harsh et al., 2011; Thiry & Laursen, 2011) and during (Morales et al., 2021a a) the pandemic. The current paper indicates that the benefits of having more competent mentors can be translated into posttraumatic growth for URM students during COVID-19. In terms of the quantity of mentoring relationships, we found that when mentoring quality and mentor-mentee concordance were controlled, having more mentors did not increase students' posttraumatic growth during the pandemic.

Students' own demographics in the ontogenic system and their demographic concordance with mentors in the microsystem added complexity to our findings. In particular, African American, Hispanic, and Asian students reported greater personal growth from COVID-19 than White students. Other studies suggest that racial/ethnic minorities have better coping skills to deal with adversity and thus are more resilient due to their previous experiences with poverty, discrimination, and other hardships (El-Gabalawy et al., 2010; Zebrack et al., 2012). Our research contributes to the literature by further demonstrating that not only were URM students' racial/ethnic identities associated with greater perseverance and growth during COVID-19, but that they were also more sensitive to mentoring in UREs. For example, URM students experienced greater posttraumatic growth from having more

URM mentors. One possible explanation is that when mentors and mentees share a similar racial minority background, they are more likely to develop a closer relationship (Blake-Beard et al., 2011; Byars-Winston et al., 2016; Campbell & Campbell, 2007; Kricorian et al., 2020). Those URM students who had more racially concordant mentoring relationships might have felt more secure and inspired to persist through the pandemic. Moreover, URM students' growth also increased if they had more women mentors. There is evidence suggesting that, in general, women mentors provide more role modeling and psychosocial support to their mentees than men mentors (Sosik & Godshalk, 2005). That additional support from women mentors might be particularly crucial to URM students during COVID-19, as they experienced generally greater hardships than non-URM students (Lederer et al., 2021; Molock & Parchem, 2021).

When looking only at women students, they exhibited a distinct pattern relative to men. They reported greater posttraumatic growth from COVID-19 than men students, which aligns with previous studies (Park et al., 1996; Shigemoto & Poyrazli, 2013; Swickert & Hittner, 2009; Tedeschi & Calhoun, 1996). Some researchers believe that women generally have better coping abilities than men that result from being primed to deal with adversities caused by gender inequality and gender-based discrimination (Zebrack et al., 2012). Others argue that women's particular coping styles (e.g., focusing on emotions, ruminating on constructive issues) lead to greater posttraumatic growth (Janoff-Bulman, 2004; Treynor et al., 2003).

Mentor-mentee gender concordance, however, did not foster more growth in women students. This is in line with previous research asserting that gender concordance has little influence on student outcomes (Byars-Winston et al., 2015; Hernandez et al., 2017). Women continue to face numerous challenges pursuing STEM education and careers. But their underrepresentation in STEM is not as severe as racial minorities, making gender concordance potentially less important. According to the National Center for Science and Engineering Statistics (2021), of all science and engineering degrees awarded in 2018, women earned about half of bachelor's degrees, 44.7% of master's degrees, and 41.2% of doctoral degrees; yet, URMs received 24.0% of bachelor's degrees, 22.1% of master's degrees, and 13.6% of doctoral degrees. Our sample reflected a similar pattern in the context of UREs. Among all undergraduates who conducted research during the pandemic, 60.0% were women, while only 44.4% were URMs. On average, students had more than 40% women mentors but only 25% URM mentors. Since women are better represented in UREs, it may be less important for women students to have gender concordant mentoring relationships; in contrast, racially concordant mentoring relationships may significantly protect and inspire more marginalized URM students, especially during a major crisis. We found that having more URM mentors was associated with greater posttraumatic growth for women students, which leaves room for future examination.

LGBQ+individuals are another marginalized group in STEM (Freeman, 2020). Our results show that LGBQ+students experienced much less posttraumatic growth from COVID-19 than their non-LGBQ+peers. If women and URMs' vulnerable social identities enhanced their personal growth during COVID-19, why might it have been difficult for LGBQ+students to find such silver linings? A possible explanation might be that due to campus closures and online learning, many LGBQ+students might have to leave the college campus community—their safe space, to return home, where their family members could have been unsupportive or even hostile (Lederer et al., 2021).

In addition, we found that the varying intersections of gender, race, and sexuality had differing influences on the posttraumatic growth of students during COVID-19. Specifically, our results showed that among URM students, women reported greater posttraumatic growth than men. This suggests that the experience of being a woman and a member of an underrepresented racial/ethnic group contributed to greater posttraumatic growth. Interestingly, we also found that women who were URM experienced significant posttraumatic growth, while women who were non-URM did not. This suggests that the three social identities interacted in complex ways to affect students' posttraumatic growth during COVID-19.

Regarding another microsystem, UREs, previous research suggests that there might be barriers related to the mentoring of LGBQ+students (Hughes, 2018). We did not find evidence to support this assertion, as the quality and quantity of mentoring relationships reported by the 153 LGBQ+students did not significantly differ from what was reported by non-LGBQ+students (table not shown). However, we acknowledge that since this study relied on student-reported data, we could not reliably measure mentors' LGBQ+status. Thus, we do not know whether having LGBQ+mentors would increase LGBQ+students' posttraumatic growth. Future studies could expand our findings by collecting data from both mentors and mentees to further investigate the effects of mentor-mentee concordance in terms of LGBQ+status.

With regard to student academic characteristics, GPA was not directly associated with posttraumatic growth, but science self-efficacy was a significant positive predictor. This may indicate that it is not students' academic performance but their confidence in their abilities to function as scientists that facilitated their growth in response to COVID-19. Science self-efficacy is often used as a student outcome to assess the success of URE programs, as it is positively associated with students' commitment to stay in research (Estrada et al., 2011). Our study sheds light on the possibly broader importance of science self-efficacy to student development beyond the unidimensional goal of recruiting and retaining them in STEM.

This study has several limitations. First, while our findings suggest that URM students experienced greater posttraumatic growth when they had more URM and women mentors, we acknowledge that the effect sizes of these results were relatively small. Secondly, in our subgroup analysis, we grouped all URM students together because of the relatively small sample sizes of some racial groups. Running separate GEE models for each group and comparing them would not be informative with such a sample size imbalance. We recognize, however, that each URM group has unique attributes that may influence their posttraumatic growth, and we encourage future studies to explore these differences more comprehensively. Third, in alignment with prior research (e.g., Estrada et al., 2016; Van Sickle et al., 2020; Whitcomb & Singh, 2021), we classified students of Asian race as non-URM in the subgroup models. However, we acknowledge that, despite their general overrepresentation in STEM fields (National Science Board, 2022), specific Asian groups, such as certain Southeast Asian subgroups, continue to be underrepresented in STEM. Compounded by the challenges faced during the COVID-19 pandemic, Asian communities have also been subjected to anti-Asian hate, potentially exerting adverse effects on Asian students. Fourth, a small group of students (n=14) self-identified as outside the gender binary. Due to the small count, we did not include them in subgroup analyses. Future researchers could consider using other sampling strategies (e.g., stratified random sampling) to include adequate numbers of gender non-binary students in their studies.

Over the past 25 years, UREs have proven to be one of the most successful educational models in the US (Kuh, 2008). However, we cannot overlook the fact that this model has operated in a relatively stable social environment. In a post-COVID world, the pressing question for educational scholars, university administrators, and program directors is: how can UREs adapt to disruptive events and thrive? It is our hope that this paper offers some answers. As our analyses demonstrated, mentorship in UREs facilitated posttraumatic growth among undergraduate researchers, particularly those with racial minority backgrounds, in response to COVID-19. That is to say, besides encouraging more students to pursue the research path, UREs also have the potential to provide a safety net for large numbers of students during crises. Therefore, we call for more research on the broader efficacy of UREs.

Declarations

Competing interest No potential competing interest was reported by the authors.

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