# Stress during the COVID-19 Pandemic Predicts Psychological, Physical, and Academic Outcomes Among STEMM Students at 2-year and 4-year Institutions

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Abstract—Science students have faced increasingly stressful educational environments as introduction of the coronavirus disease 2019 (COVID-19) forced colleges to transition to virtual instruction in 2020. The current climate might undermine efforts to engage students from underrepresented minority backgrounds in science, technology, engineering, math, and medical (STEMM) fields. Students intending to major in a STEMM field from a 2year, community college and 4-year, baccalaureate-granting institution completed a survey about psychological stress, science self-efficacy, and mental and physical health. Results indicate that college students (N = 219;  $M_{age} = 22.72$ , SD =5.14; 74.4% female) during the pandemic reported higher stress levels than national norms for this age group during the last economic downturn in 2009 and at levels comparable to students experiencing a lab stressor prepandemic in 2018, particularly community college and female students. Higher stress was predictive of greater anxiety, depressive, and somatic symptoms. It was also related to lower confidence in exceling in science courses across the year, completing a science degree, and, ultimately, pursuing a science career. The findings suggest short-term and long-term consequences of COVID-19 on student health and science education that educators and institutions should address in continuing efforts to diversify the future STEMM workforce.

*Index Terms*—COVID-19, college students, STEM education, psychological stress

## I. INTRODUCTION

In recent years, the United States has spearheaded initiatives to increase diversity, equity, and inclusion in science, technology, engineering, math and medicine (STEMM) in an effort to spur technological innovation and address complex health challenges [1], [2]. These commitments have expanded learning opportunities and STEMM training for individuals from underrepresented minority (URM) backgrounds, particularly at the postsecondary, college level. However, the recent coronavirus disease 2019 (COVID-19) pandemic has created health, psychological, and academic burdens for students that may undermine these efforts [3], [4]. A meta-analysis of the general U.S. population during the COVID-19 pandemic suggests high prevalence rates of stress (29.6%), anxiety (31.9%), and depression (33.7% [5]), perhaps particularly for younger people [6]. Among college students, 58% reported at least mild anxiety symptoms in the last two weeks [7]. Knowing someone who had been infected with COVID-19 and increased academic concerns exacerbated these feelings of stress and anxiety for students [4]-[9]. This psychological turmoil has potential long-term health implications [10].

The large-scale, abrupt nature of the pandemic, stress from the risk of death associated with the viral infection, and strict measures imposed to prevent or contain outbreaks (e.g., isolation, shifting from in-person to virtual instruction) have all also likely contributed to influencing the psychological health of students [4], [7]-[9], [11]. Educators have reported concerns about the premature suspension of in-person courses in Spring of 2020, particularly in the sciences given the complexity of the topics and limited lab time [4], [12] and for URM students who are most vulnerable to digital access inequities and the economic costs and health implications related to COVID-19 [3], [13]. In a study of majority STEMM majors at a 4-year institution (75.2% engineering, agriculture/life sciences, public health,

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veterinary medicine/biomedical sciences, general sciences), 71% of students reported increases in stress and anxiety [9]. Students relayed that, in the transition to online courses, "it's hard to have some understanding compared to the face to face [sic] meeting" and "basically doubles the time I have to dedicate each week for that class" [9, pp. 6-7]. One student even reported that the turmoil of the transition had "me questioning my entire life and my major" [9, p. 7]. In a study of STEM majors at a private, 4-year institution, a student relayed future career concerns that "nobody is hiring due to the lockdowns" [11, p. 149].

Although studies have begun to examine the effects of COVID-19 on college students within the United States and around the world, it is unclear how stress during the COVID-19 pandemic has affected students' science trajectories. persistence and career Additionally, capturing student populations at 2-year (community college) and 4- year (baccalaureate-granting) public institutions in Los Angeles, a hot-spot for COVID-19, is critical given students from URM backgrounds are more likely to begin their educational careers at a community college [14], [15]. Prior research suggests that females and ethnic minority individuals report higher stress than White adults though economic downturns are more likely to affect older. White males who are college educated [16]. In the current pandemic, worsening economic prospects are coupled with a health crisis and major academic changes, and there is evidence to suggest that students may be experiencing it acutely differently in terms of increased stress, anxiety, and academic concerns [3], [7]-[9].

Given the increased stress experienced during the pandemic can impact students in a myriad of ways, the current study examines psychological, physical and academic well-being among students with intentions to major in a STEMM field from both a community college and a baccalaureate-granting institution in Los Angeles County, a county with one of the highest number of cases in the country according to the Centers for Disease Control and Prevention [17]). We leverage collected data on a validated psychological stress measure (Perceived Stress Scale [18]) to assess (a) how psychological stress levels of college students before [19] and after the introduction of the COVID-19 pandemic compare to published national datasets [16]; (b) how psychological stress may differ for students from a 2-year and 4-year institution and across other demographic characteristics (e.g., gender, major, URM status); and (c) the relationship between student psychological stress and mental and physical well-being as well as science self-efficacy (i.e., confidence to persist in a science major over the next year, complete a science degree, and pursue a science career).

## II. METHOD

## A. Participants and Comparison Samples

Participant Characteristics: College students (N = 219;  $M_{age} = 22.72$ , SD = 5.14; 74.4% female) expecting to major in a STEMM discipline at a 2-year, community

college and 4-year, baccalaureate-granting institution in Southern California completed a survey in April 2020 after courses transitioned to virtual instruction in March 2020. Participants were included in the survey if they were community college or baccalaureate-granting institution students aged 18 or older majoring in a STEMM field based on the National Science Foundation Survey of Earned Doctorates classification [14]. Of the original 263 respondents to the survey, there were 44 participants removed from analyses who did not meet this science major criteria (e.g., undecided, majoring in art, finance, film production). The majority of science majors reported pursuing a social science degree (e.g., psychology; n = 156; 71.2%) relative to other science, engineering, technology, math, and health degrees (e.g., chemistry, biology, computer science, math, nursing, kinesiology; n = 63; 28.8%). Therefore, major was collapsed across these two field types and included in analyses. All procedures, including participant consent, was approved by the institutional review board at the 4year institution with administrative approval from the 2year institution.

At the 2-year college (n = 164,  $M_{age} = 22.99$ , SD = 5.48; 72.6% female; 67.1% social science majors), the majority of students were Latinx (81.7%; 8.5% Asian American, and 8.5% other ethnicities), the average units completed at the 2-year institution was 38.39 (SD = 27.54), average grade point average (GPA) was self-reported at 3.10 (SD = 0.55), and average parent education was between some secondary or high school (7th to 12th grade) education and high school diploma or equivalent. At the 4-year college (n = 55,  $M_{age} = 21.88$ , SD = 3.81; 80.0% female; 83.6% social science majors), most participants were Latinx (49.1%; 10.9% Asian American, 20.0% White, and 14.5% other ethnicities). In addition, the majority of students at the 4-year college were seniors (29.1%), followed by freshman (25.5%), juniors (23.6%), sophomores (18.2%), and graduate students (3.6%). GPA was self-reported at 3.36 (SD = .53) and average parent education was between a high school diploma and some vocational/technical training with or without a degree.

Comparison Samples: Students ( $M_{age} = 22.02$ , SD =3.54; 73.3% female) from the same 4-year, baccalaureategranting institution in Southern California completed an online survey in 2018 after a social lab stressor (i.e., preparation for a public speech in a modified Trier Social Stress Test; TSST [20]). Details can be found in a separate study [19]. Participants were from African American (5%), Asian American (26.7%), Latinx (43.3%), White (10%), and other ethnic backgrounds (15%). The majority were seniors (45%), followed by juniors (21.7%), graduate students (13.3%), freshmen (11.7%), and sophomores (8.3%). On average, the highest education reported for both mothers and fathers was between a technical/trade school and community college education. We also compared the sample of the current study to norms on the perceived stress scale (PSS) for this age group (age 18 - 25) collected from a national survey completed in 2009, during the last economic downturn [16]. This survey included participants age 18 and older

from an online segment of a national panel of households (Synovate's Consumer Opinion Panel), which was balanced based on pre-screening surveys to represent the general population based on region, sex, age, and household income data from the 2000 U.S. Census.

# B. Measures

*Psychological Stress:* The validated 10-item Perceived Stress Scale (PSS [18] assessed stress (e.g., "In the last month, how often have you found that you could not cope with all the things you had to do?") on a 5-point scale from 0 (*never*) to 4 (*very often*) ( $\alpha = 0.82$ ). There were four items that were positively phrased (e.g., "In the last month, how often have you felt that things were going your way?") and were reverse-coded. The 10 items were then summed, with higher scores representing great psychological stress. In the pre-pandemic, lab-stressed sample, internal reliability (Cronbach's  $\alpha$ ) was 0.84. In the 2009 national sample,  $\alpha = 0.91$  [16].

Internalizing Symptoms: The short-form, 8-item Neuro-QOL Anxiety (e.g., "In the past 7 days, I felt nervous when my normal routine was disrupted") and 8-item Depressive Symptoms scales (e.g., "In the past 7 days, I felt alone") from the National Institutes of Health (NIH) PROMIS toolkit assessed mental well-being. Participants responded to a 5-point scale from 1 (*never*) to 5 (*always*). The items for each construct were averaged and higher scores represent greater symptoms of anxiety or depressive symptoms. Cronbach's  $\alpha$ s were .91 and .94, respectively.

*Physical Symptoms:* An 8-item somatic symptoms scale [21] assessed frequency of "headaches," "feeling tired or having low energy," and "trouble sleeping" in the past 7 days on a 5-point scale from 0 (*not at all*) to 4 (*very much*). The items were averaged and higher scores reflect greater somatic symptoms in the past week ( $\alpha = 0.79$ ).

Science Self-Efficacy: Three science self-efficacy items (e.g., "how much confidence do you have in your ability to... excel in your science major over the next two semesters?" "...complete a science degree?" and "...pursue a science career?"; [22]) assessed academic outcomes in science. Participants responded to a 5-point scale from 1 (*no confidence*) to 5 (*complete confidence*). Given these items may capture different underlying factors for ethnic groups heavily represented in the sample (e.g., Latina American females) and the focus of the current study on short and long-term science persistence and career development in science, each item was analyzed separately.

#### III. RESULTS

# A. Stress Across Samples

As shown in the averages in Table I, one-sample t-tests show that psychological stress reported by students during the transition to virtual instruction in 2020 (M =19.80, SD = 6.65) was significantly higher than the norms for this age group (18 - 25) from national data collected during the last economic downturn in 2009 (M = 16.78. SD = 6.86; t(186) = 6.21, p < 0.001, Cohen's d = 0.45), and relative to White adults (t(186) = 8.43, p < .001,Cohen's d = 0.58) and Latinx adults (t(186) = 5.76, p <0.001, Cohen's d = 0.40). Additionally, students reported significantly higher psychological stress during the transition to virtual instruction in 2020 in comparison to a similar-age sample from the same 4-year university prepandemic in 2018, t(186) = 2.23, p = 0.027, d = 0.16, despite the fact that this latter group had been prepared for a social stressor in the lab. However, follow-up tests suggest that this latter result was driven by the higher levels of stress experienced by students at the 2-year college, t(146) = 2.89, p = 0.004, d = 0.23, rather than the students at the 4-year college, t(39) = -0.65, p = 0.517, d = 0.10.

 TABLE I.
 UNADJUSTED MEANS FOR PERCEIVED STRESS SCALE (PSS) ACROSS SAMPLES AND CHARACTERISTICS

	COVID Virtual Transition (2020)			Post Lab Stressor (2018)			Last Recession <sup>a</sup> (2009)		
	n	М	SD	п	М	SD	п	М	SD
Sex									
Males	43	17.79	6.94	16	15.50	7.39	968	15.52	7.44
Females	142	20.37	6.50	44	19.89	6.41	1032	16.14	7.56
Race									
URM <sup>a</sup>	154	19.90	6.72	29	18.00	6.97	180	17.00	7.45
Non-URM <sup>a</sup>	31	19.35	6.55	31	19.39	8.89	1704	15.70	7.51
Institution									
4-year	40	18.03	6.69	60	18.72	6.91	-	-	-
2-year	147	20.29	6.58	-	-	-	-	-	-
Major									
Social Science	134	19.63	6.42	-	-	-	-	-	-
Other Science	53	20.23	7.26	-	-	-	-	-	-

Note. National norms during the last economic downturn based on Reference [18].

<sup>a</sup>URM represent the PSS average for Latnix participants and non-URM represents the PSS average for White participants from this sample.

#### B. Stress Across Institutions and Other Characteristics

A 2 (male vs. female)  $\times$  2 (URM vs. non-URM)  $\times$  2 (2year vs. 4-year institution)  $\times$  2 (social science vs. other science majors) ANCOVA controlling for age (*F*(1,175) = 17.62, p < 0.001,  $\eta 2 = 0.09$ ) showed a significant main effect of gender (*F*(1, 175) = 6.78, p = 0.010,  $\eta 2 = 0.04$ ), whereby females reported higher levels of psychological stress (*M* = 19.86, *SE* = 0.75) compared to males (*M* = 16.91, *SE* = 1.13). Additionally, there was a main effect

of institution type (F(1, 175) = 7.35, p = 0.007,  $\eta 2 = 0.04$ ), whereby community college students experienced higher levels of stress (M = 20.08, SE = 0.82) compared to their counterparts at a 4-year institution (M = 16.69, SE = 1.14). There were no significant main effects of URM status (p = 0.544) or major (p = 0.854).

## C. Stress-Related Outcomes

Hierarchical linear regressions were modeled predicting well-being and science academic self-efficacy from psychological stress in Step 2 after controlling for age, gender, URM status, institution, and major in Step 1. As shown in Table II, higher psychological stress predicted higher anxiety (b = 0.11, SE = 0.01), depressive (b = 0.12, SE = 0.01), and somatic symptoms (b = 0.06, SE = 0.01), explaining 54%, 46%, and 21% of the variance, respectively. Consistent with previous analyses, females reported higher anxiety and somatic, though not depressive symptoms. Higher psychological stress was also predictive of lower confidence in students' ability to excel in their science major over the next two semesters (b = -0.04, SE = 0.02, 4%), complete a science degree (b = -0.06, SE = 0.02, 5%), and, ultimately, pursue a science career (b = -0.06, SE = 0.02, 7%). Community college students reported lower confidence in exceling in their intended science major and completing a science degree. Students pursuing a social science major reported lower confidence in obtaining a science degree and career.

TABLE II. HIERARCHICAL REGRESSIONS PREDICTING WELL-BEING AND SCIENCE SELF-EFFICACY

Anxiety Depressive Symptoms Symptoms	Somatic Symptoms	Science Major	Science Degree	Science Career
Symptoms Symptoms	• •	•		Science Career
			-	
Step 1				
Intercept 2.93 (0.12)** 2.65 (0.13)**	2.20 (0.10)**	3.86 (0.17)**	3.41 (0.21)**	3.12 (0.20)**
Age -0.01 (0.02) -0.02 (0.02)	-0.01 (0.01)	0.06 (0.02)**	0.03 (0.02)	0.00(0.02)
Gender 0.20 (0.09)* 0.15 (0.10)	0.19 (0.07)*	-0.15 (0.12)	-0.13 (0.14)	-0.16 (0.14)
URM Status -0.06 (0.10) -0.14 (0.12)	-0.05 (0.09)	-0.011 (0.15)	-0.08 (0.18)	0.04 (0.17)
Institution 0.11 (0.10) 0.17 (0.11)	0.16 (0.08)†	-0.33 (0.13)*	-0.32 (0.16)*	-0.22 (0.15)
Major -0.03 (0.08) -0.08 (0.09)	0.02 (0.07)	-0.09 (0.11)	-0.32 (0.14)*	-0.33 (0.13)*
Step 2				
Stress 0.11 (0.01)** 0.12 (0.01)**	0.06 (0.01)**	-0.04 (0.02)*	-0.06 (0.02)**	-0.06 (0.02)**
$\Delta R^2$ 0.54 0.46	0.21	0.04	0.05	0.07

*Note.* Age was mean-centered. Gender was effect-coded with male = -1 and female = 1. URM status was effect-coded and included students from African American, Latinx, Southeast Asian, and Native American ethnic backgrounds = 1 and non-URM = -1. Institution was coded with 2-year institution = 1 and 4-year institutions = -1. Major was coded with social science majors = 1 and other science majors = -1. Stress was the mean-centered PSS sum score.

 $\dagger p < 0.10. * p < .05. ** p < 0.01.$ 

## IV. DISCUSSION

Consistent with expectations, college students during the COVID pandemic experienced levels of stress comparable to those in a similar sample of college students who had experienced a social lab stressor (i.e., TSST [20]) and higher than national norms for this age group, particularly community college and female students. Though a previous study found no differences in anxiety by gender in China [6], the results of the current study align with other research in the United States that suggests females and individuals from ethnic minority backgrounds, who are often more highly represented at community colleges, report higher levels of stress [16].

Follow-up analyses showed that higher stress levels had implications for mental and physical well-being (anxiety, depressive, and somatic symptoms). Although to a lesser degree, higher stress was also predictive of lower academic and science self-efficacy (i.e., ability to excel in science courses in next two semesters, ability to complete science degree, and pursue a science career). These concerns may be due to a reduction in coping resources, limitations in employment prospects, increases in financial difficulties, changes in coursework and load, and adjustments to living conditions [3], [9], [16]. Although comparison of stress among students currently navigating the COVID-19 pandemic to stress data collected across samples in 2009 and 2018 provide evidence that socioeconomic conditions affect young adult psychological stress, mental, physical, and academic well-being, the samples are each cross-sectional and cannot establish causality. Additionally, although increases in stress appear to be linked to the current COVID-19 pandemic, we did not directly measure COVID-related concerns and the results may reflect generational patterns. Lastly, the data was collected in Southern California, a state with a large URM population as well as COVID-19 cases. The results may not generalize to other states, countries, or other types of national emergencies. Future studies should consider longitudinal designs with nationally- or globallyrepresentative samples and COVID-specific measures [7]. Future research should also identify strategies to address the specific causes of stress because this psychological stress can ultimately lead to increased risk of ill health in later adulthood [10].

#### V. CONCLUSION

Despite limitations, the findings have important implications for individuals and institutions supporting students through the current crisis, planning for reopening, and consistently engaging students from diverse backgrounds in STEMM. The results suggest mental, physical, and academic costs of the pandemic that should continue to be monitored across educational trajectories, particularly at points of increased risk for attrition such as in the transfer from 2-year to 4-year institutions [2]. Educational institutions that are able to survey, track, and follow student health over time and provide students and faculty with critical resources (e.g., financial, technological, mental health support) will likely be better able to address the negative consequences of the COVID-19 outbreak in the short-term and long-term. Given that economic and educational disparities can exacerbate or create physical and mental health disparities [23], enriching and supportive learning environments have the potential to promote scientific advances as well as national well-being.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

# AUTHOR CONTRIBUTIONS

SG and CB designed and developed the survey. SG wrote the original drafts. CB and YV advised, edited, and revised. All authors had approved the final version.

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