2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #37171

A Longitudinal Study of Student Mental Health during the Course of the COVID-19 Pandemic

Dr. Andrew Danowitz, California Polytechnic State University, San Luis Obispo

Andrew Danowitz received his PhD in Electrical Engineering from Stanford University in 2014, and is currently an Associate Professor of Computer Engineering at California Polytechnic State University in San Luis Obispo. His research interests involve student mental health and accessibility in engineering education.

Dr. Kacey Beddoes, San Jose State University

Kacey Beddoes is a Project Director in the College of Engineering Dean's Office at San Jose State University. She holds a Ph.D. in Science and Technology Studies (STS) from Virginia Tech. Further information about her work can be found at www.sociologyofengineering.org.

A Longitudinal Study of Student Mental Health During the course of the COVID-19 Pandemic

Abstract: This research paper supports the LEAD strategic priority "Inform." While COVID-19 continues to be a concern, many of the restrictions and precautions associated with the early outbreak have been relaxed. With academia and society slowly adjusting to this "new normal," it is important to know whether and to what extent the mental health of engineering students has changed throughout the pandemic. This work explores that question by analyzing longitudinal data collected four times from 2019-2021. We analyze how the prevalence of different conditions changed with the onset of the COVID-19 pandemic, and whether they have returned to pre-pandemic levels. Among other results, we found statistically significant increases in total depressive disorders between our initial sample (Fall 2019) and a sample taken immediately post-COVID (Spring 2020). While measured rates of depression decreased between Spring 2020 and Fall 2021, it was not statistically significant, potentially indicating that the student population is still recovering on this metric. Conversely, our data shows a statistically significant drop in moderate-to-major psychological distress between our Fall 2019 pre-pandemic sampling and our Fall 2021 post-pandemic sampling indicating, potentially indicating an improvement in overall mental health. Breaking the data down by gender, no significant changes were observed across any measure during the four sample periods for women respondents. Men, however, showed a significant increase in depressive disorders from Fall 2019 to Spring 2020. The biggest jump in depression, however, was observed among respondents whose parents' highest level of education was a Bachelor's degree.

Introduction

The COVID-19 pandemic led to numerous changes for engineering students across the nation. Faculty and students were forced to rapidly adapt to online learning modalities as campuses closed and individuals were affected by stay-at-home orders. Many students on residential campuses were also forced to move back home during the middle of their academic year as population-dense student dormitories were shut down to further minimize the risk of virus transmission. Against this chaotic backdrop, it is not surprising that data collected during the early stages of the COVID pandemic show a surge in mental health issues among engineering and pre-engineering students [1], [2]. By Fall 2021, however, with COVID-19 vaccines widely available, many colleges reopened for in-person learning and students began adjusting to a new, post-COVID normal.

As this process continues, and as universities continue to face ongoing waves of disruption from COVID-19 variants, it is important to understand how the mental health of students has changed during the pandemic, and whether, and to what extent mental health screen rates have returned to pre-pandemic levels. We explore this topic by analyzing the results of mental health screens completed by a cohort of engineering students recruited from 8 universities across the United States. Participants were sampled four times between Fall 2019, just before COVID-19 was known to be widespread in the United States and Fall 2021 after many universities had reopened.

Background

Even before the pandemic, mental health was an area of particular concern for engineering programs and students. While data from the U.S. shows engineering students suffering from mental health disorders at similar rates to students in other majors, they are significantly less likely to seek counseling resources for mental health issues than students in other majors [3], [4], and students who do manage to access treatment have reported several discipline-related barriers to successfully navigating their program [5]. Additionally, engineering programs have been found to foster cultures of stress [6] and shame, and are known to expose students from marginalized communities to microaggressions [7], [8]; making student mental health a particularly salient concern for the engineering education community.

Mental health data collected during the pandemic showed that incidence of mental health disorders, including anxiety, depression, and eating disorders significantly increased [9]–[11]. Data on engineering and pre-engineering students specifically show rates of depression approaching 50% [1], [2].

While the development and widespread deployment of COVID-19 vaccines and a general relaxing of COVID-19-related closures and isolation mandates have arguably relieved some of the key stressors and disruption caused by the pandemic, existing research indicates that it might take time for student mental health to recover to pre-pandemic levels; and that the conditions most affecting student mental health may have changed during the pandemic. One longitudinal study conducted Spring–Fall 2020 indicated that while levels of acute stress fell over time, incidence of depressive symptoms increased [12]. Additionally, an analysis of mental health outcomes surrounding previous pandemics and natural disasters has found that rates of depression and anxiety remained elevated for years after disasters, with children showing higher depressive and anxiety symptoms than adults [13]. These and other sources looking at the psychological effects of COVID-19 and natural disasters, however, all note that there is a dearth of longitudinal data that can show whether and to what extent mental health continues to be affected in the aftermath of such events [12]–[14]. Therefore, the data presented here serves as an important benchmark for understanding what COVID-19 mental health challenges our students may still be facing as colleges continue to move into a post-COVID model of operation.

Methods

The findings presented in this article come from a survey that was presented to a cohort of U.S. engineering students four times from Fall 2019 through Fall 2022.

Survey Design

The instrument used for this data collection was modeled off of the instrument used in numerous studies of mental health in engineering students [15], [16]. It is composed of the *Patient Health Questionnaire* [17], a survey used to determine rates of depression, anxiety, and eating disorders in a population; *The Kessler 6* [18], a survey designed to measure major and moderate [19] psychological distress; and the *PC-PTSD* [20], an instrument designed to identify PTSD-like symptoms in a population. The survey also included questions about respondent demographics,

including race/ethnicity, gender, disabilities, and sexual orientation. For this survey, "mental health" is exclusively measured by analyzing the presence or absence of a potentially diagnosable mental health condition; general aspects of "mental wellness" are not captured.

Longitudinal Design

The study that resulted in this data was designed to be introduced to first- and second-year engineering students in year 1 of data collection, with follow-up data collected as the cohort of respondents progressed through their program. Students interested in participating in follow-up surveys were asked to provide a school and permanent email address. To limit participation to first- and second-year students, our recruitment material specified that only first- and second-year engineering or pre-declared engineering students should take the survey; where possible, we also asked partner institutions to only send information about the survey to their first and second-year students. The first-year survey also contained logic to screen for first- and second-year participants: before being asked any mental health questions, the survey asked respondents their year in the program and only allowed those reporting years 1 or 2 to continue.

Data Collection

With the approval of California Polytechnic State University's Institutional Review Board and in coordination with our partner universities, this survey was issued to first- and second-year students at eight non-profit four-year universities in fall 2019 through early winter 2021 (before the COVID-19 virus was known to be widespread in the U.S.). The partner universities are located across the U.S. with sites in Arizona, California, Colorado, Florida, Iowa, and Wisconsin. The initial data collection (t1) yielded over 900 results, with over 800 respondents providing emails to be included in follow-up studies. Sites were selected to ensure broad geographic representation of students across the United States. Sites contained a mix of both public non-profit and private non-profit schools and were a mix of research-focused institutions and primarily undergraduate institutions.

Between 2019 and 2021, we contacted students who provided their email addresses three additional times to measure mental health with our survey instrument. The first follow-up collection was conducted in Summer 2020 (T1.5), soon after the onset of the COVID-19 pandemic in the U.S. The second follow-up data collection (T2) occurred in late Fall of 2020, and the third and final data collection (T3) occurred in Fall of 2021. These data collection points are summarized in Table 1. For clarity, survey points will be referred to by T1–T3 throughout this paper.

Table 1. Summary of data collections

Sampling	**Period collected**
T1	Fall 2019–Winter 2020 (pre-COVID)
T1.5	Summer 2020
T2	Fall 2020
T3	Fall 2021

Respondents

Despite the large number of respondents indicating interest in follow-up studies, relatively few respondents participated in all four data collections. Therefore, for this analysis we include all participants who participated in at least three of the four data collections. This resulted in a final sample size of 162. Total participation for each data collection period is shown in Table 2.

Table 2. Number of participants who participated in at least 3 data collections.

Data Collection	**Participants**
Initial (fall 2019–winter 2020)	162
COVID onset (summer 2020)	88
Second year (fall 2020)	149
Third year (fall 2021)	149

The demographics of these respondents are broken down in Table 3. The population is three-quarters White, with a roughly even split among men and women. Due to the relatively small and homogeneous sample size, analysis of this data set can only draw limited conclusions about how mental health changed across demographic.

Table 3. Demographics of respondents who participated in 3 or more data collections.

Race or ethnicity (n)	
White	121
Asian	21
Hispanic or Latino	12
Black or African American	2
Mixed Race	3
Prefer not to respond	3
Gender (n)	
Man	77
Woman	81
Another	2
Prefer not to respond	2
Sexuality (n)	
Heterosexual	131
LGBA	31
Parents' Education (n)	
Bachelor's Degree	76
Post-Bachelor's training	59
Completed some university	10
High school or equivalent	8
Associate's degree	4
Some formal schooling	5

Data Analysis

Quantitative analysis of this data was conducted in the R open-source statistical computing language [21]. After data was collected, mental health screens were scored for each respondent for each data collection. As a condition of IRB approval, we were not able to require respondents to answer any specific questions. Where respondents provided answers to only some questions in a screen, if they provided enough information to score the instrument, their result was included for that screen.

ANOVA analysis was used on the dataset to determine if the incidence of any mental health screen across all respondents changed significantly between data collection times. This analysis was repeated per demographic group to determine how mental health changed within different populations of engineering students over time. Due to the small sample size and relative homogeneity of the data, several demographic groups had to be condensed to allow for statistical analysis. Unfortunately, gender had to be operationalized as a binary between Man and Woman due to a lack of data from respondents indicating "another." These factors are summarized in Table 4. Additionally, mental health measures were operationalized as "moderate or major psychological distress," "any depressive disorder," "any anxiety disorder," "PTSD," and "any eating disorder."

Table 4. Condensed demographic categories

Category	**Factor**
Gender	Man
	Woman
Race or Ethnicity	White
	Asian
	Another
Parent's Education	Bachelor's degree
	Post-Bac degree or training
	Some college or Associate's degree
	High school or some formal schooling

Limitations

Some issues with this study may limit the generalizability of these results. First, this study was originally intended to provide longitudinal data on how the mental health of engineering students changed as they progressed through their program and our participants were all first- or second-year engineering students as of the first data collection. As a result, it is not fully possible to differentiate changes in mental health that occurred because of COVID-19 versus progressing through an engineering program. Additionally, since not all respondents completed all four data collections, the respondent population is slightly different for each timeframe, possibly skewing results. Finally, the homogeneity of the sample population limits our ability to determine how the pandemic affected different marginalized groups in engineering education. Despite these limitations, we believe that this dataset still provides an overview of how mental health for certain populations of engineering students changed during the pandemic.

Results

The overall mental health screening rates for our respondents are shown in Figure 1. Rates of moderate-to-major psychological distress appear to drop as time goes on. For other conditions, incidence appears to increase between T1 and T1.5 (pre-to-post COVID-19, before decreasing back towards pre-COVID levels.

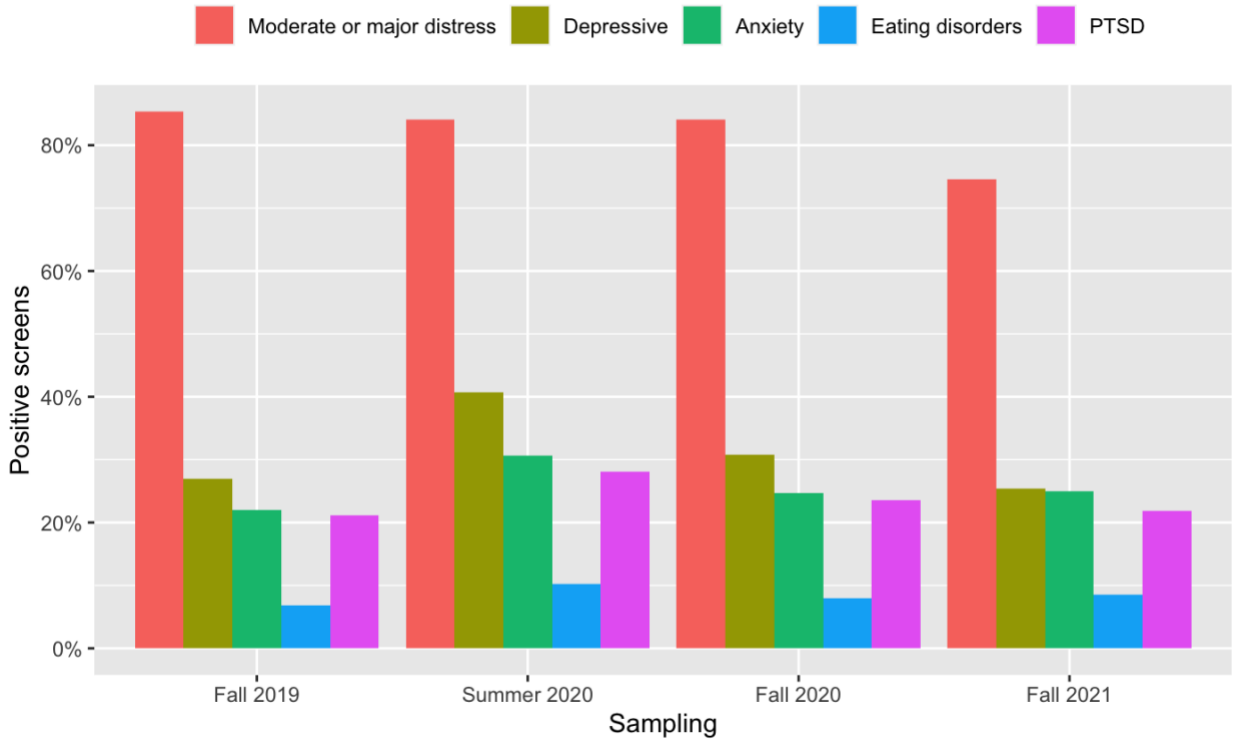

Figure 1. Mental health positive screen rates across.

The results of our ANOVA analysis of how incidence of conditions changed over time are summarized in Table 5. We found that only the changes in moderate-to-major psychological distress incidence of depressive disorders were statistically significant to a *95%* confidence interval.

Table 5. Significant changes in mental health between samplings.

Condition	**Time period**	**Absolute Change (%)**	***p***
Moderate–major distress	1–3	-10.4	.00069
	2–3	-9.5	.021
Any Depressive	1–1.5	13.2	.0049
	1.5–3	-15.4	.0046

Results of the per-demographic ANOVA analysis are summarized in Table 6. Respondents who reported their gender as men saw a significant jump in depressive disorder from the initial pre-

COVID data collection to the first post-COVID data collection. Respondents who report that their parents' highest level of education is a Bachelor's degree had a large jump in overall incidence of depressive disorder between the pre-COVID and immediately post-COVID data collections. Their rates of depression significantly decreased after the first post-COVID collection.

Table 6. Significant changes by demographic

Demographic	**Condition**	**Time**	**Absolute Change (%)**	***p***
Men	Any Depressive	1–1.5	12.1	.042
Parent with Bachelor's	Any Depressive	1–1.5	35.9	.00032
		1.5–2	-26.0	.020
		1.5–3	-29.2	.0067

For comparison, rates of depression versus time broken out by gender and by parents' education are shown in Figure 2 and Figure 3.

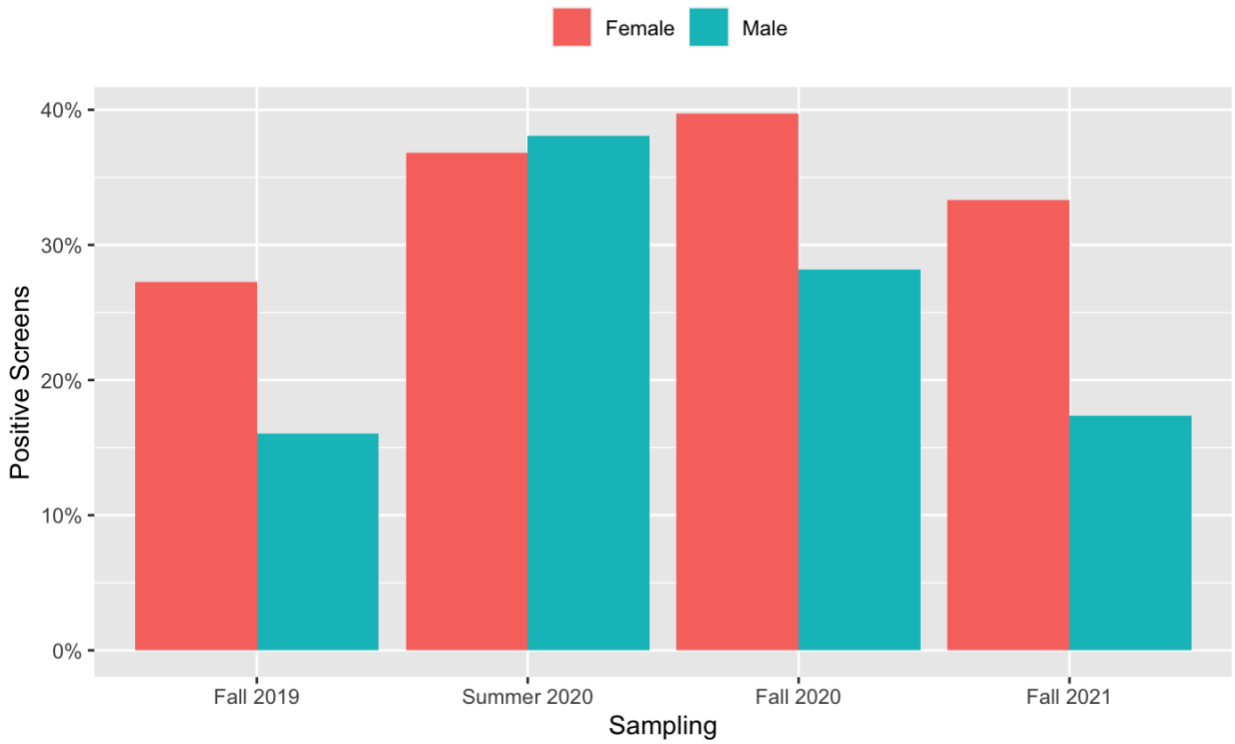

Figure 2. Total depression by gender.

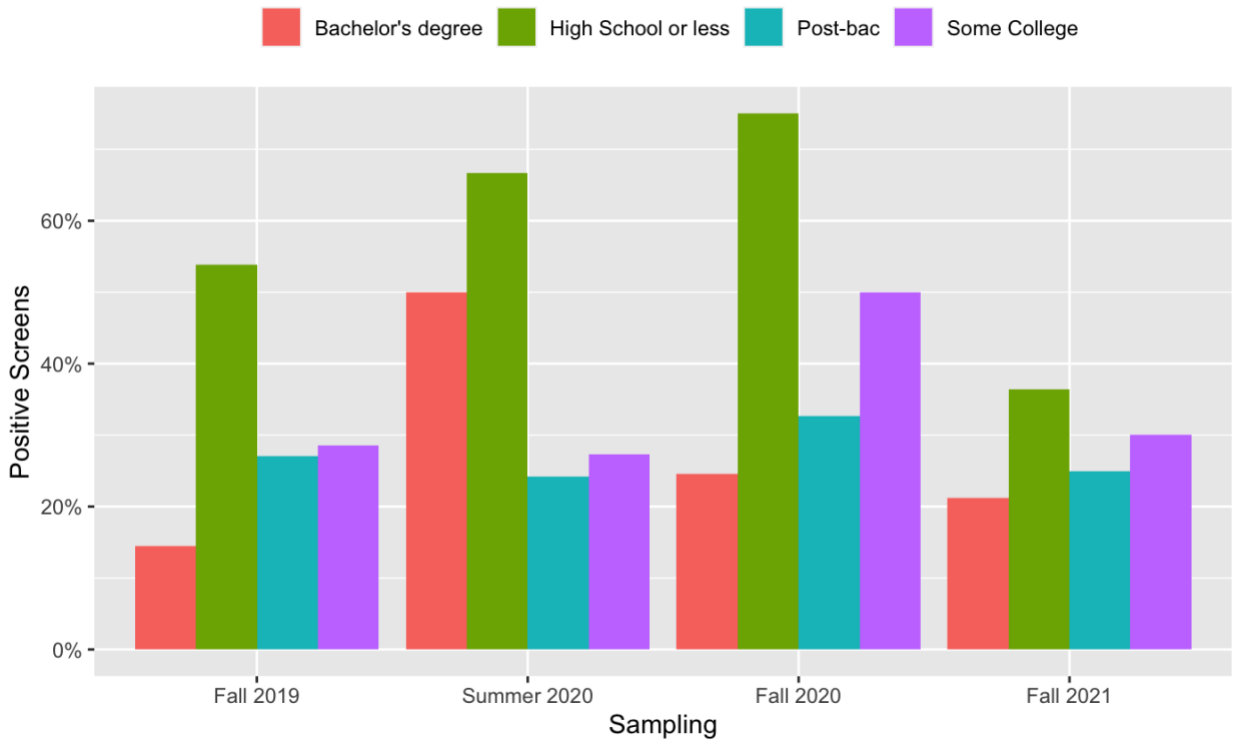

Figure 3. Total depression by parents' education.

Discussion

The longitudinal sample of students from eight partner universities across the U.S. shows a significant increase in depression from T1–T1.5. Since this correlates with the onset of the COVID-19 pandemic, this result is not surprising and is indeed consistent with what other studies have found. Our data also reveals that between T1.5 and T3, incidences of depressive disorders have receded by roughly the same amount that they increased during the initial phase of the pandemic.

Looking at the per demographic statistical analysis, the population with the biggest significant change in depression is those students whose parents' highest level of education is a bachelor's degree. The overall incidence of depression among this population increased from 15.5% to 51.4% of respondents at T1.5, before decreasing to 22.2% by T3. We also observed a statistically significant increase in depression among respondents who identify as men from T1–T1.5. This data is particularly interesting since men and students whose parents have achieved a Bachelor's degree represent two traditionally overrepresented populations in engineering education. Looking at the overall incidence of depression among demographics in Figure 2 and Figure 3 both men and student's whose parents' achieved a bachelor's degree had among the lowest incidence of depression of all population groups in T1, but show among the highest incidence of depression during T1.5. One possible explanation for this is that the T1.5 sample is not fully representative of the study population: it had roughly half the respondents of the other samplings and may be more susceptible to self-selection among our total participant pool. Another explanation is that as majority populations in engineering programs, men and students whose parents earned a bachelor's degree are more comfortable on campus and derive more of their

identity from being in a residential college program than their peers from marginalized backgrounds. The uncertainty that accompanied the onset of the COVID-19 pandemic and related campus closures may have removed some of these advantages and acted to equalize rates of depression across populations. Indeed, we see that during T1.5 rates of depression among men are roughly equal to rates of depression among women, and rates of depression among those whose parents have bachelor's degrees approach the rates of depression of first-generation college students. If this is the case, our data may suggest that some of the mental health disparities among demographic groups that have been documented in engineering education are due to campus cultures and other aspects of residential education that disparately benefit majority-in-engineering populations.

While Figure 3 shows spikes in depression in Fall 2020 for respondents whose parents had less than a Bachelor degree, these trends were not statistically significant.

The other major trend we observe in the data is that overall rates of moderate to major psychological distress significantly decrease from the pre-COVID T1 sample to the final T3 sample. There is also a significant decrease in this measure from T2 to T3. One possible explanation is that mental health in engineering education improves as students progress through their programs and near graduation. Previous research has shown that the transition to college is often associated with higher levels of stress and psychological distress [22], [23] which may be mitigated as students spend more time in the program and near graduation. Another possibility is that as time went on, the students who were able to adapt, thrive in their programs, and improve their mental health were more likely to persist, while those who were not left engineering and stopped participating in the study. Since only those respondents who completed three or more surveys were included in this analysis, those who left engineering and stopped responding are not represented in this data. Unfortunately, given the limits of our data collection, there is no way to know whether or to what extent these factors cause the observed decrease in psychological distress.

Conclusions

This study examined how rates of mental health disorders changed in engineering students changed during the pandemic. Within our sample population, only rates of depression and moderate-to-major psychological distress changed significantly. While depression peaked in the first sampling after COVID-19 became widespread in the United States, by the end of the sampling it had receded to roughly pre-COVID levels. Major-to-moderate psychological distress decreased from pre-COVID levels by the T2 and T3 samplings, indicating that certain measures of mental health improved for our respondent population.

Analyzing the data on a per-demographic basis, men and those whose parents achieved a bachelor's degree were the only groups to show a statistically significant spike in depression. In the immediate aftermath of COVID, men's rate of depression surpassed that of women, while students whose parents earned a bachelor's degree had a rate of depression second only to first-generation college students. Given that both populations are traditionally in the majority in college programs, it seems that the challenge of COVID-19 and related campus closures acted as an equalizing factor for mental health across groups.

Ultimately, other than a decrease in moderate-to-major psychological distress, our data showed that there were no statistically significant differences in the mental health between the initial pre-COVID measurement and T3: for this cohort it appears that mental health has largely returned to pre-COVID rates. It is important to note that all the students in this study were already in college by the time COVID-19 became prevalent within the United States and were nearing graduation at the time of the final data collection. Things may be different for those students who started college during the remote learning phase of the pandemic and for those who had their high-school education disrupted by the pandemic and are only now starting to matriculate in college. Further study is needed to determine how the pandemic may have changed the mental health landscape for these students.

It is also important to note that this study only looked at mental health in terms of diagnosable mental health conditions: while our data shows that rates of these conditions have normalized, there may be lingering mental wellness issues and other lasting effects of the pandemic not captured here.

Acknowledgments

We sincerely thank the students who were willing to share these difficult and personal experiences with us because they wanted to improve engineering education for others. This material is based upon work supported by the National Science Foundation under grants EEC #1929484 and #1929478. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

References

[1] A. Danowitz and K. Beddoes, "Effects of COVID-19 on Stress and Mental Health of Community College Pre-Engineering Students," in *Frontiers in Education Annual Conference*, Uppsala, Sweden, Oct. 2022.

[2] A. Danowitz and K. Beddoes, "How the COVID-19 pandemic reshaped demographic variation in mental health among diverse engineering student populations," *Australasian Journal of Engineering Education*, vol. 27, no. 2, pp. 67–76, Jul. 2022, doi: 10.1080/22054952.2023.2184912.

[3] J. K. Hyun, B. C. Quinn, T. Madon, and S. Lustig, "Graduate student mental health: Needs assessment and utilization of counseling services," *Journal of College Student Development*, vol. 47, no. 3, pp. 247–266, 2006.

[4] S. K. Lipson, S. Zhou, B. Wagner III, K. Beck, and D. Eisenberg, "Major Differences: Variations in Undergraduate and Graduate Student Mental Health and Treatment Utilization Across Academic Disciplines," *Journal of College Student Psychotherapy*, vol. 30, no. 1, pp. 23–41, 2016.

[5] K. Beddoes and A. Danowitz, "In Their Own Words: How Aspects of Engineering Education Undermine Students' Mental Health," presented at the American Society for Engineering Education Annual Conference, Minneapolis, MN, 2022.

[6] K. J. Jensen and K. J. Cross, "Engineering stress culture: Relationships among mental health, engineering identity, and sense of inclusion," *Journal of Engineering Education*, vol. 110, no. 2, pp. 371–392, 2021.
[7] M. J. Lee, J. D. Collins, S. A. Harwood, R. Mendenhall, and M. B. Huntt, "'If you aren't White, Asian or Indian, you aren't an engineer': racial microaggressions in STEM education," *IJ STEM Ed*, vol. 7, no. 1, p. 48, Sep. 2020.
[8] M. M. Camacho and S. M. Lord, "'Microaggressions' in engineering education: Climate for Asian, Latina and White women," in *2011 Frontiers in Education Conference (FIE)*, Oct. 2011.
[9] J. F. Huckins *et al.*, "Mental Health and Behavior of College Students During the Early Phases of the COVID-19 Pandemic: Longitudinal Smartphone and Ecological Momentary Assessment Study," *Journal of Medical Internet Research*, vol. 22, no. 6, Jun. 2020.
[10] A. F. Tasso, N. Hisli Sahin, and G. J. San Roman, "COVID-19 disruption on college students: Academic and socioemotional implications.," *Psychological Trauma: Theory, Research, Practice, and Policy*, vol. 13, no. 1, pp. 9–15, Dec. 2020.
[11] I. Chirikov, K. M. Soria, B. Horgos, and D. Jones-White, "Undergraduate and Graduate Students' Mental Health During the COVID-19 Pandemic," *UC Berkeley: Center for Studies in Higher Education*, 2020.
[12] C. B. Veldhuis *et al.*, "Addressing the critical need for long-term mental health data during the COVID-19 pandemic: Changes in mental health from April to September 2020," *Preventive Medicine*, vol. 146, p. 106465, May 2021, doi: 10.1016/j.ypmed.2021.106465.
[13] E. A. Newnham *et al.*, "Long term mental health trajectories after disasters and pandemics: A multilingual systematic review of prevalence, risk and protective factors," *Clinical Psychology Review*, vol. 97, p. 102203, Nov. 2022.
[14] S. K. Brooks *et al.*, "The psychological impact of quarantine and how to reduce it: rapid review of the evidence," *The Lancet*, vol. 395, no. 10227, pp. 912–920, Mar. 2020.
[15] A. Danowitz and K. Beddoes, "Characterizing Mental Health and Wellness in Students Across Engineering Disciplines," presented at the 2018 CoNECD - The Collaborative Network for Engineering and Computing Diversity Conference, Crystal City, Virginia, 2018.
[16] A. Danowitz and K. Beddoes, "Mental Health in Engineering Education: Identifying Population and Intersectional Variation," *IEEE Transactions on Education*, vol. 65, no. 3, pp. 257–266, Aug. 2022.
[17] R. L. Spitzer, K. Kroenke, J. B. Williams, and P. H. Q. P. C. S. Group, "Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study," *Jama*, vol. 282, no. 18, pp. 1737–1744, 1999.
[18] R. C. Kessler *et al.*, "Short screening scales to monitor population prevalences and trends in non-specific psychological distress," *Psychological medicine*, vol. 32, no. 6, pp. 959–976, 2002.
[19] J. J. Prochaska, H. Sung, W. Max, Y. Shi, and M. Ong, "Validity study of the K6 scale as a measure of moderate mental distress based on mental health treatment need and utilization," *Int J Methods Psychiatr Res*, vol. 21, no. 2, pp. 88–97, Feb. 2012.
[20] R. P. Cameron and D. Gusman, "The primary care PTSD screen (PC-PTSD): development and operating characteristics," *Primary Care Psychiatry*, vol. 9, no. 1, pp. 9–14, 2003.
[21] R Core Team, *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing, 2022.

[22] R. Dyson and K. Renk, “Freshmen adaptation to university life: Depressive symptoms, stress, and coping,” *Journal of Clinical Psychology*, vol. 62, no. 10, pp. 1231–1244, 2006, doi: 10.1002/jclp.20295.
[23] S. Fisher and B. Hood, “The stress of the transition to university: A longitudinal study of psychological disturbance, absent-mindedness and vulnerability to homesickness,” *British Journal of Psychology*, vol. 78, no. 4, pp. 425–441, 1987, doi: 10.1111/j.2044-8295.1987.tb02260.x.