Mental Health in Engineering Education: Identifying Population and Intersectional Variation

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Abstract*—*Contribution: **Screening rates for engineering students for several major and moderate mental health issues are reported, including unspecified psychological distress as captured by the Kessler 6 screening instrument; screening rates for depressive, anxiety, and eating disorders as measured by the patient health questionnaire (PHQ); and screening rates for post-traumatic stress disorder (PTSD) as measured by the primary care post-traumatic stress disorder (PC-PTSD) instrument. This work also explores how mental health issues affect different student demographic groups within engineering.**

Background: **Anecdotal evidence has long suggested that stress and certain mental health issues are particularly acute in the field of Engineering, and some recent research has shown elevated rates of mental health issues at different institutions around the country. This article presents the results of a previously validated mental health survey conducted with first- and second-year students at eight universities.**

Intended Outcomes: **A better understanding of which mental health issues affect engineering students as a population, and an understanding of what mental health disparities exist among different demographics in engineering. This information is intended to allow engineering programs, student groups, and other stakeholders to better target mental health resources for all engineering students.**

Application Design: **This work combines several widely used population-scale mental health diagnostic tools into a single comprehensive survey instrument that was deployed to first- and second-year engineering students at eight universities nationwide.**

Findings: **This study finds that 50% of respondents screening positive for a major mental health condition—including depression, anxiety, PTSD, an eating disorder, or major psychological distress—while only 16% of respondents report having ever received a diagnosis for a mental health condition. Women respondents are more likely to screen positive for anxiety disorders (4.4× for panic disorder, 2.2× for other anxiety, and 1.9× for PTSD) and major depressive disorder (2.3×) relative to men. Respondents reporting physical disabilities have significantly higher likelihoods of suffering from mental health issues than peers with no reported physical disabilities and are 2.9× more likely to screen positive for PTSD. Identifying as Hispanic was also a significant predictor of major depressive disorder (3.2× more likely) and PTSD (2.5× more likely).**

***Index Terms*—Accessibility, disability, equity, first and second year, inclusion, mental health, wellness.**

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This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by the IRB Approval.

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I. Introduction

STUDENT mental health issues are a major concern for college campuses [1]–[6]. College counseling centers have seen an uptick in demand for services [7]–[9], leading some experts to declare a "mental health crisis" in college education [10].

Existing data shows that engineering students suffer from conditions like anxiety and depression at rates much higher than those found in the general population [11]–[13]. While the evidence does not indicate that engineering students have a higher incidence of conditions like depression than nonengineering students [14], [15], certain aspects of engineering programs make understanding mental health a particularly important issue for this population.

One factor that makes studying mental health in engineering students particularly important is the chronically low retention rates in baccalaureate engineering programs [16]. Several studies show links between student mental health conditions and student retention and success [17], [18]. Studies have also shown that modern engineering programs foster cultures of stress [19], [20] and shame [21], which may also contribute to poor mental health in engineering students. Improving engineering student mental health overall may be an important mechanism for graduating larger cohorts of engineers.

When combined with microaggressions directed at students of color, women, and first-generation college students [5], [14], [22]–[27], it is possible that poor mental health may lead especially low retention rates and worse academic outcomes for members of marginalized groups within engineering. Therefore, understanding how mental health varies between engineering student populations may be key to graduating more diverse cohorts of engineers.

The research presented here does not directly address the link between mental health and student success; instead, it tries to lay the groundwork for future explorations into mental health by providing a U.S.-wide baseline for the prevalence of mental health issues in engineering programs. Unlike many previous studies into the mental health of engineering students which focused on a single campus or a small number of mental health measures, this analysis includes data from numerous sites across the United States. This analysis relies on validated population-scale mental health instruments to allow for

meaningful comparisons between engineering students and the general population across eight different mental health measures. Finally, it explores whether and to what extent mental health disparities exist among different demographic groups in engineering education. To that end, the following research questions are explored.

RQ1: What percentage of engineering students suffer from or are likely to suffer from a mental health issue?

RQ2: What differences, if any, exist among the mental health of different groups of engineering students?

The data presented and analyzed here were collected by early 2020, before COVID-19 was known to be prevalent in the United States and before many U.S. institutions closed campuses and transitioned to online learning. This work, therefore, represents the mental health and inequities found in engineering education during "regular" times. Data from during the pandemic are reported elsewhere [28]–[30].

II. Background

Students' mental health challenges are increasingly an issue universities must address [2], [3], [6], [10]. The number of students dealing with depression is increasing [4], [8], and a national survey of 26 000 undergraduate students found that 40% had been so depressed or anxious that it was difficult to function [31]. It is, therefore, not surprising that psychological distress plays a key role in student attrition [17], [18].

Beyond attrition, poor mental health can lead to tragic consequences for students and college communities: suicide is the second leading cause of death for college students [5], and, according to a recent study, 13% of college students have considered suicide [31].

Given the severe consequences of mental health issues, studying and understanding student mental health, especially in high-stress majors like engineering should be a high priority for educators. Indeed, mental health research specific to engineering students, while relatively scarce, has grown rapidly in recent years. Interventions designed to support the mental health of engineering graduate and undergraduate students have been implemented in recent years [32]–[36].

Some of the earliest research in this field investigated relationships between mental health and participation in service-learning activities [37]–[39]. A 2008 survey of 582 engineering students who identify as men found that more than 44% exhibited some symptoms of depression [11]. More recently, several surveys have found that engineering students suffered from mental health issues at significantly higher rates than the general population [13].

While engineering students have not been found to suffer from mental health issues at higher rates than other college students [14], [15], they are less likely than students in other majors to seek treatment for mental health issues [40]. Research also indicates that engineering programs in general foster cultures of stress [41] and shame [21]. These characteristics may indicate that engineering students have different mental health needs than other students.

In the U.S. national population, there are discrepancies in the mental health between different demographic groups. The National Institute of Mental Health reports that, in general, women screen positive for any anxiety disorder at a factor of 1.6 times the rate of men [42], the same agency also suggests that women also screen higher than men for major depression by a factor of 1.6 [43]. Barzega *et al.* [44] indicated that women screen positive for panic disorder at 1.3×–5.8× the rate of men. Prior research also shows that women, LGBTQA (Lesbian, Gay, Transsexual, Queer or Questioning, and Asexual), and Black, Latinx, Asian, Indigenous, and People of Color college students experience more psychological challenges than white cisgender heterosexual men [22]–[26]. Given that the culture of Engineering and STEM programs is known to be particularly unwelcoming for Black, Indigenous, Latinx, Asian, women, and other marginalized populations, with a high prevalence of microaggressions, stereotype threats, and other stressors [45]–[47], it is worth exploring whether marginalized engineering students face additional mental health burdens compared to peers.

The preliminary research that belonging to a marginalized group (LGBTQ, person-of-color, indigenous, women or nonbinary, or having a disability) in engineering increases the likelihood of depression, anxiety, and higher stress levels in general [13], [48]. One regional survey found numerous differences among various demographic groups, including that Asian women and Latinas have higher post-traumatic stress disorder (PTSD) and major psychological distress symptoms [49]. These findings mirror others in which women engineering students were more likely to have higher stress than men engineering students [50], and findings that STEM environments, with their gendered and racialized interactions, have negatively impacted women and African American's mental health [51], [52]. LGBTQA identity also significantly predicts a range of mental health challenges [53], [54].

For individuals who belong to more than one marginalized identity group (including but not limited to women of color, LGBTQ men of color, and People of Color with disabilities), STEM environments can be particularly unwelcoming [55], [56], which highlights the need for intersectional analyses.

In addition to gender, sexuality, and race/ethnicity, status as a first-generation student (FGCS) and identifying as having a disability are also correlated with unique stressors and challenges in higher education [57], [58]. Studies report that first-generation students may suffer from a lack of effective family support and confidence as they pursue higher education [59], and have been found to have lower overall mental health and lower utilization of campus mental health resources than non-FGCS students [60], [61]. Additionally, studies indicate that students who identify as having a disability face unique challenges integrating into and obtaining adequate support from institutes of higher education [57], [62].

III. Methods

A. Survey Design

The survey for this study is largely based on the instrument used in [49]. This survey was selected since baseline

engineering data from this instrument already exists for a region of the United States, allowing for an easy comparison between the national results presented here to the existing literature.

The survey is composed of preexisting mental health surveys that have been validated for measuring population-scale mental health via remote correspondence. Instruments used include the Kessler 6 [63], the patient health questionnaire (PHQ) [64], and the primary care PTSD scale (PC-PTSD) [65].

The Kessler 6 is a short scale designed to assess the overall mental health of a population. Consisting of six Likert-style questions [66], the Kessler was originally designed to screen for the presence of severe (diagnosable) mental health issues in respondents. Additional work has shown that the screen is also able to identify individuals suffering from moderate psychological distress [67]. While the Kessler 6 instrument provides a comprehensive picture of overall mental health, it is not able to differentiate among the mental health conditions from which respondents are suffering.

The PHQ is a modular instrument with portions to screen for somative, depressive, anxiety, and eating disorders, as well as a portion to screen for alcohol abuse. For this research, the module for somative disorders was excluded since the authors reasoned that somative symptoms may be confounded by other aspects of residential college life (including diet, late night social activities, alcohol use, etc.). The module to screen for alcohol abuse was also omitted as the instrument collected e-mail identifiers from some participants for future longitudinal studies, and the research team did not wish to expose underage students to any potential legal liabilities as a result of their responses to questions in this study.

Finally, the PC-PTSD scale is included to determine whether and to what extent students are suffering from post-traumatic-stress like symptoms. This instrument relies on the older DSM-IV definition of PTSD, rather than the updated DSM-V definition [68]. The DSM-IV instrument was used since it encapsulates a broader range of traumatic experiences than the DSM-V definition; all of which may contribute to poor student outcomes. Additionally, many available statistics on PTSD in the U.S. are based on the DSM-IV PTSD definition [69], [70], so the use of a DSM-IV instrument allows for a direct comparison of the incidence of traumatic experiences in engineering students with the incidence in the general population.

These three instruments were selected to get a broad understanding of how engineering students are affected by depressive disorders (PHQ), anxiety disorders (PHQ and PC-PTSD), and to determine the overall rates at which engineering students suffer from mental health conditions (Kessler 6). These instruments were also selected since they have already been used in other studies of engineering student mental health [13], [28], [49], [71].

Respondents were also asked a number of demographic questions, including race, gender, sexuality, major, parents' highest level of education, whether they have been diagnosed with learning or physical disabilities, and whether they have ever been diagnosed with or are undergoing treatment for a mental health or wellness condition.

B. Participants and Data Collection

With the IRB approval, the survey was distributed to students at eight nonprofit four-year universities across the United States. Partners include universities in California, Arizona, Colorado, Florida, Iowa, and Wisconsin. Partner institutions vary greatly in program size and include both primarily undergraduate universities and Ph.D. granting institutions.

As data initial collection was intended to lay the groundwork for longitudinal research, the survey was only distributed to first- and second-year engineering students. Additionally, the survey included a mechanism to screen out participants from other years: if a potential respondent self-reported that they were from a program year other than 1 or 2, they were met with an early disqualification page before being shown any of the mental health screening instruments. While it is possible a student from another program year could have answered the screening question dishonestly, it is not believed that this represents a large portion of respondents.

Students were recruited over e-mail with an initial solicitation and, if needed, a reminder e-mail sent out roughly two weeks after the initial solicitation (timing of the reminder e-mail varied by up to a few weeks depending on the availability and needs of partner institutions). Depending on the schedule of the partner institution, the survey was sent either in Fall 2019 or Winter 2020.

Overall, 16% of respondents had previously been diagnosed with a mental health condition. 67% of respondents identified as White, 14% identified as Asian, and 10% identified as Latinx or Hispanic. 56% of respondents identified as men, 42% identified as women, and members of the remaining 2% largely self-identifying as nonbinary. 82% of respondents identified as heterosexual, with 8% reporting bisexual sexuality, and 17% overall identifying as members of an LGBTQA group. 53% of respondents are in their first year, and 47% are in their second year.

Data was collected on a range of other characteristics, including parents' highest level of education, status as an international student, and previous diagnosis with either a learning or physical disability. Table I shows a breakdown of the respondent population across all of the screened demographics.

C. Data Analysis

The survey yielded 924 results total, with participation numbers of 187, 104, 95, 94, and 60 from the five primarily undergraduate universities; and 235, 85, and 64 respondents from Ph.D. granting institutions. The average response rate across all sites was approximately 8%.

To address RQ1, screen rates for various mental wellness conditions were determined using the screening guidelines associated with each instrument. In some situations, a respondent answered some, but not all questions in a screen. In these cases, if the respondent provided enough information for the instrument to be conclusively scored their result was included. If the respondent did not offer enough information to compute a given screen, the respondent was left out of the results for that screen. Positive and negative screen rates for each condition are used to assess the mental health of the

TABLE I
EXPANDED DEMOGRAPHIC INFORMATION

Demographic	Respondents
Race or Ethnicity	
White (not Hispanic)	626
Asian	134
Hispanic or Latin(x)	94
Black or African American	14
American Indian or Alaska Native	5
Native Hawaiian or Other Pacific Islander	5
Mixed Race	29
Prefer not to respond	17
Gender	
Men	518
Women	389
Another	13
Prefer not to respond	4
Sexuality	
Heterosexual	756
LGBTQA	151
Bisexual	70
Questioning or unsure	25
Gay	18
Lesbian	10
Another orientation	28
Prefer not to respond	17
Year in program	
First	488
Second	436
Disability	
Learning disability	57
Physical disability	46
Parents' Education	
Bachelor's degree	371
Post-Bachelor's Training	340
High-school diploma or equivalent	78
Completed some college	68
Associate's degree	43
Some formal schooling	20
Prefer not to respond	4
Other Factors	
Diagnosed with mental health condition	132
International student	48
Veteran of Armed Forces	17

overall population. For the Kessler 6, the scoring threshold for moderate psychological distress proposed and validated by Prochaska *et al.* [67] is used. With the screening instruments, certain conditions are mutually exclusive: a person with a positive screen for Kessler Major Psychological Distress automatically receives a negative screen for Kessler Moderate Distress. The same is true for Major versus Other Depressive disorders.

After mental health screen rates were computed, RQ2 was addressed by running a logistic regression for each mental health issue against demographic factors to determine whether any groups of respondents have significantly different screening rates ($p \leq 0.05$) from the baseline population.

Previous research has suggested that women students of color and may suffer from mental health issues at higher rates than White women students and men students of color [49], [55], [56], [72], [73]. To explore how intersecting identities affected mental health, the regression model incorporated two-way interactions between gender and race, gender and sexuality, and race and sexuality. Unfortunately, there were not enough respondents in each race, gender, and sexuality category to allow regressions analyzing three-way interactions to converge.

Several population categories from Table I had sample sizes too small to allow for regression models to converge. These categories include Black or African American, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, and Mixed Race for race; another gender for gender; Lesbian, Gay, unsure or questioning, and "another" for sexuality; veterans for veteran status; and students with parents who only completed "some formal schooling." Since substantial existing literature on the mental health of marginalized sexual identities aggregates identities into LGBTQ or LGBTQA groupings, this analysis also aggregates these identities rather than excluding all nonheterosexual and nonbisexual respondents. Additionally, respondents whose parents completed some formal schooling were grouped with those whose parents completed high school into an "HS or less" group. Unfortunately, for the race categories, there was no reasonable aggregation that allowed the regression models to converge. Therefore, these groups were excluded from further analysis.

Bulimia and binary eating screens were also excluded from regression analysis as the low number of positive screens for these conditions overall meant that only models with few demographic groupings would be able to converge on a meaningful solution.

After reducing the data set, the population groups shown in Table II were used for regression. These are encoded as 12 independent binomial regression variables. Overrepresented populations were used as baseline populations, as summarized in Table III. Filtering the data to just these populations left 830 responses for the regression.

Data analysis was conducted using the R programming language [74] in RStudio [75]. Plots for this work were generated using the ggplot2 R-package [76].

D. Limitations

There are some limitations to this study that may limit the generalizability of the results. First, despite working with several partner universities nationwide and collecting nearly 1000 usable responses, this data did not include a significant number of respondents identifying as African American, Indigenous, Native Hawaiian, or Pacific Islanders. The racial groupings used in this survey were also limited, with no separate categories for South Asian, Southeast Asian, or Middle Eastern. Both of these factors mean that the experiences and challenges faced by several marginalized groups are not captured here. Another limitation is that due to low response rates from

TABLE II
POPULATIONS USED IN REGRESSION ANALYSIS

Factor	Selected Groups
Race	White (not Hispanic) Hispanic or Latin(x) Asian
Gender	Men Women
Sexuality	Heterosexual LGBTQA
Learning disability	Yes No
Physical disability	Yes No
Parents' Education	Bachelor's degree Post-Bachelor's training Associate's degree No College Some college
Private school	Yes No
International student	Yes No

TABLE III
BASELINE POPULATION FOR EACH DEMOGRAPHIC FACTOR

Factor	Population
Race	White, Non-Hispanic
Gender	Men
Sexuality	Heterosexual
International student	No
Learning disability	No
Physical disability	No
Parents' education	Bachelor's Degree
University type	Public

individuals belonging to marginalized sexual identities, individuals with different sexual identities needed to be grouped into a single LGBTQA group for regression analysis. While this grouping is common in the existing literature, it likely masks unique challenges faced by each sexual identity group. To address this limitation of quantitative research, future work will explore other methods for better understanding such groups.

Finally, since this data was collected as part of a broader, longitudinal study on engineering student mental health, the sample population is limited to first- and second-year engineering students only. Therefore, this work is unable to discuss how time in the program affects student mental health.

IV. SURVEY RESULTS

The overall screening rates for various mental health conditions and the 95% confidence intervals are shown in Fig. 1. Each screening instrument provides a binomial (positive and negative) result.

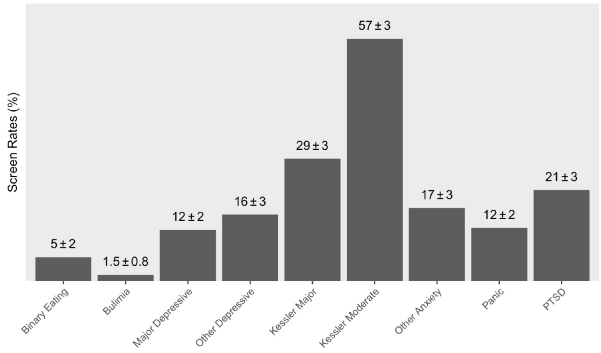

Fig. 1. Positive screen rates with 95% confidence intervals for all respondents.

The screening results for this population indicate that 85% of respondents were experiencing at least a moderate level of psychological distress, with nearly one-third of students suffering from major—potentially indicative of a DSM diagnosable mental health condition—distress. 28% of respondents screened positive for some form of depressive disorder, and more than a fifth of respondents reported suffering from PTSD-like symptoms. In all, 50% of the 717 respondents who completed all mental health screens in the survey screened positive for at least one diagnosable condition (all measures except Kessler moderate), while only 16% of these 717 respondents reported having received a mental health diagnosis.

A logistic regression was used to determine which subsamples of respondents were more or less likely than the baseline population to screen positive for a given diagnosis. For the sake of brevity, the results of this analysis and upper and lower 95% confidence intervals are summarized in Table IV. Populations not shown in Table IV, including Asian Americans and respondents who identified as "international students," did not have significantly different odds of screening positive or negative for any condition relative to the baseline population. The baseline population varies with each demographic as summarized in Table III.

Identifying as a woman in engineering was a statistically significant predictor of positive screen rates for more conditions than any other respondent grouping included in the regression analysis. Respondents identifying as women were nearly four times more likely to screen positive for panic disorder than their men peers, nearly twice as likely to screen positive for other anxiety, and 1.8 times more likely to screen positive for PTSD-like symptoms. Women respondents were also more than 50% more likely to screen positive for major depressive disorder versus men respondents.

Respondents with physical disabilities also scored significantly higher than the baseline population on several screening instruments and had the highest statistically significant odds of screening positive for PTSD-like symptoms of any group examined.

Identifying as Hispanic or Latinx was also a significant predictor of certain screens. Respondents in this category were among the most likely to screen positive for major depressive

TABLE IV
ODDS RATIO AND 95% CONFIDENCE INTERVALS FOR STATISTICALLY SIGNIFICANT PREDICTORS OF MENTAL HEALTH SCREENS BY DEMOGRAPHIC

Population	Condition	Odds Ratio	Lower Interval	Upper Interval	p
Women	Major depressive	2.3	1.2	4.3	.012
	Panic disorder	4.4	2.2	9.3	$<$ .001
	Other anxiety	2.2	1.3	3.7	.003
	PTSD	1.9	1.2	3.0	.010
Hispanic or Latinx	Major depressive	3.2	1.2	7.7	.017
	PTSD	2.5	1.2	5.2	.013
Parents' education: HS or less	Major depressive	2.1	1.0	4.0	.040
	Other anxiety	2.1	1.1	4.1	.026
Parents' education: Assc deg	Major depressive	3.2	1.2	8.2	.017
	PTSD	2.5	1.1	5.5	.029
Parents' education: Some col	Kessler major	2.2	1.2	3.9	.012
Parents' education: Post-Bac	Other anxiety	1.6	1.0	2.7	.035
Physical disability	Kessler major	2.2	1.1	4.5	.025
	Other depressive	3.3	1.5	6.9	.002
	PTSD	2.9	1.3	6.0	.005
LGBTQA Women	Kessler moderate	0.39	0.16	0.93	.037

disorder and two-and-a-half times as likely as the baseline white group to suffer from PTSD-like symptoms.

Finally, all respondents whose parents' highest level of education was not a bachelor's degree had higher odds of screening positive on certain instruments. Two out of three "first generation" groups saw significantly increased odds of screening positive for major depression. Respondents whose parents have more than a bachelor's degree were more than 1.5 times as likely to screen positive for other anxiety.

Among other groups, neither identifying as Asian or as LGBTQA were significant predictors of any mental health screen. Most of the explicit two-way interaction variables among race, gender, and sexuality yielded no statistically significant differences from baseline populations. The one exception was that respondents identifying as LGBTQA Women had lower odds of screening positive for moderate psychological distress than baseline groups.

V. DISCUSSION

The sample of respondents from eight universities across the United States experienced very high incidences of moderate-to-major psychological distress, with a population average of 86%. Overall, respondents also screen positive for Panic Disorder at nearly five times the rate of the general population [42]. Incidence of Major Depressive Disorder was within the margin of error of the national average for 18–25-year-olds (12% for survey respondents versus 13% nationally) [43], while total depression rates for engineering students were lower than has been reported for college students [77]. Finally, at 21% positive screen rate, respondents are more than five times as likely to experience PTSD-like symptoms than the rest of the population [69].

Delving into the data, respondents identifying as women were significantly more likely to screen positive for all anxiety-related conditions (panic, other anxiety, and PTSD-like) than men respondents. Women respondents were also more likely to screen positive for major depressive disorders. Some of this difference mirrors nationwide population trends. Respondents identifying as women are 1.9 times more likely to screen positive for PTSD-like symptoms than those identifying as men, which is a smaller gap than has been reported at a national level [69]. Given that women respondents are significantly more likely to screen positive for over half of the mental health conditions in these regressions it is likely that there are factors related to engineering specifically exacerbating mental health issues for women. Indeed, hurdles facing women in engineering environments are well known and include factors like micro-aggressions, stereotype threat, and feelings of isolation [78]–[81], and these factors have been previously linked to worse mental health outcomes in women engineering students [82]. Indeed, follow-up interviews with engineering students identified aspects of engineering education that exacerbate mental health challenges for women [83].

Identifying as Hispanic or Latinx also significantly increased the odds of a respondent screening positive for major depression and PTSD-like conditions, with Hispanic respondents having over three times the odds of screening positive for major depression and 2.5 times the odds of screening positive for PTSD. These results match with the previous literature indicating that Hispanic students face unique stressors and mental health challenges in higher education [84], [85]. With students of color being exposed to micro-aggressions and stereotype threat in higher education [84], [86], it is possible the environment of engineering education makes students from the certain racial and ethnic background more prone to mental health diagnoses.

Surprisingly, sexuality overall was not a statistically significant predictor of any of the analyzed mental health screens.

This result was unexpected given that LGBTQA students face unique challenges and stressors in higher education and engineering programs [25], [53], [54], [87]. It is possible that this is an artifact of grouping so many different identities into a single LGBTQA group: if different groups are prone to struggle with different mental health challenges, it may be that no one diagnosis comes out as statistically significant. Regardless, future study into this group is warranted.

Beyond race, ethnicity, and gender, identifying as having a physical disability was a predictor of several mental health screens, and, indeed, the group had the highest odds of positive screens for both major psychological distress and PSTD-like symptoms among any group analyzed. This suggests that there may be a significant need for mental health resources for this community. Indeed, significant prior research has identified continued issues of stigma and social isolation for students with disabilities [88]–[90], to the point that those with nonapparent disabilities may not disclose or may actively deidentify as disabled and forgo available accommodations as a way to avoid stigma [91]. Students with certain apparent physical disabilities arguably lack even the choice to forgo institutional support for social acceptance. There is also evidence of significant structural and cultural barriers facing those with disabilities in engineering, with some faculty reluctant to provide necessary accommodations even if students navigate the process of engaging with college-level support services [90]. Finally, there may be perceived barriers for students: previous research on geoscience degree programs has drawn a link between program focus on "students tackling challenging environments" and perceptions of accessibility for program applicants with physical disabilities [92]. Engineering programs, with their focus on "field work" and "hands-on" learning may inadvertently create an atmosphere of physical able-ism that serves to exclude those with physical disabilities.

While identifying as having a physical disability was a significant predictor for several mental health screens, identifying as having a learning disability was not. This is important to note since previous research has shown that all individuals with all disabilities—including learning disabilities—may be subject to some social stigma [89], and recent research suggests that navigating the norms and contexts of engineering programs provides a significant challenge for individuals with nonphysical disabilities who may qualify for academic accomodations [58]. This could be indicative that those with learning disabilities are able to successfully publicly deidentify [91], and partially escape the social stigma. The discrepancy between mental health outcomes in learning disabled and physically disabled, however, bears more in-depth exploration, and follow-up work should consider a broader spectrum of "disability" beyond the simple categories of "physical" and "learning."

Parents' education was also a predictor of student mental health. Having parents whose highest level of education was either an Associate's degree or high school or less corresponded with significantly higher odds that a respondent would screen positive for major depressive disorder. Having parents whose highest level of education includes some college is correlated with increased odds of a positive screen for major psychological distress. As significant research has documented the unique challenges and struggles faced by "first-generation" students, it is not surprising that students in these groups also face unique mental health challenges. Much previous research looking at first-generation students treats these students as a single group, and the precise definition of first generation varies across publications from those whose parents ceased schooling at high school or below [93], to those for whom neither parent has received a bachelor's degree [94]. The significant difference in mental health screens between the three categories of first-generation students presented here (HS or less, some college, and Associate's) suggests that monolithic groupings of first-generation students may obscure the unique experiences and challenges faced by these students. This research also suggests different types of first-generation students may need different mental health support and resources.

This study's results also suggest that respondents from families where at least one parent has completed post-Baccalaureate training also face unique mental health challenges. These respondents arguably grew up in a context that valued higher education and likely have access to family-based support systems that are familiar with some of the challenges and experiences of higher education. Additionally, to the extent that parents' education is a significant predictor of socio-economic class, these students are arguably less likely to have unmet material needs or financial difficulties compared to their peers. Therefore, the result that respondents in this group may have unique mental health challenges is surprising. While there does not appear to be much literature exploring the mental health of students whose parents have high levels of academic achievement, a recent study has suggested a link between highly educated parents and child anxiety in certain academic tasks [95].

Finally, this analysis attempted to identify whether respondents belonging to multiple marginalized groups in engineering have different mental health experiences than respondents who identify as a member of fewer marginalized groups. While specific interaction variables in the regression were largely not statistically significant (with the exception of LGBTQA Women and moderate psychological distress), it is important to note that odds ratios for logistic regression are multiplicative across groups. Respondents identifying as Hispanic have 3.2 times the odds of screening positive for major depressive order as a white student, and women respondents have 2.3 times the odds of screening positive for the major depressive disorder than men, a respondent identifying as a Hispanic woman may have 7.4 times the odds of screening positive for major depressive disorder than a white man. The wide confidence intervals on the regression results mean that such numbers must be taken with a grain of salt: the odds of a Latina screening positive for major depressive disorder may be as low as 1.44 times the odds of a white male screening positive (or potentially even lower if a 95% confidence is to be maintained). Regardless, the regression results do indicate that being a member of multiple marginalized groups can be associated with higher odds of mental health challenges than being a member of just one.

VI. Conclusion

This work explored the mental health of engineering students at eight institutions across the United States. The results confirm that engineering students face higher rates of anxiety and depressive disorders than the general U.S. population. Engineering students, however, may suffer from depressive disorders at lower rates than college students overall [77].

This analysis showed a large gap between engineering students likely suffering from mental health issues and those seeking help. While only 16% of respondents report that they have been diagnosed with a mental health condition, 50% of respondents who completed all screens screened positive for at least one diagnosable condition. For comparison, roughly 37% of college students have received some sort of mental health diagnosis during their lifetime [77]. Additionally, 21% screen positive for PTSD-like symptoms. Together, these results suggest that engineering students are either under-served by campus mental health resources, or, as suggested by previous research, are simply less likely to use these resources [40], [96]. Regardless of the cause, engineering students could benefit from targeted outreach by campus mental health and counseling services.

To better understand how different demographic factors influence mental health in engineering, a logistic regression was run for the seven mental health screens for which there was sufficient data. Gender was found to be a significant predictor for positive screens across a range of conditions. Women were statistically more likely than men to screen positive for all anxiety-related disorders and major depression. While this trend mirrors national mental health trends for anxiety and depressive conditions [42], [43], the magnitude at which women versus men screen positive for these conditions indicates that some aspects of engineering culture and campus life are especially burdensome for women in engineering. Additionally, respondents identifying as Hispanic were significantly more likely to suffer from major depressive disorder and PTSD-like symptoms than their White peers. These results are also in line with the previous literature suggesting women of color and other members of multiple marginalized groups face additional challenges in the field of STEM: those identifying as a Hispanic woman or Latina would have higher odds of screening positive for major depressive disorder and PTSD-like symptoms than would those identifying as either a white woman or Hispanic man.

Perhaps the most interesting finding is only physical disability and not learning disability was a significant predictor for elevated positive screens for mental health conditions. Respondents with physical disabilities are nearly three times as likely to screen positive for PTSD-like symptoms as their peers, which is the highest likelihood for this condition among any measured populations. These results may indicate that colleges have been more successful at promoting inclusion, accommodation, and equity for those with learning disabilities versus those with physical disabilities, or that there are characteristics of engineering programs that make participation challenging for those with physical disabilities. Regardless, the increased likelihood of PTSD among these individuals as well as increased odds of screening positive for other depression and PTSD-like symptoms indicate a real need to reach out and provide resources to the physically disabled community.

Overall, the data indicates that there are significant mental health discrepancies between demographic groups in engineering education. These discrepancies favor dominant populations in engineering. To address these gaps, it is imperative that more support be targeted to different demographic populations in engineering programs, especially those with disabilities, and those who identify with multiple marginalized identity groups. Follow-up interviews were also conducted and will play a key role in identifying cultural and structural factors that lead to these results [83]. Finally, more data must be collected to see how mental health issues affect students from other marginalized groups, including but not limited to, African Americans, Native Americans, Gay, Lesbian, and transgender individuals.

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